Master of Library & Information Science
I - Semester
323 13

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Rapid globalization coupled with the growth of the Internet and information technology (IT), has led to a complete transformation in the way businesses or organizations function today. This has affected management cultures and also led to increased competition in terms of market and resources. E-business is gaining popularity because businesses have become more customer-driven. Even the traditional means of correspondence have given way to online dealings, e-mails and chats. This paradigmatic shift in business approach has resulted in the need for a specialized system that has the ability to handle the various departments and functions in an organization. An information system can be called an organized and well-structured system that is introduced in an organization to collect, store, process and disseminate data in the form of information. Management can thus ensure that the organization is running in a smooth manner.

This book, *Information Technology and Information System*, follows the SIM format or the self-instructional mode wherein each Unit begins with an Introduction to the topic followed by an outline of the ‘Objectives’. The detailed content is then presented in a simple and organized manner, interspersed with Check Your Progress questions to test the understanding of the students. A Summary along with a list of Key Words and a set of Self Assessment Questions and Exercises is also provided at the end of each unit for effective recapitulation.
A computer is an electronic device that is used to carry out sequences of arithmetic or logical operations automatically. Input device is a hardware component that is used to enter data in the computer while output device provides the result after arithmetic and logical operations. Memory is used for storing data and information temporarily or permanently. You will also learn about the evolution and various types of computers. Computer generation terminology is change in technology a computer. It is used to distinguish between varying hardware technologies. Computers can be classified on the basis of their size, processing speed and cost. It can be classified in Digital, Analog and Hybrid. You will also learn about the networking components used in communication.

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

- Discuss the different types of computers and its generations
- Discuss different types of hardware components used in networking
- Explain the different types of networking cables
1.2 COMPUTER GENERATION AND CLASSIFICATION

Computers can be classified on the basis of their size, processing speed and cost. The various types of computers are as follows:

- Personal computers (PC)
- Workstations
- Notebook/laptop computers
- Tablet PC
- PDA (Personal Digital Assistant)
- Mainframe computers
- Supercomputers

Some other types of computers are discussed as follows:

Analog Computers

These types of computers are involved in industrial process controls and measure physical quantities, such as pressure, temperature, and so on. These computers do not use binary digits but use electrical signals to provide output with electrical resistance, voltage, and so on. The memory of these computers is not much and they can be used only for specific calculations; however, their speed is more than digital computers.

These electrical properties allow calculations to be performed in real time or even faster at the speed of light. The main mathematical operations it applies include summation, inversion, exponentiation, logarithm, integration, differentiation, multiplication and division.

Digital Computers

These types of computers are primarily involved in data processing and problem solving for specific programs. In digital computers, data is stored as digits (numbers) and processes. Letters, words, symbols and complete texts are digitally represented, that is, using only two digits 0 and 1. Digital computers have a lot of memory for storing data.

Digital computers constitute input-output devices, main memory, control unit and arithmetic logic unit. Data is processed with logical circuits, also known as digital circuits. All the circuits processing data inside a computer function in an extremely synchronized mode; this is further controlled using a steady oscillator acting as the computer’s ‘clock’. Hence, the digital computers operate on very high speed and are able to perform trillions of logical or arithmetic operations per second to provide quick solution to problems, which is not possible for a human being to do manually.
Hybrid Computers

Hybrid computers are a mixture of digital and analog computers. A hybrid computer uses the best characteristics of digital and analog computers. It helps the user to process both continuous and discrete data. Hybrid computers are generally used for weather forecasting and industrial process control.

The digital component basically functions as a controller to provide logical operations, whereas the analog component provides solutions of differential equations. Remember that the hybrid computers are different from hybrid systems. A hybrid system is a digital computer equipped with an analog-to-digital converter for input and a digital-to-analog converter for output. The term ‘hybrid computer’ represents a combination of different digital technologies to process specific applications with the help of various specific processor technologies.

General Purpose Computers

Workstations are high-end, general-purpose computers designed to meet the computing needs of engineers, architects and other professionals who need computers with greater processing power, larger storage and better graphic display facilities. These are commonly used for Computer Aided Design (CAD) and for multimedia applications, such as creating special audio-visual effects for television programmes and movies. A workstation looks like a PC and can be used by only one person at a time. The characteristics of a workstation, which are often used to differentiate it from a PC, are as follows:

- **Display Facility:** Most workstations have a large screen monitor (21 inches or more) capable of displaying high resolution graphics as compared to PCs, which have a small screen monitor (19 inches or less).
- **Storage Capacity:** Workstations have a larger main memory than PCs, which have only a few hundred MB of main memory. The hard disk capacity of workstations is also more than that of PCs.
- **Processing Power:** The processing power of workstations is several times greater than that of PCs.
- **Operating System:** PCs can run on any of the five major operating systems—MS DOS (Microsoft Disk Operating System), MS-Windows, Windows-NT, Linux and UNIX—but all workstations generally run the UNIX operating system or a variation of it, such as AIX (used in IBM workstations), Solaris (used in SUN workstations) and HPUX (used in HP workstations).
- **Processor Design:** PCs normally use CPUs (Central Processing Units) based on the Complex Instruction Set Computer (CISC) technology, whereas workstation CPUs are based on the Reduced Instruction Set Computer (RISC) technology.
Special Purpose Computers

These types of computers are digital or an analog computers which are specifically designed to perform desired specific tasks. These are high performance computing systems with special hardware architecture, which is dedicated to solve a specific problem. This is performed with the help of specially programmed FPGA (Field Programmable Gate Array) chips or custom VLSI (Very-Large-Scale Integration) chips. They are used for special applications, for example, astrophysics computations, GRAPE-6 (for astrophysics and molecular dynamics), Hydra (for playing chess), MDGRAPE-3 (for protein structure computations), and so on.

Micro, Mini, Mainframe and Supercomputers

These are as follows:

(i) Microcomputers

Microcomputers are developed from advanced computer technology. They are commonly used at home, classroom and in the workplace. Microcomputers are called home computers, personal computers, laptops, personal digital assistants, and so on. They are powerful and easy to operate. In recent years, computers were made portable and affordable. The major characteristics of a microcomputer are as follows:

- Microcomputers are capable of performing data processing jobs and solving numerical programs. Microcomputers work rapidly like minicomputers.
- Microcomputers have reasonable memory capacity which can be measured in megabytes.
- Microcomputers are reasonably priced. Varieties of microcomputers are available in the market, which can be as per the requirement of smaller business companies and educational institutions.
- Processing speed of microcomputers is measured in megahertz. A microcomputer running at 90 MHz works approximately at 90 MIPS.
- Microcomputers have drives for floppy disks, compact disks and hard disks.
- Only one user can operate a microcomputer at a time.
- Microcomputers are usually dedicated to one job. Millions of people use microcomputers to increase their personal productivity.
- Useful accessory tools, such as clock, calendar, calculator, daily schedule reminders, scratch pads, and so on, are available in a microcomputer.
- Laptop computers, also called notebook computers, are microcomputers. They use the battery power source. Laptop computers have a keyboard, mouse, floppy disk drive, CD drive, hard disk drive and monitor. Laptop computers are expensive in comparison to personal computers.
(ii) Minicomputers

Minicomputers are a cheaper version of mainframe computers. The processing power and cost of a minicomputer are less than that of the mainframe. Minicomputers have big memory sizes and faster processing speed compared to the microcomputers. Minicomputers are also called workgroup systems because they are well suited to the requirements of the minor workgroups within an organization. The major characteristics of a minicomputer are as follows:

- Minicomputers have great problem-solving capabilities.
- Minicomputers have reasonable memory capacity which can be measured in megabytes or gigabytes.
- Minicomputers have quick processing speeds and operating systems facilitated with multitasking and network capabilities.
- Minicomputers have drives for floppy disk, magnetic tape, compact disk, hard disks, and so on.
- Minicomputers can serve as network servers.
- Minicomputers are used as a substitute of one mainframe by big organizations.

(iii) Mainframe Computers

Mainframe computers are generally used for handling the needs of information processing of organizations, such as banks, insurance companies, hospitals and railways. This type of system is placed in a central location with several user terminals connected to it. The user terminals act as access stations and may be located in the same building (see Figure 1.1).

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**Fig. 1.1 Mainframe Computer**
Mainframe computers are bigger and more expensive than workstations. They look like a row of large file cabinets and need a large room with closely monitored humidity and temperature levels. A mainframe system of lower configuration is often referred to as a minicomputer system. The various components of a mainframe computer are as follows:

- **Host, Front-End and Back-End Computers**: A mainframe system consists of several computers, such as a host computer that carries out most of the computations and has direct control over all other computers. The front-end portion is used for handling communications to and from all the user terminals connected to the mainframe computer. The back-end portion is used to handle data input/output operations. The host computer and other computers are located in the systems room, to which entry is restricted to system administrators and maintenance staff only.

- **Consoles**: Console terminals are directly connected to the host computer and are mainly used by the system administrator to perform certain administrative tasks, such as installing new software on the system, taking system backups and changing the configuration of the system.

- **Storage Devices**: A mainframe computer has several magnetic disk drives directly connected to the back-end computer. The host computer, via the back-end computer, gets all data from these magnetic disks. In addition, a mainframe computer also has a few tape drives and a magnetic tape library (located in the systems room) for restoration and backup of data. The tape drives are present in the users’ room, so that users’ tapes can be used for input and output.

- **User Terminals**: User terminals are used to access the required stations, which may be present at different locations. Since mainframe computers support multiprogramming with time-sharing, they can run different operating systems for multiple users at the same time.

- **Output Devices**: A mainframe computer has several output devices, such as printers and plotters, connected to the back-end computer, so that these devices can be used for taking outputs by the users.

(iv) **Supercomputers**

Supercomputers are the most powerful and expensive computers available today. They are mainly used for processing scientific applications that involve tasks with highly complex calculations and for solving problems with mechanical physics, such as weather forecasting and climate research systems, nuclear weapon simulation and simulation of automated aircrafts. Supercomputers are mainly used by military organizations, major research and development centers, universities and chemical laboratories.

Supercomputers use multiprocessing and parallel processing technologies to solve complex problems quickly. They use multiprocessors, which help the user to divide a complex problem into smaller problems. A parallel program is
written in a manner that can break up the original problem into smaller modules. Supercomputers also support multiprogramming, which allows simultaneous access to the computer by multiple users. Some of the manufacturers of supercomputers are IBM, Silicon Graphics, Fujitsu and Intel.

**Personal Computers**

A PC is a small single user microprocessor-based computer that resides on your desktop, and is generally used at homes, offices and schools. As the name implies, PCs were mainly designed to meet the personal computing needs of individuals. Personal computers are used for preparing normal text documents, spreadsheets with predefined calculations and business analysis charts, database management systems, accounting systems, and also for designing office stationary, banners, bills and handouts.

The configuration varies from one PC to another depending on its usage. However, it consists of a CPU or system unit, a monitor, a keyboard and a mouse. It has a main circuit board or motherboard (consisting of the CPU and the memory), hard disk storage, floppy disk drive, CD-ROM (Compact Disk-Read Only) drive and some special add-on cards (like Network Interface Card) and ports for connecting peripheral devices like printers.

PCs are available in two models—desktop and tower. In the desktop model, the monitor is positioned on top of the system unit, whereas in the tower model, the system unit is designed to stand by the side of the monitor or even on the floor to save desktop space. Due to this feature, the tower model is more popular.

Some popular operating systems for PCs are MS DOS, MS-Windows, Windows-NT, Linux and UNIX. Most of these operating systems can perform many functions at the same time, which ease operation and save time when a user has to switch between two or more applications while performing a job. Some leading PC manufacturers are IBM, Apple, Compaq, Dell, Toshiba and Siemens.

**Types of Personal Computers**

Different types of personal computers are as follows:

1. **Notebook/Laptop Computers**

Notebook computers are battery operated personal computers. Smaller than the size of a briefcase, these are portable computers and can be used in places, such as libraries, in meetings or even while travelling. Popularly known as laptop computers, or simply laptops, notebook computers are usually more expensive as compared to desktop computers; however, they have almost the same functions. But since they are sleeker and portable, they have a complex design and are more difficult to manufacture. These computers have large storage space and other peripherals, such as serial port, PC card, modem or network interface card, CD-ROM (Compact Disk-Read Only Memory) drive and printer. They can also be
A notebook computer uses the MS DOS or WINDOWS operating system. The data processing capability of a notebook computer is as good as an ordinary PC because both use the same type of processor, such as an Intel Pentium processor. However, a notebook computer generally has lesser hard disk storage than a PC.

2. Tablet PC

Tablet PC is a mobile computer that looks like a notebook or a small writing slate but uses a stylus pen or your finger tip to write on the touch screen. It saves whatever you scribble on the screen with the pen, in the same way as you have written it. The same picture can then be converted to text with the help of an HR (Hand Recognition) software.

3. PDA

A Personal Digital Assistant (PDA) is a small, palm sized, hand-held computer which has a small color touch screen with audio and video features. They are nowadays used as smart phones, Web-enabled palmtop computers, portable media players or gaming devices.

Most PDAs today typically have a touch screen for data entry, a data storage/memory card, bluetooth, Wi-Fi or an infrared connectivity, and can be used to access the Internet and other networks.

Computer Generations

The history of computer development can be divided into different phases, which are often referred to as generations of computing devices. ‘Generation’ in computer terminology is a ‘step’ in technology. Each generation of computers is characterized by a major technological development that fundamentally changes the way computers operate, resulting in increasingly smaller, cheaper, and more powerful,
efficient and reliable devices which have decreased the energy consumption and resulted in lesser heat dissipation.

Originally, the term ‘generation’ was used to distinguish between varying hardware technologies, but nowadays, it includes both hardware and software.

The following are the characteristics of each generation of computers:

1. **First Generation (1940–1956): Vacuum Tubes**
   The first computers used vacuum tubes in their electronic circuits and magnetic drums for memory. A vacuum tube was a delicate glass device that used filaments as a source of electrons, and could control and amplify electronic signals. Figure 1.3 displays a vacuum tube.

   ![A Vacuum Tube](image)

   **Fig. 1.3 A Vacuum Tube**

   These computers could perform computations in milliseconds but were enormous in size, occupying almost an entire room. They were very expensive to operate and in addition to using a great deal of electricity, generated a lot of heat, resulting in malfunctioning.

   First generation computers relied on machine language (binary-coded programs) to perform operations and could solve only one problem at a time. Input was based on punch cards and paper tape, and output was displayed on printouts.

   Early computers, such as ENIAC, EDVAC and UNIVAC I can be classified as first generation computers.

   Transistors, developed in 1947, replaced vacuum tubes in the second generation computers. The transistor was far superior compared to vacuum tube, making computers smaller, faster, cheaper, more energy efficient and more reliable than their first generation predecessors. Although transistors also generated a great deal of heat that could damage the computer, it was a great improvement over the vacuum tube. Second generation computers still relied on punched cards for input and printouts for output.

   The cryptic binary machine language was followed by the symbolic or assembly language that allowed programmers to specify instructions in words.
High-level programming languages like COBOL and FORTRAN were also being developed at this time.

These were also the first computers that stored their instructions in the memory, which advanced from magnetic drum to magnetic core technology. The first computers of this generation were specifically developed for the atomic energy industry.


Transistors were clearly an improvement over the vacuum tube but still generated a lot of heat resulting in computer damage.

Fig. 1.4 An IC Chip

The development of integrated circuit (IC) (see Figure 1.4) by American electrical engineer Jack Kilby in 1958, an engineer with Texas Instruments, was the greatest achievement of the third generation of computers.

Instead of punched cards and printouts, users interacted with third generation computers through devices like keyboards and monitors. They also interfaced with an operating system that allowed the device to run many different applications at one time with a central program that monitored the memory.

Now, the computers became accessible to the masses because they were substantially smaller and cheaper than their predecessors.


Large Scale Integration (LSI) were developed which could fit hundreds of components onto a single chip. By 1980s, Very Large Scale Integration (VLSI) squeezed thousands of components onto a single chip. Ultra Large Scale Integration (ULSI) increased that number to millions.

The ability to fit so much processing capability in an area so small, helped to reduce the size and price of the computers. It also increased its power, efficiency and reliability.
Initially, the IC technology was used only for constructing the processor, but it was soon discovered that the same technology could also be used for the construction of memory. The first memory chip was constructed in 1970 and could hold 256 bits. Figure 1.4 displays an IC chip.

As more and more components were fabricated on a single chip, fewer and fewer chips were needed to construct the processor. The Intel 4004 chip, developed in 1971, located all the components of the computer — from Central Processing Unit and Memory to Input/Output controls — on a single chip. This was the first microprocessor. Figure 1.5 displays the Intel pentium microprocessor chip.

IBM introduced its first computer in 1981 for the home users, and in 1984, Apple introduced the Macintosh. Microprocessors also advanced from the realm of desktop computers to advanced technologies and many areas of life as more and more everyday devices began to use microprocessors.

As computers increased in computing power, it was possible to connect them together to form networks, which eventually led to the development of the Internet. Fourth-generation computers also marked the development of GUls (Graphical User Interfaces), the mouse and various handheld devices.

5. Fifth Generation (Present and Beyond): Artificial Intelligence
The fifth generation computers are being developed using the technology of artificial intelligence; for instance, voice recognition systems. Parallel processing and supercomputers have lead to the further development of artificial intelligence. In the future, quantum computation and molecular technology will tremendously transform computers. The fifth generation aims at creating devices that respond to input in natural language and are capable of learning and self organization.
Table 1.1 provides a list of various computer generations.

### Table 1.1 Generation of Computers

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<th>Software</th>
<th>Features</th>
<th>Examples</th>
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<td>I</td>
<td>1942–</td>
<td>Vacuum Tubes</td>
<td>Machine Language (Binary Language)</td>
<td>High-speed electronic switching device; memory type was electromechanical; bulky in size; generated a large amount of heat; frequent technical faults required constant maintenance; used for scientific purposes; air-conditioning required</td>
<td>ENIAC, EDVAC, EDAC, UNIVAC I</td>
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<td>1955</td>
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<tr>
<td>II</td>
<td>1955–</td>
<td>Transistors</td>
<td>High-Level Languages</td>
<td>Better electronic switching device than vacuum tubes; made of germanium semiconductor; memory type was magnetic core; powerful and more reliable; easy to handle; much smaller than vacuum tubes; generated less heat as compared to vacuum tubes; used for business and industries for commercial data processing; air-conditioning required</td>
<td>Livermore, Atomic Research Computer (LARC), IBM</td>
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<tr>
<td>III</td>
<td>1964–</td>
<td>Integrated Circuits (ICs)</td>
<td>High-Level Languages</td>
<td>ICs were smaller than transistors; consumed less power; dissipated less heat as compared to transistors; more reliable and faster than earlier generations; capable of performing about 1 million instructions per second; large storage capacity; used for both scientific and commercial purposes; air-conditioning required</td>
<td>Mainframe, Mini computers</td>
</tr>
<tr>
<td></td>
<td>1975</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>1975–</td>
<td>Microprocessors</td>
<td>Advanced Java (J2EE, JDO, JavaBeans), PHP, HTML, XML, SQL</td>
<td>Microprocessors had control over logical instructions and memory; semiconductor memories; personal computers were assembled; used in LAN and WAN to connect multiple computers at a time; used graphical user interface; smaller, more reliable and cheaper than third-generation computers; had secondary storage memories; had Computer Supported Cooperative Working (CSCW); air-conditioning not required</td>
<td>Personal Computers (PCs), LAN, WAN, CSCW</td>
</tr>
<tr>
<td></td>
<td>1989</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>1989–</td>
<td>Optical Disks</td>
<td>Artificial Intelligence, PROLOG, OPS, Memory</td>
<td>PCs were assembled – portable and non-portable, powerful desktop PCs and workstations; less prone to hardware failure; user-friendly features – Internet, e-mailing; air-conditioning not required</td>
<td>Portable PCs, Palmtop Computers, Laptops</td>
</tr>
<tr>
<td></td>
<td>Present</td>
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<td></td>
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</tbody>
</table>

1.3 UNDERSTANDING IT AND COMPONENTS OF IT COMPUTERS AND COMMUNICATION TECHNOLOGIES

Development in communication technology involve many small steps towards the technology. With the time many new hardware, software (Protocol) were developed in communication technology. In common language communication technology is networking. Networking involve many hardware devices as well as software...
(Protocol) for data communication. In this section we will discuss about different hardware and protocols involved in communication technology.

**Different hardware used in networking**

Communication or transmission requires different hardware for data transmission. Commonly used hardware needed to transfer data in network are as follows:

- Gateway
- Router
- Network bridges
- Modem
- Wireless Access Point (WAP)
- Networking Cables
- Switches
- Hub
- Repeaters
- Ethernet adaptor

**Gateway:** A gateway is a piece of hardware used in data communication for network. Gateway allows data to flow from one separate network to another. Gateways are distinct from router or switches. They communicate using more than one protocol and can operate at any of the 7 layers of the OSI model. A gateway is an essential feature of most routers, although other devices such as any PC or server. Any PC or server can act as a gateway. A default gateway is the computer (node) in a network using the IP (Internet Protocol) that serves as the forwarding host to other networks when no other route specification matches the destination IP address of a packet. A gateway is a hardware device that acts as a "gate" between two networks. It may be a router, firewall, server or other device that enables traffic to flow in and out of the network.

*Fig. 1.6 Gateway*
Router

A router is a networking device which is used to forward data packets between computer networks. Routers perform the traffic directing functions on the Internet. Data sent through the internet, such as a web page or email, is in the form of data packets. A packet is typically forward from one router to another router through the networks that constitute an internetwork until it reaches its destination computer. A router is connected to two or more data lines from different networks. When multiple routers are used in interconnected networks, the routers can exchange information about destination addresses using a routing protocol which are based on routing algorithm. Each router builds up a routing table listing the preferred routes between any two systems on the interconnected networks. The main purpose of a router is to connect multiple networks and forward packets destined either for its own networks or other networks. A router is considered a layer-3 (Network device) device because its primary forwarding decision is based on the information in the layer-3 IP packet, specifically the destination IP address.

Fig. 1.7 Router

Network bridges

A network bridge is a type of networking device that creates a single collective network from multiple network. Bridging is different from routing. Bridging allows multiple networks to communicate independently and yet remain separate, whereas bridging connects two separate networks as if they were a single network. OSI model bridging is performed in the layer 2 (data link layer). If segments of the network are wireless, the device is known as a wireless bridge. Wireless bridge transfer the data between wireless networks. Bridges are also known as Layer 2 switches.
Modem

Modem stands for “Modulator / Demodulator.” It is a hardware component that allows a computer or other device, such as a router or switch, to connect to the Internet. It converts or “modulates” analog signal from a telephone line or cable wire to a digital signal that a computer understand. Similarly, it converts outgoing digital data from a computer or other device to an analog signal.

Modern modems are typically DSL or cable modems which are considered “broadband” devices. DSL modems operate over standard telephone lines, but use a wider frequency range. This allows for higher data transfer rates than dial-up modems and enables them to not interfere with phone calls. Cable modems send and receive data over standard cable television lines, which are typically coaxial cables. Most modern cable modems support Data over Cable Service Interface Specification, which provides an efficient way of transmitting TV, cable Internet, and digital phone signals over the same cable line.

Wireless Access Point (WAP)

Wireless Application Protocol (WAP) is a standard for accessing information over a mobile or wireless network. Most modern handset internet browsers now fully support HTML, so they do not need to use WAP mark-up for web page compatibility, and therefore, most are no longer able to render and display pages written in WML, WAP’s mark-up language.
WAP is the set of rules governing the transmission and reception of data by computer applications on or via wireless devices like mobile phones. WAP allows wireless devices to view specifically designed pages from the Internet using only plain text and very simple black-and-white pictures.

WAP is a standardized technology for cross-platform, distributed computing very similar to the Internet’s combination of Hypertext Mark-up Language (HTML) and Hypertext Transfer Protocol (HTTP), except that it is optimized for:

- low-display capability
- low-memory
- Low-bandwidth devices, such as personal digital assistants (PDAs), wireless phones, and pagers.

Networking Cables

Cables used in networking are called network cable. Different type of networking cable is used as per the requirement. Following cables are used in networking:

- Coaxial Cable
- Twisted pair cable
- Fibre optics
- USB cables
- Crossover cables

Coaxial Cables

Coaxial cable was invented in the 1880s, “coax” was best known as the kind of cable that connected television sets to home antennas. Coaxial cable is also a standard for 10 Mbps Ethernet cable. When 10 Mbps Ethernet was most popular, during the 1980s and early 1990s, networks typically utilized one of two kinds of coax cable - thinnet (10BASE2 standard) or thicknet (10BASE5). These cables consist of an inner copper wire of varying thickness surrounded by insulation and
Coaxial cable is a two conductor electrical cable consisting of a center conductor and an outer conductor with an insulating spacer between the two. Primarily, coaxial cables are used for the transmission of Radio Frequency energy. The system offers tight control over electrical impedance. This yields excellent performance at high frequencies and superior EMI control/shielding. A broad range of applications exist for coaxial cabling. The two primary impedance values of 50 and 75 Ohms determine specific applications with 50 Ohms primarily used in data signal applications and 75 Ohms used in video signal applications.

![Coaxial Cable](Fig. 1.11)

Coaxial cable is primarily used for audio and visual purposes. Modern homes are typically equipped with at least one coaxial cable outlet in each room. This is because cable companies primarily use coaxial cables to bring cable television to their customers. Coaxial cables can be connected from the wall outlet directly to the customer’s television or cable box. A second use for coaxial cables is connecting VCRs to a television. A final use of the coaxial cable is attaching a personal antenna to a television set or digital converter box.

**Twisted Pair Cables**

Twisted pair cable is the leading cabling standard for Ethernet, starting with 10 Mbps (10BASE-T, also known as Category 3 or Cat3), later followed by improved versions for 100 Mbps (100BASE-TX, Cat5, and Cat5e) and successively higher speeds up to 10 Gbps (10GBASE-T).

Ethernet twisted pair cables contain up to eight (8) wires twisted together in pairs to minimize electromagnetic interference. The purpose of twisted pair cable is to reduce the effect of electromagnetic interference (noise) on an electronic signal. Date transfer will be more reliable on twisted pair cable. This cable is connected with RJ-45 connector for connection with LAN card. Twisted pair cable is crimped with crimper.
Electromagnetic interference can be external or from other data lines in the same cable. This is known as crosstalk.

Two types of twisted pair cable are generally used:

**Unshielded Twisted Pair (UTP)**

**Shielded Twisted Pair (STP).**

STP is more reliable as compared to UTP. Modern Ethernet cables use UTP wiring due to its lower cost, while STP cabling can be found in some other types of networks such as Fiber Distributed Data Interface (FDDI).

**Fiber Optics**

These network cables are flexible and made of glass. They have proven especially useful in WAN (Wide Area Network) installations and implementation where long distance underground or outdoor cable runs are required and also in office buildings where a high volume of communication traffic is common.

Two primary types of fiber optic cable industry standards are defined – single-mode (100BaseBX standard) and multimode (100BaseSX standard). Long-distance telecommunications networks more commonly use single-mode for its relatively higher bandwidth capacity, while local networks typically use multimode instead due to its lower cost. Fibre optics provides the best option for networking and provide high speed data communication over network without any interference.
Crossover Cables

A crossover cable is sometimes known as Null modem. Null modem cables are one example of the category of crossover cable. A crossover cable joins two network devices of the same type, such as two computers or two switches.

The use of Ethernet crossover cables was especially common on older home networks years ago when connecting two PCs directly together. Externally, Ethernet crossover cables appear nearly identical to ordinary the only visible difference being the order of color-coded wires appearing on the cable’s end connector. Manufacturers typically applied special distinguishing marks to their crossover cables for this reason. Nowadays, though, most home networks utilize routers that have built-in crossover capability, eliminating the need for these special cables. Possible reasons to connect two computers directly to each other using crossover cable include:

- Playing a game competitively (one person at each computer) with fast response time
- Testing one computer by examining its behaviour at the other computer
- Saving the cost of a hub when we want to interconnect two devices.

Switches

Switch is a device that channels incoming data from any of multiple input ports to the specific output port that will take it toward its intended destination. In LAN (Local Area Network) using Ethernet, a network switch determines where to send each incoming message frame by looking at the physical device address (also known as the Media Access Control address or MAC Address). Switches maintain tables that match each MAC address to the port from which the MAC address has been received. Switch is a Layer 2 or data-link layer device in the Open Systems Interconnection (OSI) communications model.

Hub

A hub is a hardware device that relays communication data. A hub sends data packets (frames) to all devices on a network, regardless of any MAC addresses.
A switch is different from hub. Hub keeps a record of all MAC addresses of all connected devices. It knows which device or system is connected to which port. When a data packet is received, the switch immediately knows which port to send it to. Unlike a hub, a 10/100 Mbps switch will allocate the full 10/100 Mbps to each of its ports, and users always have access to the maximum bandwidth—a huge advantage of a switch over a hub. Common types of hubs used in networking are network hubs, passive hubs, intelligent and switching hubs.

- **Network Hubs**: These are common connection points for network devices, which connect segments of a LAN (local area network) and may contain multiple ports—an interface for connecting network devices such as printers, storage devices, workstations and servers.
- **Passive Hubs**: These hubs serve as paths for data transfer from one device, or network segment, to another.
- **Intelligent Hubs**: Also known as manageable hubs, these hubs allow system administrators to monitor data passing through and to configure each port, meaning to determine which devices or network segments are plugged into the port. Some ports may even be left open with no connection.
- **Switching Hubs**: These hubs actually read the attributes of each unit of data. The data is then forwarded to the correct or intended port.

Repeaters

A **repeater** is an electronic device that receives a signal and retransmits it. Repeaters are used to extend transmissions so that the signal can cover longer distances or be received on the other side of an obstruction. A repeater is implemented in computer networks to expand the coverage area of the network, regenerate a weak or broken signal and or service remote nodes. Repeaters amplify the received/input signal to a higher frequency domain so that it is reusable, scalable and available.

Repeaters were introduced in wired data communication networks due to the limitation of a signal in propagating over a longer distance and now are a common installation in wireless networks for expanding cell size. Repeaters are also known
as signal boosters. Repeaters are generally considered to be non logical devices because they propagate every signal regardless of its size, type, etc. Repeaters support both analog and digital signals and can repeat electrical and light-based signals. Repeaters can be wired or wireless. Wired Repeaters are used for signal regeneration. Repeaters can be wireless and wired.

**Fig. 1.16 Wireless Repeater for signal strengthen**

**Fig. 1.17 Wireless Repeater**

**Ethernet adaptor**

An Ethernet adapter is a piece of hardware that allows a device or workstation to access an Ethernet connection. Ethernet adapters can be add-ons that go into an expansion board, or they can be directly installed in the motherboard of a computer or device. The most common kind of Ethernet adapter is a PC card, which has an Ethernet connection and a circuit board. Some versions of these adapters can be simply fitted into a corresponding hole in the plastic tower of a desktop computer.
Ethernet adapters can use various kinds of Cat5 or Cat6 cables to hook up to an Ethernet connection. As more local networks started to use wireless systems, the Ethernet adapter started to lose ground to network adapter cards that fit into various devices to allow wireless connections. An Ethernet adapter is still instrumental in affecting physical cabled hookups, but many users choose to use a wireless router and wireless adapters for individual devices. It is an adapter which convert USB port into Ethernet port.

**Fig. 1.18 Ethernet adaptor**

**Data processing Cycle**

Data processing, manipulation of data by a computer includes the conversion of raw data to machine-readable form, flow of data through the CPU and memory to output devices, and formatting or transformation of output. Any use of computers to perform defined operations on data can be included under data processing.

**Check Your Progress**

1. What is hybrid computer?
2. Define gateway?
3. What is switch?

**1.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS**

1. Hybrid computers are a mixture of digital and analog computers. A hybrid computer uses the best characteristics of digital and analog computers.
2. Gateway is a piece of hardware used in data communication for network. Gateway allows data to flow from one separate network to another.
3. Switch is a device that channels incoming data from any of multiple input ports to the specific output port that will take it toward its intended destination.

1.5 SUMMARY

- Digital computers are primarily involved in data processing and problem solving for specific programs. In digital computers, data is stored as digits and processes.
- Microcomputers are developed from advanced computer technology. They are commonly used at home, classroom and in the workplace.
- Mainframe computers are generally used for handling the needs of information processing of organizations, such as banks, insurance companies, hospitals and railways.
- A Personal Computer is a small single user microprocessor-based computer that resides on your desktop, and is generally used at homes, offices and schools.
- A router is a networking device which is used to forward data packets between computer networks.
- A network bridge is a type of networking device that creates a single collective network from multiple network.
- Switch is a device that channels incoming data from any of multiple input ports to the specific output port that will take it toward its intended destination.
- An Ethernet adapter is a piece of hardware that allows a device or workstation to access an Ethernet connection.
- A hub is a hardware device that relays communication data. A hub sends data packets (frames) to all devices on a network, regardless of any MAC addresses contained in the data packet.

1.6 KEY WORDS

- **Network bridge**: A network bridge is a type of networking device that creates a single collective network from multiple network. Bridging is different from routing. Bridging allows multiple networks to communicate independently and yet remain separate.
- **Gateway**: A gateway is a piece of hardware used in data communication for network.
1.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions
1. What are micro, mini and mainframe computers?
2. Discuss the different types of personal computers.
3. What is a router?

Long-Answer Questions
1. Explain the characteristics of each generation of computer?
2. What are the different types of networking cables? Explain.
3. Write a note on different types of hardware components used in data transfer.

1.8 FURTHER READINGS


UNIT 2  ROLE OF COMPUTERS IN INFORMATION TRANSFER

Structure
2.0 Introduction
2.1 Objectives
2.2 Block Diagram of Computer
2.3 Answers to Check Your Progress Questions
2.4 Summary
2.5 Key Words
2.6 Self Assessment Questions and Exercises
2.7 Further Readings

2.0 INTRODUCTION

In this unit, you will learn about the various components of a computer. The control unit is necessary if the CPU is to function efficiently and information/data is to be transferred between the CPU and other devices. The arithmetic logic unit or ALU enables arithmetic and logic operations. Arithmetic operation (add, subtract, multiply, divide) or a logic operation (equal to, less than, greater than), it passes control to the ALU. The ALU has the necessary circuitry to carry out these arithmetic and logic operations. RAM is the main memory is the central storage unit in a computer system. It is used to store programs and data during computer operations.

2.1 OBJECTIVES

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

- Understand the block diagram of a computer system
- Discuss the function of ALU and control unit

2.2 BLOCK DIAGRAM OF COMPUTER

Figure 2.1 shows the block diagram of a computer. Input unit, CPU and output unit are three major components of a system.
Execution of programs is the main function of the computer. The **program** to be executed is a set of instructions that is stored in the computer’s memory. Tasks are completed when the instructions of the program are executed by the Central Processing Unit (CPU). Also, all the major calculations and comparisons are carried out inside the CPU. Additionally, the CPU is responsible for activating and controlling the operations of various units of the computer system. It activates the peripherals to perform input or output.

The CPU is made up of three major components (as seen in Figure 2.2): the register set (associated with the main memory) that stores the intermediate data during the execution of instructions, the Arithmetic Logic Unit (ALU) that performs the required micro-operations for executing the instructions, and the control unit that supervises the transfer of information between the registers and instructs the ALU as to which operation to perform.

**Control unit**

The **control unit** is necessary if the CPU is to function efficiently and information/data is to be transferred between the CPU and other devices. It does not perform the actual processing of the data, but manages and coordinates the entire computer system, including the input and output devices. It retrieves and interprets the...
instructions from the program stored in the main memory, and issues signals that cause the other units of the system to execute them.

It does this through some special purpose registers and a decoder. The special purpose register called the **Instruction register** holds the current instruction to be executed, and the **Program control register** holds the next instruction to be executed. The decoder interprets the meaning of each instruction supported by the CPU. Each instruction is also accompanied by a **Microcode**, i.e., the basic directions to tell the CPU how to execute the instruction.

**Arithmetic logic unit**

The arithmetic logic unit or ALU enables arithmetic and logic operations. This means that when the control unit encounters an instruction that involves an arithmetic operation (add, subtract, multiply, divide) or a logic operation (equal to, less than, greater than), it passes control to the ALU. The ALU has the necessary circuitry to carry out these arithmetic and logic operations.

As an example, a comparison of two numbers (a logical operation) may require the control unit to load the two numbers in the requisite registers and then pass on the execution of the ‘compare’ function to the ALU.

Figure 2.3 represents the basic structure of a CPU.

![Fig. 2.3 Basic Structure of a CPU](image)
Computer Memory: Primary and Secondary

Data and instructions are stored and subsequently retrieved from a computer’s memory. We saw earlier that the CPU contains several registers for storing data and instructions. But these can store only a few bytes. If all the instructions and data being executed by the CPU were to reside in secondary storage (like magnetic tapes and disks) and be loaded into the registers of the CPU as the program execution proceeded, it would lead to the CPU being idle for most of the time. This is because the speed at which the CPU processes data is much higher than the speed at which data can be transferred from disks to registers. Every computer thus requires storage space where instructions and data of a program can reside temporarily when the program is being executed. This temporary storage area is built into the computer hardware and is known as the primary storage or main memory. Devices that provide backup storage (like magnetic tapes and disks) are called secondary storage or auxiliary memory.

Thus, the following three sets of memories form the memory system.

(a) **Primary storage or main memory**: The primary storage refers to a large memory that is faster than the auxiliary memory and slower than the internal memory. It is primarily based on internal circuits and directly interacts with the CPU.

(b) **Secondary storage or auxiliary memory or backing store**: This exceeds the main memory in size, but falls behind it in speed. All the software and system programs are usually stored in the secondary memory.

(c) **Internal processor memory**: It consists of a small set of high-speed registers that are internal to a processor and are used as temporary locations for the actual processing to be done.

Another type of memory, the cache memory, is widely gaining acceptance in modern computers. Its logical position is between the main memory and the internal memory (registers). Its primary function is to store and cache parts of the main memory’s contents that the processor is currently using. Figure 2.4 shows the hierarchy of memory in a computer system.

![Fig. 2.4 The Memory Hierarchy](image-url)
The total memory capacity of the computer can therefore be visualized as being a hierarchy of components consisting of all storage devices employed in a computer system from the slow, but high-capacity auxiliary memory to a relatively faster main memory to an even smaller and faster cache memory accessible to the high-speed processing logic. Thus, as one goes down in the hierarchy, the following conditions occur:

1. Decreasing cost per bit
2. Increasing capacity
3. Increasing access time
4. Decreasing frequency of access of the memory by the processor

**Memory Capacity**

Capacity, in a computer system, is defined in terms of the number of bytes that it can store in its main memory. This is usually stated in terms of kilobytes (kB) which is 1024 bytes, or Megabytes (MB) which is equal to 1024 KB (10,48,576 bytes). The rapidly increasing memory capacity of computer systems has resulted in defining the capacity in terms of Gigabytes (GB) which is 1024 MB (1,07,37,41,824 bytes).

Thus, a computer system having a memory of 256 MB is capable of storing \((256 \times 1024 \times 1024)\) 26,84,35,456 bytes or characters.

**RAM**

The main memory is the central storage unit in a computer system. It is a relatively large and fast memory. It is used to store programs and data during computer operations. The principal technology used for the main memory is based on semiconductor-integrated circuits. There are two possible modes in which the integrated circuit RAM chips are available. These modes are static and dynamic.

The static RAM (SRAM) stores binary information using clocked sequential circuits. The stored information remains valid only as long as power is applied to the unit. On the other hand, dynamic RAM (DRAM) stores binary information in the form of electric charges that are applied to capacitors inside the chip. The stored charge on the capacitors tends to discharge with time and so must be periodically recharged by refreshing the dynamic memory. The dynamic RAM offers larger storage capacity and reduced power consumption. Therefore, large memories use dynamic RAM, while static RAM is mainly used for specialized applications.

The different types of memory discussed here are both of the read/write type. What about a memory where only one of the operations is possible, for example, if we allow only reading from the memory, that is, we cannot change the information in the memory, then the memory might have major importance; like an important bit of the computer’s operating system which normally does not change can be stored in this kind of memory. Such a memory is called ROM (Read Only Memory).
ROM

Most of the memory in a general-purpose computer is made of RAM integrated circuit chips, but a portion of the memory may be constructed using ROM chips. Originally, RAM was used to refer to Random-Access Memory, but now we use the term read/write memory to distinguish it from Read-Only Memory (since ROM is also random access). RAM is used for storing the bulk of the programs and data that is subject to change, while ROM is used to store programs that permanently reside in the computer and do not change once the production of the computer is completed.

Among other things, the ROM portion of the main memory is used for storing an initial program called the bootstrap loader, whose function is to get the computer software operating when power is turned on. Since RAM is volatile, its contents are destroyed when power is turned off. The contents of ROM remain unchanged even after the power is turned off and on again.

Read-only memories can be manufacturer-programmed or user-programmed. When the data is burnt into the circuitry of the computer by the manufacturer, it is called manufacturer-programmed ROM. For example, a personal computer manufacturer may store the boot program permanently in the ROM chip of the computers manufactured by it. Such chips are supplied by the manufacturer and are not modifiable by users. This is an inflexible process and requires mass production. Thus, a new type of ROM, known as Programmable Read-only Memory (PROM), was designed. This is also non-volatile in nature. It can be written only once using some special equipment. The supplier or the customer can electrically perform the writing process in PROM.

In both ROM and PROM, you can perform write operations only once and you cannot change whatever you have written. But what about the cases where you mostly read, but also write a few times? Another type of memory chip called EPROM (Erasable Programmable Read-only Memory) was developed to take care of such situations. EPROMs are typically used by R&D personnel who experiment by changing micro-programs on the computer system to test their efficiency.

EPROM chips are of two types; EEPROMs (Electrically EPROM) in which high voltage electric pulses are used to erase stored information, and UVEPROM (Ultra Violet EPROM) in which stored information is erased by exposing the chip for a while to ultraviolet light.
Figure 2.5 summarizes the various types of Random Access Memories.

**RAM (Random Access Memory)**

- **Read/Write (Volatile)**
  - **SRAM** (Static)
  - **DRAM** (Dynamic)

- **Read Only – ROM (Non-Volatile)**
  - Manufacturer Programmed
  - User Programmed

**Check Your Progress**

1. What are the main components of a computer?
2. What are the two modes of RAM?

**2.3 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS**

1. Input unit, CPU, and output unit are the three major components of a computer.
2. Static and dynamic are the two modes of RAM.

**2.4 SUMMARY**

- The control unit is necessary if the CPU is to function efficiently and information/data is to be transferred between the CPU and other devices.
- The arithmetic logic unit or ALU enables arithmetic and logic operations. The control unit encounters an instruction that involves an arithmetic operation (add, subtract, multiply, divide) or a logic operation (equal to, less than, greater than), it passes control to the ALU.
- Capacity, in a computer system, is defined as the number of bytes that it can store in its main memory.
The static RAM (SRAM) stores binary information using clocked sequential circuits.

RAM is used for storing the bulk of the programs and data that is subject to change, while ROM is used to store programs that permanently reside in the computer and do not change once the production of the computer is completed.

Data and instructions are stored and subsequently retrieved from a computer’s memory.

2.5 KEY WORDS

- **Primary storage**: The primary storage refers to a large memory that is faster than the auxiliary memory and slower than the internal memory.
- **Secondary storage**: It is a non-volatile memory (does not lose stored data when the device is powered down) that is not directly accessible by the CPU, because it is not accessed via the input/output channels.

2.6 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short-Answer Questions**

1. Define computer memory.
2. What does control unit perform?
3. Discuss the basic structure of CPU.

**Long-Answer Questions**

1. Explain the block diagram of a computer system.
2. Explain the hierarchy of memory in a computer system.

2.7 FURTHER READINGS


UNIT 3  INPUT/ OUTPUT DEVICES

Structure
3.0 Introduction
3.1 Objectives
3.2 Storage Devices
3.3 Input Devices
3.4 Output Devices
3.5 Answers to Check Your Progress Questions
3.6 Summary
3.7 Key Words
3.8 Self Assessment Questions and Exercises
3.9 Further Readings

3.0 INTRODUCTION

Memory is used for storage and retrieval of instructions and data in a computer system. However, these can store only located bytes. If all the instructions and data are stored in secondary storages (such as magnetic tapes and disks), and loaded into the registers of the CPU as the program execution proceed, it would lead to the CPU being idle most of the time, since the speed at which the CPU processes data is much higher than the speed at which data can be transferred from disks to registers. Every computer thus requires storage space where instructions and data of a program can reside temporarily when the program is being executed. This temporary storage area is built into the computer hardware and is known as the primary storage or main memory. Devices that provide backup storage (such as magnetic tapes and disks) are called secondary storage or auxiliary memory.

3.1 OBJECTIVES

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

- Know the significance of storage devices
- Discuss the types of storage devices
- Explain the types of input and output devices
3.2 STORAGE DEVICES

Secondary Storage Devices

As discussed earlier, RAM is a volatile memory having limited storage capacity. The cost of RAM is also relatively higher as compared to secondary memory. Logic dictates that a relatively cheaper medium, showing some sort of permanence of storage, be used. As a result, additional memory called either external or auxiliary memory or secondary storage is used in most computers.

The magnetic medium was found to be long lasting and fairly inexpensive, therefore, became an ideal choice for large storage requirements. Magnetic tapes and disks are commonly used as storage media. With the advancements in optical technology, optical disks are making inroads as one of the major secondary storage devices. The characteristics of all these are discussed in detail in this section.

1. Magnetic Tapes

Magnetic tapes are used for storing files of data that are sequentially accessed or not used very often and are stored offline. They are typically used as backup storage for archiving of data.

![Data Organization on a Magnetic Tape](image)

In case of magnetic tapes, a tape (plastic ribbon usually 1/2 inch or 1/4 inch wide and 50 to 2400 feet long) is wound on a spool and its other end is threaded manually on a take-up spool. The beginning of the tape (BOT) is indicated by a metal foil called a marker. When a write command is given, a block of data (records are usually grouped in blocks of two or more) is written on the tape. The next block is then written after a gap (called Inter Block Gap or IBG). A series of blocks are written in this manner. The end of tape (EOT) is indicated by an end-of-tape marker which is a metal foil stuck in the tape. After the data is written, the tape is rewound and kept ready for reading.

Fig. 3.1(a) Data Organization on a Magnetic Tape
The tape is read sequentially, i.e., data can be read in the order in which the data has been written. This implies that if the desired record is at the end of the tape, all the earlier records have to be read before it is reached. A typical example of a tape can be seen in a music tape cassette where to listen to the fifth song one must listen to, or traverse, the earlier four songs. The access time of information stored on tape is therefore, very high as compared to that stored on a disk.

The storage capacity of the tape depends on its data recording density and the length of the tape. Data recording density refers to the amount of data that can be stored or the number of bytes that can be stored per linear inch of tape. The data recording density is measured in BPI (Bytes per inch).

Thus,

\[
\text{Storage capacity of a tape} = \text{Data recording density} \times \text{Length of tape}
\]

It is worth noting that the actual storage capacity for storing user data, is much less owing to the file header labels, file trailer labels, BOT and EOT markers, and the use of IBGs.

Some commonly used magnetic tapes are the following:

- 1/2 inch tape reel
- 1/2 inch tape cartridge
- 1/4 inch streamer tape
- 4 mm DAT (Digital Audio Tape) – typical capacity of 4GB to 14 GB
2. Magnetic Disks

Magnetic disks are direct-access medium and hence they are the most popular online secondary storage devices. Direct-access devices are also called random-access devices because information is literally available at random or in any order. Access to any location on the device is direct and so approximately equal access time is required for each location. An example of this is a music CD, where if you wish to listen to the fifth song, you can directly select the fifth track. It does not require you to fast forward the previous four songs.

![Fig. 3.2 Logical Layout of a Magnetic Disk](image)

A magnetic disk is a circular plate made of metal or plastic, coated with magnetized material. Often both sides of the disk are used. Data is recorded on the disk in the form of magnetized and non-magnetized spots (not visible to the naked eye) representing 1s and 0s.

Data is stored in concentric rings or tracks. To minimize the interference of magnetic fields, the adjacent tracks are separated by inter-track gaps. Tracks are commonly divided into sections called sectors. In most systems, the minimum quantity of information that can be transferred is a sector. Usually, eight or more sectors per track are found.

A track in a given sector near the circumference is longer than the track near the centre of the disk. If bits are recorded with equal density, some tracks would contain more bits than the other tracks. To ensure that each sector can store equal amounts of data, some disks use variable recording density with higher density on tracks near the centre than on tracks near the circumference.

Multiple disks are usually stacked and used together to create disk storage systems having large capacities. In this case, multiple disks are fixed on a central shaft, one below the other to form a disk pack. This is then mounted on a disk drive that has a motor which rotates the disk pack about its axis. The disk drive also has an access arm assembly with a separate read/write head for each surface of the disk pack. The access arms for all the disk surfaces move together. A disk system, is thus addressed by the disk number, the disk surface, the sector number and the track within the sector.
For faster access of data from disk packs, a concept called cylinders is used. As can be seen in Figure 3.3, a set of corresponding tracks on all the recording surfaces of the disk pack together form a cylinder. Thus, if there are 100 tracks on each disk surface, there are 100 cylinders in the disk pack.

Cylinder-based organization provides faster data access. The related records of a file can be stored on the same cylinder (on multiple disks of a disk pack) and subsequently with one movement of the access arm, all records on, say cylinder 5, (fifth track of every recording surface) can be simultaneously read.

The storage capacity of a disk system can be determined as follows:

\[
\text{Storage capacity} = \text{Number of recording surfaces} \times \text{Number of tracks per surface} \times \text{Number of sectors per track} \times \text{Number of bytes per sector}
\]

Example: Consider that a disk pack consists of 4 plates each having 2655 tracks with 125 sectors per track. Also, each sector can store 512 bytes. Then,

\[
\text{Storage capacity} = 6 \times 2655 \times 125 \times 512 = 1,01,95,20,000 \text{ bytes} = 1 \times 10^9 \text{ bytes approximately or 1 GB or 1 Gigabyte.}
\]

\text{Note: We have six recording surfaces since there are four disk plates.}

\textbf{Access time on disks}

As detailed earlier, the disk address is specified in terms of the surface number, the track or cylinder number, and the sector number. The read/write heads need to be first positioned on the track on which the data is to be recorded or from which data needs to be read. Information is always written from the beginning of a sector and can be read only from the beginning of the desired track. Thus, the disk access time depends on the following factors:

- \textbf{Seek time:} The time taken to position the head on a specific track. The seek time would vary depending upon the position of the access arms at the time the read/write command was received, i.e., if the access
arm was positioned on the outermost track and the current read operation
required it to be positioned on the fifth track, then the time taken to
position the access arm on track 5 is the seek time. It is obvious from
this example that moving from the outermost to the innermost track or
vice versa would result in the maximum seek time. The average seek
time in most systems is 10–100 milliseconds.

- **Latency time**: The time required by the desired sector to be positioned
under the read/write head, i.e., the time required to spin the desired
sector under the head is called latency. Latency is also known as
rotational delay and varies depending on the distance of the desired
sector from the initial position of the head on the specified track. The
rotational speed of a disk is measured in rotations per minute (rpm) and
can be anywhere between 300 to 7200 rpm. On an average, latency is
equal to half the time taken for a rotation by the disk.

In addition to these two factors, the time taken to read a block of words
(Transfer rate) can also be considered. But this is usually too small in comparison
to seek time and latency time, and disk access time is generally considered to be
a sum of seek time and latency time. Further, since access times to disk are large,
a sizeable portion of the data is read in a single go. That is why disks are referenced
in blocks.

Based on the size and packaging of the disks, they can be classified into
two types—floppy disks and hard disks. Further, disks that are permanently
attached to the unit assembly and cannot be removed by the occasional user are
called hard disks. A drive using removable disks is called a floppy disk drive.

3. Floppy Disks

The disks used with a floppy disk drive are small removable disks made of plastic
coated with magnetic recording material. Disks of two sizes are commonly used
with diameters of 5¼ and 3½ inches.

- The 5¼ inch disk is a floppy disk of diameter 5¼. Earlier such disks recorded
data only on one side and were called single-sided (SS) disks. Today, both
the surfaces are used for recording and are called double-sided (DS) disks.
These are available in two capacities—double density (DD), and high density
(HD), where density refers to the number of bits that can be stored per
square inch area.

- The 3½ inch disk is a disk of 3½ inch diameter. These record data on both
sides and are therefore called double-sided disks. These disks come in
three different capacities—double density, high density, and very high density.
These are smaller and can store more data than can the 5¼ inch disks.
Fig. 3.4 A 3½ Inch Floppy Disk

The storage capacity for any disk can be calculated as:

\[
\text{Storage capacity} = \text{Number of recording surfaces} \times \text{Number of tracks per surface} \times \text{Number of sectors per track} \times \text{Number of bytes per sector}
\]

Thus, for a 3½ inch high density disk which has eighty tracks, eighteen sectors/track, and 512 bytes/sector, the disk storage capacity can be calculated as follows:

\[
2 \times 80 \times 18 \times 512 = 14,74,560 \text{ bytes or 1.4 MB (approximately)}
\]

The following table provides the necessary details and associated storage capacities of various types of floppy disks:

Floppy disks are extensively used in personal computers as a medium for distributing software to computer users.

Table 3.1 Details of Various Floppy Disks

<table>
<thead>
<tr>
<th>Size (diameter in inches)</th>
<th>No. of Recording Surfaces</th>
<th>No. of Tracks</th>
<th>No. of Sectors/Tracks</th>
<th>No. of Bytes/Sector</th>
<th>Storage Capacity (approx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5¼</td>
<td>2</td>
<td>40</td>
<td>9</td>
<td>512</td>
<td>3,68,640 bytes or 360kB</td>
</tr>
<tr>
<td>5¼</td>
<td>2</td>
<td>80</td>
<td>15</td>
<td>512</td>
<td>12,28,800 bytes or 1.2 MB</td>
</tr>
<tr>
<td>3½</td>
<td>2</td>
<td>40</td>
<td>18</td>
<td>512</td>
<td>7,37,280 bytes or 720 kB</td>
</tr>
<tr>
<td>3½</td>
<td>2</td>
<td>80</td>
<td>18</td>
<td>512</td>
<td>14,74,560 bytes or 1.4 MB</td>
</tr>
<tr>
<td>3½</td>
<td>2</td>
<td>80</td>
<td>36</td>
<td>512</td>
<td>29,49,120 or 2.8 MB</td>
</tr>
</tbody>
</table>

4. Hard Disks

Unlike floppy disks, hard disks are made up of rigid metal. The sizes for the disk platters range between 1 to 14 inches in diameter. Depending on the way they are packaged, hard disks can be categorized as disk packs or Winchester disks.
• **Disk packs**: consist of two or more hard disks mounted on a single central shaft. Because of this, all disks in a disk pack rotate at the same speed. It consists of separate read/write heads for each surface (excluding the upper surface of the topmost disk platter and the lower surface of the bottommost disk platter). Disk packs are removable in the sense that they can be removed and kept offline when not in use (typically stored away in plastic cases). They have to be mounted on the disk drive before they can be used. Thus, different disk packs can be mounted on the same disk drive at different instances, thereby providing virtually unlimited (modular) storage capacity.

![Fig. 3.5 A Disk Pack](image)

• **Winchester disks**: also consist of two or more hard disk platters mounted on a single central shaft but are of the fixed type. The disk platters are sealed in a contamination-free container. Due to this fact all the disk platters, including the upper surface of the topmost disk platter and the lower surface of the bottommost platter, are used for storing data. So, even though Winchester disks have limited storage capacity as opposed to disk packs, they can store larger amounts of data as compared to the same number of disk platters.

![Fig. 3.6 A Winchester Disk](image)
Another type of disk called the zip disk is very common today. This consists of a single hard disk platter encased in a plastic cartridge. Such a disk typically has a capacity of about 100 MB. Also, the zip drive can be fixed or portable. The fixed zip drive is permanently connected to the computer system while the portable ones can be carried around and connected to any computer system for the duration of its use. In both cases however, the zip cartridge (the actual storage medium) is portable just like a floppy, albeit with a nearly 100 times larger storage capacity.

5. Optical Disks

Optical disks are storage devices with huge storage capacity. It is a relatively new storage medium and uses laser beam technology for writing and reading data.

Optical disks consist of one large track that starts from the outer edge and spirals inward towards the centre (this is unlike the magnetic disk in which tracks are concentric circles on the disk platter). An optical disk is also split up into sectors, but these are of the same length regardless of its location on the track. Data is therefore packed at maximum density over the disk.

The storage capacity of an optical disk is determined as follows:

\[ \text{Storage capacity} = \text{Number of sectors} \times \text{Number of bytes per sector} \]

(Note that we do not consider the number of tracks since there is only one track in this case.)

Thus, a 5.25 inch optical disk with 3,30,000 sectors and storing 2,352 bytes per sector, will have a storage capacity of

\[ 3,30,000 \times 2352 = 77,61,60,000 \text{ bytes or } 740 \text{ MB (approx.).} \]

The technology used in optical disks uses laser beams to write and read data as opposed to the read/write head used in magnetic disks. Data is recorded by etching microscopic pits (burnt surface) on the disk surface. A high intensity laser beam is used to etch the pits, while a low intensity laser beam is used for data retrieval.
Three optical memory devices that are becoming increasingly popular in various computer applications are CD-ROM, WORM, and Erasable optical disks.

**CD-ROM:** CD-ROM (Compact disk read only memory) is a direct extension of the audio CD. It is usually made from a resin named polycarbonate that is coated with aluminium to form a highly reflective surface. The information on a CD-ROM is stored as a series of microscopic pits on the reflective surface (using a high-intensity laser beam). The process of recording information on these disks is known as ‘mastering’. This is so-called because this master disk is then used to make a die, using which copies are made.

Information is retrieved from a CD-ROM using a low-powered laser, which is generated in an optical disk drive unit. The disk is rotated and the laser beam is aimed at the disk. The intensity of the laser beam changes as it encounters a pit. A photosensor detects the change in intensity, thus recognizing the digital signals recorded on the surface of the CD-ROM and converts them into electronic signals of 1s and 0s.

As the name suggests, information stored in CD-ROM can only be read. It cannot be modified in any way. It is therefore useful for applications in which there is a database of information that is useful as it is and does not need changing in any way, e.g., a directory such as Yellow Pages. CD-ROMs are very useful for distributing large amounts of information to a large number of users. The advantages of CD-ROMs lie in the fact that they provide the following:

- Large storage capacity for information/data
- Fast and inexpensive mass replication
- Suitable for archival storage since they are removable disks

The disadvantages of CD-ROMs are the following:

- They are read-only and cannot be updated
- The access time is greater than that of a magnetic disk

**WORM:** The drawbacks of CD-ROM were partially resolved by the introduction of WORM (‘write-once, read many’).
In certain applications, only a few copies of compact disks are required to be made which makes production of CD-ROM economically unviable from a commercial point of view. This is because manufacturers do CD-ROM duplication by using expensive duplication equipment. For such cases, write-once read-many CDs have been developed.

WORM disks allow users to create their own CDs by using a CD-recordable (CD-R) drive. This can be attached as a peripheral device to the computer system. WORM disks recorded in this manner, can be read by any CD-ROM drive.

**Erasable optical disk**: The most recent development in optical disks is the erasable optical disk. The data in this type of optical disk can be changed repeatedly as in the case of magnetic disks. Erasable optical disks are therefore also known as rewritable optical disks.

These disks integrate the magnetic and optical disk technologies to enable rewritable storage with the laser-beam technology and so are also called magneto-optical disks. In such systems, a laser beam is used along with a magnetic field to read or write information on a disk which is coated with magnetic material.

To write, the laser beam is used to heat a specific spot on the magnetic coated material. At this elevated temperature, a magnetic field is applied so that the polarization of that spot can be changed, thereby recording the desired data. This process does not cause any physical changes in the disk and so can be repeated many times. Reading is done by detecting the degree of rotation of the polarized laser beam reflected from the surface. This implies that as the disk spins, the polarized spots pass under the laser beam and depending on their orientation or alignment some of them reflect the light while others scatter it. This produces patterns of ‘on’ and ‘off’ that are converted into electronic signals of binary 1s and 0s.

The capacity of an erasable disk is very high in comparison to that of a magnetic disk. For example, a 5¼ inch optical disk can store around 650 MB of data, while Winchester disks normally can store a maximum capacity of 320 MB. This is why magneto-optical disks are ideal for multimedia applications that require large storage capacities.

**6. Mass Storage Devices**

Any physical storage medium has a limit to its capacity and performance. There is a constant effort towards improving such media, and as a result larger capacity secondary storage devices have emerged. These are characterized by using multiple units of the same storage medium, as a single unit, to provide higher storage capacity. Disk arrays (Multiple disks), tape libraries (multiple tapes), and CD-ROM jukebox (multiple CDs) are the three most commonly used mass storage devices.

Mass data storage devices are characterized by relatively slow access time. This is because additional time in terms of first locating the desired disk, tape, or
CD-ROM (as the case may be) needs to be accounted for. However, they are more cost effective in case of applications that require huge storage capacity and for which rapid access to data is not the prime consideration.

They can also be used for offline or archival storage of information/data since they can support huge volumes of information/data to be backed up.

**Disk array (RAID):** RAID (Redundant Array of Inexpensive Disks) is an acronym for a disk array and consists of a number of hard disks and disk drives with a controller in a single box.

The basic idea of RAID was to combine multiple small, inexpensive disk drives into an array of disk drives which yields performance exceeding that of a Single Large Expensive Drive (SLED). Additionally, this array of drives appears to the computer as a single logical storage unit or drive.

![Fig. 3.9 A RAID consisting of Eight Disks](image)

The concept was pioneered through academic research funded by Digital Equipment Corporation and has now become a standard in the computing industry for applications requiring fast and reliable storage of large volumes of data.

There are several different types of RAID configurations that are described in terms of "levels". The various levels of RAID storage are as follows:

- **RAID 0:** Data is split across drives, resulting in higher data throughput. Since no redundant information is stored, performance is very good, but the failure of any disk in the array results in data loss. This level is commonly referred to as striping.

- **RAID 1:** It provides redundancy by writing all data to two or more drives. The performance of a level 1 array tends to be faster on reads and slower on writes compared to a single drive, but if either drive fails, no data is lost. This level is commonly referred to as mirroring. Mirroring is the most expensive RAID option (since it doubles storage requirements), but it offers the ultimate in reliability.

- **RAID 0+1:** It is a combination of striping and mirroring. This configuration provides optimal speed and reliability, but possesses the same cost problem as RAID1.
**RAID 5:** It employs a combination of striping and parity checking. The use of parity checking provides redundancy without having to double the disk capacity of the overhead. Simply put, parity checking involves determining whether each given block has an odd or even value. These values are summed across the stripe sets to obtain a parity value. With this parity value, the contents of a failed disk can be easily determined and rebuilt on a spare drive.

There are other RAID configurations in addition to the ones described here, but these are the ones most commonly used in the industry.

As can be noticed, RAID configurations result in higher reliability due to the use of multiple disks. In addition to this, both mirroring and striping (techniques used in distributing data across the disks) also result in speeding up the read process since different parts of the same file residing on different disks, can be read at the same time.

**Tape libraries:** Network administrators are hungry for technologies that will allow them to efficiently and economically manage the explosive growth in data stored on networks. As the amount of data increases, the backup process takes longer. Simply adding another tape drive to reduce the backup time does not really help. Further, systems operated in this manner, represent one of the largest operational costs of a data centre and also typically represent the predominant need for human intervention.

The solution to this problem is the multi-drive automated tape libraries. These libraries consist of a set of magnetic tapes with a controller mounted in a single unit. The unit may have one or more tape drives to read and write data on the tapes in the tape library. Automated tape libraries allow random access to large numbers of tape cartridges and concurrent use of two or more drives, rather than manually loading one tape after another. The unit typically has robotic arms to retrieve the appropriate tape from the tape library and mount it on one of the tape drives for processing.

Automated tape libraries can be designed to provide extremely precise control and support for tape drives. Properly implemented, library automation can significantly enhance the operational reliability of tape drives by eliminating the highly variable human/machine interface. In this particular case, the objective of the system design is to avoid failures rather than to tolerate them, as is the case in RAID systems.

Automated tape libraries are typically used for data archiving purposes and as an online data backup device for automated backup.

**CD-ROM jukebox:** The CD-ROM jukebox is much like the automated tape library but consists of a set of CD-ROM disks instead of the magnetic tapes. The set of CD-ROM disks along with a controller are mounted in a single unit. Here, also the unit can have one or more drives to read data from the disks in the
CD-ROM jukeboxes are typically used for archiving read-only data that can be accessed online, e.g., online encyclopedias, online directories, etc. A large CD-ROM jukebox may consist of hundreds of disks providing a storage capacity of terabytes.

Data Backup

Data stored on an online storage device, such as a hard disk, can be damaged or lost due to any one of the following reasons:

- Disk crash
- Virus attack
- Accidental deletion by users
- Hardware malfunction
- Natural calamity (e.g., earthquake, fire, floods etc.)

Useful and sensitive data needs to be protected against such eventualities. Data should therefore be copied from online storage devices to secondary storage devices (like magnetic tapes, floppy disks, zip disks) and stored in safe locations. This process is known as backing up of data.

Data backup now constitutes an essential part of IT policies in most of the organizations. Different types of backup media may be appropriate for different users and applications depending upon the volumes, periodicity, accessibility, security, sensitivity etc. However, determining the appropriate backup policy which would depend on the unique requirements of each organization, which is outside the scope of this book.

Check Your Progress

1. What are the two categories of memory?
2. On which factors the disk access time depends?

3.3 INPUT DEVICES

An input device accepts data from the outside world and transforms it into a form the computer can interpret. Keyboards are the most commonly used input devices. Point-and-draw devices are used to point to, and select menu items or icons displayed on screen. They provide a means for graphical user interface (GUI). The mouse, trackball, joystick, light pen, and touch screen are commonly used point-and-draw devices. However, scanning devices that provide direct data input
from source documents are of two types—CONTACT and LASER. Electronic card readers read the data encoded on electronic cards and convert it to machine-readable form, for further processing. This unit also describes other voice recognition devices that input data in the form of human voice, thereby providing an easy means of data input.

Consider the following example: The average marks of a student need to be calculated based on his marks obtained in various subjects. The marks would typically be available in the form of a document containing the student’s name, roll number, and marks scored in each subject. This data must be first stored in the computer’s memory after converting it into machine-readable form. The data will then be processed (average marks calculated) and sent from the memory to the output unit, which will present the data in a form that can be read by users.

Figure 3.10 shows the role of I/O devices in a computer system.

![Roles of I/O Devices](image)

The I/O devices that provide a means of communication between the computer and the outside world are known as peripheral devices. This is because they surround the CPU and the memory of a computer system. While input devices are used to enter data from the outside world into the primary storage, output devices are used to provide the processed results from the primary storage to the users.

As mentioned earlier in this section, input devices are used to transfer user data and instructions to the computer. The most commonly used input devices can be classified into the following categories:

- **Keyboard devices** (general and special purpose, key-to-tape, key-to-disk, key-to-diskette)
- **Point-and-draw devices** (mouse, trackball, joystick, light pen, touch screen)
- **Scanning devices** (optical mark recognition, magnetic ink character recognition, optical bar code reader, digitizer, electronic-card reader)
- **Voice recognition devices**
- **Vision-input devices** (webcam, video camera)

### 1. Keyboard Devices

Keyboard devices allow input into the computer system by pressing a set of keys which are mounted on a board connected to the computer system. Keyboard
Input/Output Devices

NOTES

Self-Instructional 48 Material

Input/Output Devices

devices are typically classified into general-purpose keyboards and special-purpose keyboards.

General-purpose keyboard

The most familiar means of entering information into a computer is through a typewriter-like keyboard that allows a person to enter alphanumeric information directly.

The most popular keyboard used today is the 101-keys with a traditional QWERTY layout, having an alphanumeric keypad, twelve function keys, a variety of special-function keys, numeric keypad, and dedicated cursor-control keys. It is so called because of the arrangement of its alphanumeric keys in the upper left row. Figure 3.11 shows QWERTY keyboard layout.

- **Alphanumeric keypad**: Contains keys for the English alphabets, numbers, 0 to 9, and special characters * + – / [ ].
- **12 function keys**: These are keys labelled F1, F2 ... F12 and are a set of user-programmable function keys. The actual function assigned to a function key differs from one software package to another. These keys are also called soft keys since their functionality can be defined by the software.
- **Special-function keys**: Have special functions assigned to each of these keys. For example, the enter key is used to send the keyed-in data into the memory. Other special keys include:
  - **Shift**: used to enter capital letters or special characters defined above the number keys.
  - **Spacebar**: used to enter a space at the cursor location.
  - **Ctrl**: used in conjunction with other keys to provide added functionality on the keyboard.
  - **Alt**: like Ctrl, it is used to expand the functionality of the keyboard.
**Input/Output Devices**

- **Tab** – used to move the cursor to the next tab position defined.
- **Backspace** – used to move the cursor one position to the left and also delete the character in that position.
- **Caps Lock** – to toggle between the capital letter lock feature – when ‘on’, it locks the keypad for capital letters input.
- **Num Lock** – to toggle the number lock feature on and off – when ‘on’, it inputs numbers when you press the numbers on the numeric keypad.
- **Insert** – used to toggle between the insert and the overwrite mode during data entry – when ‘on’, entered text is inserted at the cursor location.
- **Delete** – used to delete the character at the cursor location.
- **Home** – used to move the cursor to the beginning of the work area which could be the line, screen or document depending on the software being used.
- **End** – used to move the cursor to the end of the work area.
- **Page Up** – used to display the previous page of the document being currently viewed on screen.
- **Page Down** – used to view the next page of the document being currently viewed on screen.
- **Escape** – usually used to negate the current command.
- **Print Screen** – used to print what is being currently displayed on the screen.
- **Numeric keypad** consists of keys having numbers (0 to 9) and mathematical operators (+, -, *) defined on them. It is usually located on the right side of the keyboard and supports quick entry of numerical data.
- **Cursor-control keys** defined by the arrow keys used to move the cursor in the direction indicated by the arrow (top, down, left, right).

Another well-known key arrangement is the Dvorak system, which was designed to be easier to learn and use. The Dvorak keyboard has the most common consonants on one side of the middle or the home row and the vowels on the other side, so that typing tends to alternate keystrokes back and forth between hands. Although the Dvorak keyboard has never been widely used, it has its adherents.

**Special-purpose keyboard**

These are standalone data entry systems used for computers deployed for specific applications. These typically have special purpose keyboards to enable faster data entry. A very typical example of such keyboards can be seen at the automatic teller machines or the ATMs, where the keyboard is required for limited functionality.
(support for some financial transactions) by the customers. Point-of-sale or POS terminals at fast food joints, air/railway reservation counters are some other examples of special-purpose keyboards. These keyboards are specifically designed only for special types of applications.

Key-to-tape, key-to-disk, key-to-diskette
These are standalone data entry stations. These units usually have a small processor attached to a keyboard and a visual display unit. The processor checks for the accuracy of data at the time of entry. The screen displays data as it is being entered. These facilities are very useful and desirable during mass data entry and are therefore becoming very popular in data processing centres.

2. Point-and-Draw Devices
The keyboard facilitates input of data only in the text form. While working with display based packages, we usually point to a display area and select an option from the screen (fundamentals of GUI applications). For such cases, the sheer user-friendliness of input devices that can rapidly point to a particular option displayed on screen and support its selection, resulted in the advent of various point-and-draw devices.

Mouse
A mouse is a small device that a computer user pushes across a desk surface in order to point to a place on a display screen and to select one or more actions possible from that position. The mouse first became a widely used computer tool when Apple Computer made it a standard part of the Apple Macintosh. Today, the mouse is an integral part of the graphical user interface (GUI) of any personal computer. The mouse apparently got its name by being about the same size and colour as a toy mouse.

Figure 3.12 shows a mouse.

![A Mouse](image)

Fig. 3.12 A Mouse

The most conventional type of mouse has two buttons on top: the left one is used most frequently. In the windows operating systems, it lets the user click once to send a 'Select' indication that provides the user with feedback that a particular position has been selected for further action. The next click on a selected position or two quick clicks on it causes a particular action to take place on the selected
object. For example, in Windows operating systems, it causes a program associated with that object to be started. The second button, on the right, usually provides some less-frequently needed capability. For example, when viewing a Web page, you can click on an image to get a pop-up menu that, among other things, lets you save the image on your hard disk. Some models have a third button for additional capabilities. Some mouse manufacturers also provide a version for left-handed people.

**Trackball**

The trackball is a pointing device that is much like an inverted mouse. It consists of a ball inset in a small external box, or adjacent to—and in the same unit as—the keyboard of some portable computers. Figure 3.13 shows a trackball.

![Fig. 3.13 A Trackball](image)

It is more convenient and requires much less space than the mouse since here the whole device is not moved (as in the case of a mouse). Trackball comes in various shapes but supports the same functionality. Typical shapes used are a ball, a square, and a button (typically seen in laptops).

**Joystick**

The joystick is a vertical stick that moves the graphic cursor in the direction the stick is moved. It consists of a spherical ball which moves within a socket, and has a stick mounted on it. The user moves the ball with the help of the stick that can be moved left or right, forward or backward, to move and position the cursor in the desired location. Joysticks typically have a button on top that is used to select the option pointed by the cursor. Video games, training simulators, and control panels of robots are some common uses of a joystick. The following figure shows a joystick:

![Fig. 3.14 A Joystick](image)
Light pen

The light pen is a pen-shaped device which allows natural movement on the screen. It is made up of a light sensitive cell and a lens assembly designed in such a way that it focuses onto itself any light in its field of view. The pen contains a light receptor and is activated by pressing the pen against the display screen. The receptor is the scanning beam that helps in locating the pen’s position (X and Y coordinates on the screen). Suitable system software is provided to initiate the desired action once the area on the display screen is located with the help of the light pen. Light pens are typically used in CAD (Computer Aided Design) applications to directly draw on screen. The following figure shows a light pen:

![Light Pen Image](image.png)

**Fig. 3.15  A Light Pen**

Touch screen

A touch screen is probably one of the simplest and most intuitive of all input devices. It uses optical sensors in or near the computer screen which can detect the touch of a finger on the screen. Once the user touches the screen at a particular position, sensors communicate the position to the computer. This is then interpreted by the computer to understand the user’s choice for input. The most common usage of touch screens is in information kiosks, where users can receive information at the touch of a screen. These devices have become very popular today.

3. Scanning Devices

Scanning devices are input devices used for direct data entry from the source document into the computer system. Scanners facilitate capturing of information and storing it in a graphical format for displaying it back on the graphical screen. They consist of two components, one to illuminate the page so that the optical image can be captured and the other to convert the graphical image into a digital format for storing. The graphical images thus scanned can be seen and processed directly by the computer.

There are two types of scanners, CONTACT and LASER. Both bounce a beam of light off an image, and then measure the reflected light to determine the value of the image. Hand-held contact scanners make contact as they are brushed over the printed matter to be read. Laser-based scanners are more versatile and can read data passed near the scanning area. Hand-held scanners are used where
the information to be scanned or the volume of documents to be scanned is very low. They are much cheaper as compared to the flat-bed scanners. The following figures shows hand-held and flatbed scanners:

Capturing information using scanners reduces the possibility of human error typically seen during large data entry. The reduction in human intervention improves the accuracy of data, besides saving time.

Most recent trends for data input are towards source data automation. The equipment used for source data automation, capture data as a by-product of a business activity, thereby completely eliminating manual input of data. Some common examples of these are described as follows:

**Optical mark recognition**

OMR devices can sense marks on computer readable paper. This type of device is typically used by academic institutions to grade aptitude tests, where candidates need to mark the correct option from a number of alternatives on a special sheet of paper. These answer sheets can be then directly read by the optical mark recognition device and can be used for further processing by the computer.

The actual technique used by an OMR device also involves focusing light on the page being scanned, thereby detecting the reflected light pattern for the marks. Pencil marks made by the user reflect the light determining which responses are marked. The following figure shows an example of a pre-printed answer sheet that can be read by an OMR device:

**Fig. 3.16 (a) Hand-held Scanner**

**Fig. 3.16 (b) Flatbed Scanner**

**Fig. 3.17 An Example of a Pre-printed Answer Sheet**
Magnetic ink character recognition (MICR)

Magnetic ink character recognition (MICR) is similar to optical mark recognition and is used exclusively by the banking industry. MICR devices are used by the banking industry to read the account numbers on cheques directly and subsequently do the necessary processing.

Banks using the MICR technology print chequebooks on special types of paper. The necessary details of the bank (like the bank’s identification code, the relevant account number, and the cheque number) are pre-printed on the cheques using ink that contains iron oxide particles that can be magnetized.

MICR readers are used to read and sort cheques and deposits. An MICR reader-sorter reads the data on the cheques and sorts the cheques for distribution to other banks and customers or for further processing. The following figure shows a bank cheque using MICR technology:

![A Bank Cheque using MICR Technology](image)

Optical bar code reader (OBR)

Data coded in the form of small vertical lines forms the basis of bar coding. Alphanumeric data is represented using adjacent vertical lines called barcodes. These are of varying widths and spacing between them and is used to uniquely identify books, merchandise in stores, postal packages, etc. The following is an example of a barcode used on one of the books for its unique identification.

A barcode reader uses laser beam technology. The laser beam is moved across the pattern of bars in a bar code. These bars reflect the beam in different ways. The reflected beam is then sensed by a light-sensitive detector, which then converts the light patterns into electrical pulses, thereby transmitting them to logic circuits for further conversion to alphanumeric value.

Barcode devices are available as hand-held devices. The following figures show a barcode reader and a barcode:
Digitizer

Digitizers are used to convert drawings or pictures and maps into a digital format for storage in the computer. A digitizer consists of a digitizing or graphics tablet, which is a pressure sensitive tablet, and a pen with the same X and Y coordinates as on the screen. Some digitizing tablets also use a crosshair device instead of a pen. The movement of the pen or the crosshair is reproduced simultaneously on the display screen. When the pen is moved on the tablet, the cursor on the computer’s screen moves simultaneously to the corresponding position on the screen (X and Y coordinates). This allows the user to draw sketches directly or input existing sketched drawings easily. Digitizers find most common usage by architects and engineers as a tool for computer aided designing (CAD). The following figure shows a digitizing tablet:

Fig. 3.20 A Digitizing Tablet
**Electronic-card reader**

Card readers are devices that also allow direct data input into a computer system. The electronic-card reader is connected to a computer system and reads the data encoded on an electronic card and transfers it to the computer system for further processing.

Electronic cards are plastic cards with data encoded on them and meant for a specific application. Typical examples of electronic cards are the plastic cards issued by banks to their customers for use in automatic teller machines or ATMs. Electronic cards are also used by many organizations for controlling access of various types of employees to physically secured areas.

Depending on the manner in which the data is encoded, electronic cards may be either magnetic strip cards or smart cards. Magnetic strip cards have a magnetic strip on the back of the card. Data stored on magnetic strips cannot be read with the naked eye, a useful way to maintain confidential data. The following figure shows an access card security system:

![An Access Card Security System](image)

**Smart cards**

Smart cards, going a stage farther, have a built-in microprocessor chip where data can be permanently stored. They also possess some processing capability making them suitable for a variety of applications. For example, to gain access, an employee inserts a card or a badge in the reader. This device reads and checks the authorization code before permitting the individual to enter a secured area. Since smart cards can hold more information as compared to magnetic strip cards, they are gaining in popularity.

**4. Voice Recognition Devices**

One of the most exciting areas of research involves recognition of an individual human voice as the basis of input to the computer system. Eliminating the keying-in of data, basic commands can very easily be given, facilitating quick operation.

Voice recognition devices consist of a microphone attached to the computer system. A user speaks into the microphone to input data. The spoken words are then converted into electrical signals (this is in the analog form). A digital-to-analog converter then converts the analog form to digital form (0s and 1s) that can be
interpreted by the computer. The digitized version is then matched with the existing pre-created dictionary to perform the necessary action.

Voice recognition devices have limited usage today because they have several problems associated with them. Not only do they require the ability to recognize who is speaking, but also what is being said (the message). This difficulty arises primarily because people speak with different accents and different tone pitches. The computer requires a large vocabulary to be able to interpret what is being said. Today’s voice recognition systems are therefore successful in a limited domain. They are limited to accepting words and tasks within a limited scope of operation and can handle only small quantities of data.

Figure 3.22 shows different steps in a voice recognition system.

Most speech recognition systems are SPEAKER-DEPENDENT, that is, they respond to the unique speech of a particular individual, a feature not necessarily inconvenient, but nevertheless limiting in generalized applications. They require a database of words for each person using the system.

5. Vision Input System

A vision input device allows data input in the form of images. It usually consists of a digital camera, which focuses on the object whose picture is to be taken. The camera creates the image of the object in the digital format, which can be then stored within the computer. The system then compares the digitized image to be interpreted with the pre-recorded digitized images in the computer’s database, much like a speech recognition system does with a voice input. The computer identifies the image by matching the structure of the input image with the images in the database. Based on whether or not the match is found, an appropriate action is taken.

Video input or capture is the process of entering full-motion recording into a computer and storing the video on a hard disk or some other medium. Video capture cards are needed for entering video information in the computer. The video files thus created, usually take up huge amounts of space on a hard disk (three minutes of high-quality video can occupy one gigabyte of space) and so are
usually compressed before storage. The most popular standard used for compression is the MPEG (Motion Pictures Expert Group).

Webcams and video cameras are the most commonly used devices to input visual data.

### Check Your Progress

3. What is mouse?

4. What are electronic cards?

### 3.4 OUTPUT DEVICES

The output can normally be produced in two ways—on a display unit/device, or on paper. Other types of output like speech output and mechanical output are also used in certain applications. Output produced on display units or speech output that cannot be touched, are referred to as softcopy output, while output produced on paper or material that can be touched, is known as hardcopy output. A wide range of output devices are available today and can be broadly classified under the following categories:

- Display devices (monitors; multimedia projectors; terminals—dumb, smart, Intelligent; X terminals)
- Printers (dot matrix, inkjet, laser)
- Plotters (flatbed, drum)
- Computer output microfilm (COM)
- Voice response systems (voice reproduction system, speech synthesizer)

#### 1. Display Devices

One of the most common and important peripherals in a computer system is the display device. Conventional computers used display terminals known as alphanumeric terminals. These used a form of multi-dot \((7 \times 5\) or \(9 \times 7\)) array to display characters. These were used to read text information displayed on the screen. The increasing demand for displaying graphs and pictures, for visual presentation of information (more effective for user interaction), brought about the advent of graphic display devices.

Graphic display is typically made up of a series of dots called ‘pixels’ (picture elements) whose pattern produces the image. Each dot on the screen can be addressed uniquely and directly. Owing to the fact that each dot can be addressed as a separate unit, it provides greater flexibility for drawing pictures. Display screen technology may be one of the following three categories:

#### Cathode ray tube (CRT)

The main components of a cathode ray terminal are the electron gun, the electron beam controlled by an electromagnetic field, and a display screen which is phosphor-
coated. The screen’s phosphor coating is organized into a grid of dots called pixels. The electron gun emits an electron beam which is directed towards the phosphor-coated display by an electromagnetic field, and this in turn creates the image. There are two types of CRT displays:

- **Vector CRT display**: In which the electron beam is directed only to places where the image is to be created.

- **Raster scan display**: In which the image is projected on the screen by directing the electron beam across each row of the picture elements from the top to the bottom of the screen. This type of display provides a high dynamic capability since the image is continuously refreshed. It offers full colour display at a relatively low cost and is therefore, becoming increasingly popular.

The quality of display is indicated by the resolution of the display device. The number of horizontal and vertical pixels determines the resolution. Typical resolutions in graphic display range from (800 × 600) to (640 × 768) to (1024 × 1024) pixels. Based on the resolution and the number of colours supported, several standards for colour monitors have evolved. The most popular of these include:

- **Color graphics adapter (CGA)**, which has a resolution of (320 × 200) and supports up to sixteen colours.

- **Extended graphics adapter (EGA)** has a resolution of (640 × 350) and supports up to sixteen colours.

- **Video graphics adapter (VGA)** has a resolution of (640 × 480) and supports up to 256 colours.

- **Super VGA** has a resolution ranging (800 × 600) to (1280 × 1024) and supports up to 256 or more colours.

Note that each one of these is implemented by installing an add-on card in the computer, commonly known as graphics adapter or the video card. This card is then connected to the appropriate monitor.

**Liquid crystal display (LCD)**

LCD was first introduced in watches and clocks in the 1970s and is now applied to the display terminals. In this, the cathode ray tube was replaced by liquid crystal to produce the image. It does not have colour capability and the image quality is relatively poor. The main advantage of LCD is its low energy consumption.

It finds its most common usage in portable devices where compactness and low energy requirements are of prime importance.

**Projection display**

Projection display technology is characterized by replacing the personal size screen with large screens upon which the images are projected. These systems are connected to the computer and whatever appears on the computer terminal gets...
enlarged and projected on a large screen. These are being used today for large group presentations.

2. Monitors

A monitor uses a cathode ray tube (CRT) to display information. It resembles a television screen and is similar to it in other respects. The monitor is typically associated with a keyboard for manual input of characters. The screen displays information as it is keyed in, enabling a visual check of input before it is transferred to the computer. It is also used to display the output from the computer, and hence, serves both as an input and an output device. The monitor along with the keyboard is called a visual display unit (VDU). This is the most commonly used input/output device today and is also known as the soft copy terminal. A printing device is usually required to provide a hard copy of the output. Figure 3.23 shows a CRT monitor.

![Fig. 3.23 CRT Monitor](image)

### Table 3.2 Difference between CRT and LCD Monitor

<table>
<thead>
<tr>
<th>Features</th>
<th>CRT (cathode ray tube)</th>
<th>LCD (liquid crystal display)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material and working</td>
<td>CRT works by moving an electron beam back and forth across the back of the screen. Each time the beam makes a pass across the screen, lights up the phosphor dots and illuminate the active part of the screen.</td>
<td>In order to illuminate the LCD screen uses two sheets of polarizing material with a liquid crystal solution between them.</td>
</tr>
<tr>
<td>Resolution and viewing quality</td>
<td>CRT provides flexible resolution up to 1600 by 1200 and higher.</td>
<td>The resolution is fixed in LCD monitor called as native resolution.</td>
</tr>
<tr>
<td>Image sharpness</td>
<td>Picture quality is same in these monitors when you viewed at different angles.</td>
<td>LCD monitors results in change in picture quality when you viewed at some odd angles, you may notice the picture fade and possibly look as if it will disappear from view.</td>
</tr>
<tr>
<td>Refresh rate</td>
<td>CRT users may notice a bit of annoying flicker. In order to get rid of this, graphics card can be used.</td>
<td>Refresh rate is not an issue in these monitor. LCDs are flicker-free.</td>
</tr>
<tr>
<td>Physical size</td>
<td>CRT monitors are big, bulky and heavy.</td>
<td>On the other hand, LCD monitors are small, compact and lightweight.</td>
</tr>
<tr>
<td>Power consumption</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>
3. Multimedia Projectors

A multimedia projector is an output device used to project information from the computer onto a large screen so that it can be viewed by a large group of people. Prior to this, the standard mode of giving presentations was to make transparencies and project them using an overhead projector. This was a tedious and time-consuming activity, since for every change in the subject matter, a new transparency had to be prepared. And of course, since electronic cut, copy and paste was not possible, this meant additional work.

A multimedia projector can be directly plugged into the computer system and information projected on a large screen, thereby making it possible to present information to a large audience. The presenter can also use a pointer to emphasize specific areas of interest in the presentation.

Another popular method used today is to connect the computer to an LCD flat screen and then project the LCD image using an overhead projector. Owing to its convenience and applicability, multimedia projectors are increasingly becoming popular in seminars, presentations and classrooms.

4. Terminals—Dumb, Smart, Intelligent

Terminals are classified into dumb, smart and intelligent based on their processing capability. These are being used as online remote data-entry devices.

**Dumb terminal**

A dumb terminal consists of a terminal and a keyboard for data input. The data entered is sent directly to the main computer. The terminal itself does not possess any processing capability. Data entered through dumb terminals is referred to as ‘dirty’ data since it is sent to the main computer along with any errors. This may lead to delays in processing data since data needs to be first ‘cleaned’ before processing can be done.

**Smart terminal**

A smart terminal is characterized by an additional microprocessor and limited internal storage. It, therefore, supports editing input data before sending it to the main computer. This means that it supports preliminary processing of data locally, thereby assuring that only ‘clean’ data is transmitted to the main computer for further processing. However, users cannot program smart terminals.

**Intelligent terminal**

Intelligent terminal computers have a built-in microprocessor, and memory which users can program. Such terminals also have their own online secondary storage devices like disks. Data can be stored locally and small jobs can be processed by the terminal itself without the need to interact with the CPU of the main computer.
Current technology has brought about a low price differential between dumb, smart and intelligent terminals. This has increased the use of intelligent terminals.

5. X Terminals

X terminals are graphic terminals supporting a wide variety of commands. These encompass a rich set of commands to draw graphics and images along with display of characters. They support managing areas on the screen also known as ‘windows’. Opening a new window, resizing the existing window, closing an existing window, are typical commands available for handling windows. X terminals (typically used with servers) are very commonly used today.

6. Printers

Printers are used for producing output on paper. There are a large variety of commercially available printers today (estimated to be 1500 different types). These printers can be classified into categories based on:

- Printing technology
- Printing speed
- Printing quality

Printing technology

Printers can be classified as impact or non-impact printers, based on the technology they use for producing output.

- **Impact printers:** They use variations of the standard typewriter printing mechanism, where a hammer strikes the paper through an inked ribbon. These printers have a mechanism that touches the paper in order to create an image. Dot matrix printers and character printers fall under this category.

- **Non-impact printers:** They do not touch the paper when creating an image. They use chemical, heat or electrical signals to etch symbols on paper. Many of these require special coated or treated paper. Inkjet, laser and thermal printers fall under this category of printers.

Printing speed

This refers to the number of characters printed in a unit of time. Based on speed, these may be classified as character printers (prints one character at a time), line printers (prints one line at a time), and page printers (prints the entire page at a time). Printer speeds are therefore measured in terms of characters-per-second or cps for a character printer, lines-per-minute or lpm for a line printer, and pages-per-minute or ppm for a page printer.

Printing quality

Printing quality is determined by the resolution of printing and is characterized by the number of dots that can be printed per linear inch, horizontally or vertically. It
is measured in terms of dots-per-inch or dpi. Printers can be classified as near-letter-quality or NLQ, letter-quality or LQ, near typeset quality or NTQ, and typeset-quality or TQ, based on their printing quality. NLQ printers are of resolutions of about 300 dpi, LQ of about 600 dpi, NTQ of about 1200 dpi, and TQ of about 2000 dpi. NLQ and LQ printers are used for ordinary printing in day-to-day activities, while NTQ and TQ printers are used to produce top-quality printing, typically required in the publishing industry. The following section explains the working of some commonly used printers.

### Table 3.3 Difference between Types of Printers

<table>
<thead>
<tr>
<th>Dot matrix</th>
<th>Inkjet</th>
<th>Laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dot matrix printers were the most popular impact printers used in personal computing. These printers use a print head consisting of a series of small pins to strike a ribbon coated with ink, causing the ink to transfer to the paper at the point of impact.</td>
<td>Inkjet printers use a series of nozzles to spray drops of ink directly on the paper. These therefore fall under the category of non-impact printers.</td>
<td>Laser printers use dry ink (toner), static electricity, and heat to place and bond the ink onto the paper.</td>
</tr>
<tr>
<td>The speed, versatility and ruggedness, combined with low cost, tend to make such printers particularly attractive in the personal computer market.</td>
<td>Inkjet printers are cheaper to buy but are more expensive in running costs (the ink cartridge cost is considerably higher than that of the DMP ribbon).</td>
<td>Laser is high quality, high speed, high volume, and non-impact technology that works on plain paper or pre-printed stationery. This technology is relatively expensive, but is becoming very popular because of the quality, speed and noiseless operations.</td>
</tr>
<tr>
<td>Printing speeds in case of dot matrix printers range between 40 – 1000 cps (characters-per-second).</td>
<td>Inkjet printers are slower than dot-matrix printers (40 – 300 cps).</td>
<td>Laser printers are faster in printing speed than other printers. Their speeds can range from ten pages a minute to about 200 pages per minute, depending upon the make/model.</td>
</tr>
</tbody>
</table>

![Fig. 3.24(a) Dot Matrix Printer](image)

![Fig. 3.24(b) Characters formed using Dots](image)
7. Plotters

Plotters are used to produce graphical output on paper. They are devices capable of producing charts, drawings, graphics, maps, etc. They are much like printers, but is designed to print graphs instead of alphanumeric characters.

Based on the technology used, plotters may be pen plotters or electrostatic plotters. While pen plotters have an ink pen attached to draw the images, electrostatic plotters work in a similar manner to a laser printer. An image is produced by charging the paper with high voltage. This voltage attracts the toner, which is then melted onto the paper with heat. Electrostatic plotters are fast, but the quality is generally considered to be poor when compared to pen plotters. This is why, pen plotters are more extensively used as compared to electrostatic plotters. Flatbed plotters and drum plotters constitute the most commonly used plotters.
Flatbed plotters

Flatbed plotters have a flat base like a drawing board on which the paper is laid (as shown in Figure 3.27(a)). One or more arms, each of them carrying an ink pen, moves across the paper to draw. The arm movement is controlled by a microprocessor (chip). The arm can move in two directions, one parallel to the plotter and the other perpendicular to it (called the x and y directions). With this kind of movement, it can move very precisely to any point on the paper placed below.

The computer sends the commands to the plotter which are translated into x and y movements. The arm moves in very small steps to produce continuous and smooth graphics. The size of the plot in a flatbed plotter is limited only by the size of the plotter’s bed.

The advantage of flatbed plotters is that the user can easily control the graphics. He can manually pick up the arm anytime during the production of graphics and place it on any position on the paper to alter the position of graphics to his choice. The disadvantage here is that flatbed plotters occupy a large amount of space.

Drum plotters

Drum plotters use a drum revolver to move the paper during printing (as shown in Figure 3.27(b)). The arm carrying a pen moves only in one direction, perpendicular to the direction of motion of the paper. Thus, in drum plotters the pen is moved in a single axis track and the paper itself moves on a cylindrical drum to add the other axis or dimension. The combination of the pen and the paper movement creates the graphics.

Fig. 3.27(a) Top View of a Flatbed Plotter
The size of the graph is therefore limited only by the width of the drum and can be of any length. Drum plotters are very compact and lightweight as compared to flatbed plotters. This is one of the advantages of such plotters. The disadvantage, however, is that the user cannot freely control the graphics when they are being created.

Plotters are more expensive when compared to printers. Typical application areas for plotters include: CAE (computer-aided engineering) applications like CAD (computer-aided design) and CAM (computer-aided manufacturing), architectural drawing and map drawing.

8. Computer Output Microfilm (COM)

COM is a process characterized by copying/printing data from media located on PCs, mini or mainframe computers, onto a microfilm. It consists of a high-speed recorder, which transfers digital data onto a microfilm using laser technology, and a processor that develops the microfilm once exposed to the light source.

A computer output microfilm device translates information normally held on magnetic tape into miniature images on a microfilm (also called microfiche—’fiche’ pronounced as ‘fish’). The device displays information as characters on a CRT screen and then using photographic methods, records the display onto the film. Drawings and images can also be displayed along with narrative text.

A special reader/printer can subsequently be used to view the processed film. The reader operates on a ‘back projection’ principle displaying one frame at a time on a translucent screen, typically about A4 size. The printer can then be used selectively to produce a hard copy of what is presented on screen. Figure 3.28 identifies the various steps in COM production.

A COM system provides an easy and compact way of recording and storing information, and subsequently retrieving the desired pieces of information. It offers various advantages like reduction of paper, reduction in cost (since it is cheaper
than most electronic media), improved quality (COM technology provides superior image quality), and electronic record retention/archiving.

COM is ideal for data that requires long-term storage, because microfilm is less volatile than magnetic media such as disks and tapes. It stores data in a very compact format; up to 270 pages can be contained in a single 4 × 6 inch fiche.

Converting magnetic tapes to microfilm is quite inexpensive for closed files. However, if the data is highly active, or requires regular updating, microfilm may be less efficient than retaining the information online. It is therefore useful for data that must be archived for long periods of time and referenced only occasionally, e.g., information that must be archived to comply with legal regulations, information maintained by insurance companies, banks, government agencies, and various organizations of this type.

![Fig. 3.28 Steps in a COM Production](image)


Voice response systems enable the computer to talk to its users. It consists of an audio-response device that produces the audio output. Voice response systems are typically of two types: voice reproduction system and speech synthesizer.

**Voice reproduction system**

Voice reproduction systems produce an audio output by selecting the appropriate response from a predefined set of responses. These responses may be in the form of speech (words or phrases spoken by human beings), musical sounds, alarms, or other sounds. The pre-recorded responses are first converted into digital data and stored in the computer. Once the appropriate response is selected, it is converted back to analog form to produce the audio output.

This is an appropriate method where standard replies to requests for information are all that is required. Potential applications of voice response systems
Speech synthesizer

A speech access system converts text to spoken words. The system consists of a synthesizer that does the speaking (hardware component) and the screen access program that directs the synthesizer (software component). Some synthesizers and speech access programs are linked and sold as a package, while others are sold independently.

The screen access software allows the user to access commercial software applications and to convert text or display into verbal output. Users can hear their keystrokes spoken aloud and can read the display on command.

The building blocks of speech output are phonemes. Phoneme is the smallest segment of sound such that if one phoneme in a word is substituted with another, the meaning itself will change. For example, substituting the first phoneme in the word ‘coffee’ can change the word to ‘toffee’. Because the definition is somewhat subjective, it is not possible to say precisely how many phonemes are there in the English language, but it is generally agreed that there are around forty.

There are various applications of synthetic speech, but in particular, two areas of applications exist for people with disabilities: augmentative communication and computer access for the visually handicapped.

'Augmentative communication’ refers to the use of technology (usually computer-based) to facilitate personal communication. In other words, someone who cannot speak for one reason or another may use a device through which he or she can specify utterances to be communicated to another person. The obvious medium of communication for such a device is (synthetic) speech, since it is the voice that is being replaced. Cosmologist Stephen Hawking uses one of these devices.

The other major application relies on the fact that text on a computer screen can be converted into speech. This is carried out by a ‘screen reader,’ which is a piece of software that runs alongside other programs, capturing whatever they display on the screen. The great advantage of a screen reader is that it will work with standard application software, so it is not necessary to develop (say) a talking word processor or a talking spreadsheet.

Like all computer technology, speech synthesizers have greatly reduced in price over recent years. As always, the main aim of research and development is to improve quality, and progress is being made. Already synthesizers exist, based on new technology, which produce voices that would be hard to distinguish from a recording of human speech.
Check Your Progress
5. On which factors, printer classification is based on?
6. What are the two types of plotters?

3.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS
1. Primary and secondary memory.
2. Seek and latency time are the two factors on which disk access time depends.
3. A mouse is a small device that a computer user pushes across a desk surface in order to point to a place on a display screen and to select one or more actions possible from that position.
4. Electronic cards are plastic cards with data encoded on them and meant for a specific application.
5. These printers can be classified into categories based on:
   - Printing technology
   - Printing speed
   - Printing quality
6. Flatbed plotters and drum plotters constitute the most commonly used plotters.

3.6 SUMMARY
- Secondary Memory stores all the system software and application programs and are basically used for data backups.
- Magnetic tapes are used for storing files of data that are sequentially accessed or not used very often and are stored offline. The tape is read sequentially, i.e., data can be read in the order in which the data has been written.
- Magnetic disks are direct-access medium and hence they are the most popular online secondary storage devices. Direct-access devices are also called random-access devices because information is literally available at random or in any order.
- The disk access time depends on the Seek time, Latency time.
- An input device accepts data from the outside world and transforms it into a form the computer can interpret. Keyboards are the most commonly used input devices. Point-and-draw devices are used to point to, and select menu items or icons displayed on screen.
Input/Output Devices

NOTES

- A mouse is a small device that a computer user pushes across a desk surface in order to point to a place on a display screen and to select one or more actions possible from that position.
- Scanning devices are input devices used for direct data entry from the source document into the computer system. Scanners facilitate capturing of information and storing it in a graphical format for displaying it back on the graphical screen.
- Digitizers are used to convert drawings or pictures and maps into a digital format for storage in the computer.
- Printers can be classified as impact or non-impact printers, based on the technology they use for producing output.
- Dot matrix, Inkjet, Laser are the types of printers available in the market.
- Plotters are used to produce graphical output on paper. They are devices capable of producing charts, drawings, graphics, maps, etc. They are much like printers, but is designed to print graphs instead of alphanumeric characters.
- Voice response systems enable the computer to talk to its users. It consists of an audio-response device that produces the audio output. Voice response systems are typically of two types: voice reproduction system and speech synthesizer.

3.7 KEY WORDS

- **Seek time**: The time taken to position the head on a specific track.
- **Latency time**: The time required by the desired sector to be positioned under the read/write head.
- **Scanning devices**: These are input devices used for direct data entry from the source document into the computer system. Scanners facilitate capturing of information and storing it in a graphical format for displaying it back on the graphical screen.
- **Digitizers**: These are devices which are used to convert drawings or pictures and maps into the digital format for storage in the computer.

3.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short-Answer Questions**

2. Write a short note on the role of monitors as output devices.
3. What are mass storage devices?
4. What is the need for data backup?
5. Write short notes on plotters.

**Long-Answer Questions**

1. Discuss few of the secondary storage devices.
2. Describe how input devices are used to enter information in a computer.
3. Explain how voice recognition devices and vision input devices are used to input data in a computer.
4. Write an essay on the different types of display devices.
5. Define printers and also explain its types.
6. What are plotters? Explain its types.

**3.9 FURTHER READINGS**


4.0 INTRODUCTION

In this unit, you will learn about number systems and character codes. In mathematics, a ‘number system’ is a set of numbers together with one or more operations, such as addition or multiplication. The number systems are represented as natural numbers, integers, rational numbers, algebraic numbers, real numbers, complex numbers, etc. A number symbol is called a numeral. A numeral system or system of numeration is a writing system for expressing numbers. For example, the standard decimal representation of whole numbers gives every whole number a unique representation as a finite sequence of digits. You will also learn about ASCII and Unicode later in this unit.

4.1 OBJECTIVES

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

- Understand the binary number system and their conversion
- Discuss the different types of codes
4.2 NUMBER SYSTEM

There are four systems of arithmetic, which are often used in digital systems. These systems are:

1. Decimal
2. Binary
3. Hexadecimal
4. Octal

In any number system, there is an ordered set of symbols known as digits. Collection of these digits makes a number which in general has two parts, integer and fractional, and are set apart by a radix point (.). Hence, a number system can be represented as

\[ N = \sum_{i=0}^{n} a_i b^{-i} + \sum_{i=1}^{m} a_i b^{-i} \]

Here,
- \( N \) = A number
- \( b \) = Radix or base of the number system
- \( n \) = Number of digits in integer portion
- \( m \) = Number of digits in fractional portion
- \( a_{n-1} \) = Most significant digit (MSD)
- \( a_{-1} \) = Least significant digit (LSD)
- and \( 0 \leq (a_i \text{ or } a_j) \leq b-1 \)

**Base or Radix:** The base or radix of a number is defined as the number of different digits that can occur in each position in the number system.

**Decimal Number System**

The number system which utilizes ten distinct digits, i.e., 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9 is known as the decimal number system. It represents numbers in terms of groups of ten, as shown in Figure 4.1.

We would be forced to stop at 9 or to invent more symbols if it were not for the use of positional notation. It is necessary to learn only ten basic numbers and the positional notational system in order to count any desired figure.

\[
\begin{array}{cccccccccccc}
10^8 & 10^7 & 10^6 & 10^5 & 10^4 & 10^3 & 10^2 & 10^1 & 10^0 & \ldots & \ldots & \ldots \\
\text{MSD} \ldots & & & & & & & & & & & \text{LSD} \\
\text{Decimal point} \\
\end{array}
\]

*Fig. 4.1 Decimal Position Values as Powers of 10*
Decimal number system has a base or radix of 10. Each of the ten decimal digits 0 through 9 has a place value or weight depending on its position. The weights are units, tens, hundreds, and so on. The same can be written as the power of its base as \(10^0, 10^1, 10^2, 10^3, \ldots\), etc. Thus, the number 1993 represents quantity equal to 1000 + 900 + 90 + 3. Actually, this should be written as \(1 \times 10^3 + 9 \times 10^2 + 9 \times 10^1 + 3 \times 10^0\). Hence, 1993 is the sum of all digits multiplied by their weights. Each position has a value ten times greater than the position to its right.

**Example 4.1** Show the representation of the number 379.

Solution:

\[
\begin{align*}
100 & \quad 10 \quad 1 \\
10^2 & \quad 10^1 & \quad 10^0 \\
3 & \quad 7 & \quad 9 \\
\Rightarrow & \quad 3 \times 100 + 7 \times 10 + 9 \times 1 \\
& = 3 \times 10^2 + 7 \times 10^1 + 9 \times 10^0
\end{align*}
\]

In this example, 9 is the least significant digit (LSD) and 3 is the most significant digit (MSD).

**Example 4.2** Show the representation of the number 1936.469.

Solution:

\[
\begin{align*}
1936.469_{10} & = 1 \times 10^3 + 9 \times 10^2 + 3 \times 10^1 + 6 \times 10^0 + 4 \times 10^{-1} + 6 \times 10^{-2} + 9 \times 10^{-3} \\
& = 1000 + 900 + 30 + 6 + 0.4 + 0.06 + 0.009 = 1936.469
\end{align*}
\]

It is seen that powers are numbered to the left of the decimal point starting with 0 and to the right of the decimal point starting with \(-1\).

The general rule for representing numbers in the decimal system by using positional notation is as follows:

\[
a_n a_{n-1} \ldots a_2 a_1 a_0 = a_n 10^n + a_{n-1} 10^{n-1} + \ldots + a_2 10^2 + a_1 10^1 + a_0 10^0
\]

Here, \(n\) is the number of digits to the left of the decimal point.

**Binary Number System**

A number system that uses only two digits, 0 and 1, is called the binary number system. The binary number system is also called a base two system. The two symbols, 0 and 1, are known as bits (binary digits).

The binary system groups numbers by twos and by powers of two, shown in Figure 4.2. The word binary comes from a Latin word meaning two at a time.

![Fig. 4.2 Binary Position Values as a Power of 2](image)
The weight or place value of each position can be expressed in terms of 2, and as $2^0$, $2^1$, $2^2$, etc. The least significant digit has a weight of $2^0 (= 1)$. The second position to the left of the least significant digit is multiplied by $2^1 (= 2)$. The third position has weight equal to $2^2 (= 4)$. Thus, the weights are in the ascending powers of 2 or 1, 2, 4, 8, 16, 32, 64, 128, etc.

The numeral $10_{\text{two}}$ (one, zero, base two) stands for two, the base of the system.

In binary counting, single digits are used for none and one. Two-digit numbers are used for $10_{\text{two}}$ and $11_{\text{two}}$ (2 and 3 in decimal numerals). For the next counting number, $100_{\text{two}}$ (4 in decimal numerals) three digits are necessary. After $111_{\text{two}}$ (7 in decimal numerals) four digit numerals are used until $1111_{\text{two}}$ (15 in decimal numerals) is reached, and so on. In a binary numeral, every position has a value two times the value of the position to its right.

A binary number with 4 bits is called a nibble and a binary number with eight bits is known as a byte.

**Example 4.3** Show the representation of the number $1011_2$.

**Solution:**

$$
1011_2 = 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0
$$

$$
= 1 \times 8 + 0 \times 4 + 1 \times 2 + 1 \times 1
$$

∴

$$
1011_2 = 8 + 0 + 2 + 1 = 11_{10}
$$

In general,

$$
[b_n b_{n-1} \ldots b_1 b_0]_2 = b_n 2^n + b_{n-1} 2^{n-1} + \ldots + b_1 2^1 + b_0 2^0
$$

**Example 4.4** Show the representation of the binary number 10101.011.

**Solution:**

$$
\begin{array}{cccccccc}
\text{MSD} & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 \\
\text{LSD} & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 & 2^{-1} & 2^{-2} & 2^{-3}
\end{array}
$$

∴

$$
10101.011_2 = 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0
$$

$$
+ 0 \times 2^{-1} + 1 \times 2^{-2} + 1 \times 2^{-3}
$$

$$
= 16 + 0 + 4 + 0 + 1 + 0 + 0.25 + 0.125 = 21.375_{10}
$$

In each binary digit, the value increases in powers of two starting with 0 to the left of the binary point and decreases to the right of the binary point starting with power $-1$.

**Why is a Binary Number System is Used?**

Binary number system is used in digital computers because all electrical and electronic circuits can be made to respond to the two states concept. For instance, a switch can be either opened or closed, only two possible states exist. A transistor

\[ \text{Self-Instructional Material} \]
can be made to operate either in cut-off or saturation; a magnetic tape can be either magnetized or non-magnetized; a signal can be either HIGH or LOW; a punched tape can have a hole or no hole. In all these cases, each device is operated in any one of the two possible states and the intermediate condition does not exist. Thus, 0 can represent one of the states and 1 can represent the other. Hence, binary numbers are convenient to use in analysing or designing digital circuits.

Binary fractions

A binary fraction can be represented by a series of 1s and 0s to the right of a binary point. The weights of digit positions to the right of the binary point are given by $2^{-1}$, $2^{-2}$, $2^{-3}$, and so on.

Example 4.5 Show the representation of the binary fraction 0.1011.

Solution: 

$$0.1011 = 1 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3} + 1 \times 2^{-4}$$

$$= 1 \times 0.5 + 0 \times 0.25 + 1 \times 0.125 + 1 \times 0.0625$$

$$0.1011_2 = 0.6875_{10}$$

Mixed numbers

Mixed numbers contain both integer and fractional parts. The weights of mixed numbers are $2^3$, $2^2$, $2^1$, $2^{-1}$, $2^{-2}$, $2^{-3}$, etc.

Example 4.6 Show the representation of the mixed binary number 1011.101.

Solution: 

$$1011.101 = 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3}$$

$$= 1 \times 8 + 0 \times 4 + 1 \times 2 + 1 \times 1 + 1 \times 0.5 + 0 \times 0.25 + 1 \times 0.125$$

$$\therefore [1011.101]_2 = [11.625]_{10}$$

When different number systems are used, it is customary to enclose the number within big brackets and the subscripts indicate the type of the number system.

Decimal to Binary and Binary to Decimal Conversions

Decimal to Binary Conversion

There are several methods for converting a decimal number into a binary number. The first method is simply to subtract values of powers of 2 which can be subtracted from the decimal number until nothing remains. The value of highest power of 2 is subtracted first, then the second highest, and so on.
Example 4.7 Convert the decimal integer 29 into its binary form.

Solution: First the value of highest power of 2 which can be subtracted from 29 is found. This is $2^4 = 16$.

Then, $29 - 16 = 13$

The value of highest power of 2 which can be subtracted from 13 is $2^3 = 8$.

Then, $13 - 8 = 5$.

The value of highest power of 2 which can be subtracted from 5 is $2^2 = 4$.

The remainder after subtraction is 1 or $2^0$. Therefore, the binary representation for 29 is given by

$$29_{10} = 2^4 + 2^3 + 2^2 + 2^0 = 16 + 8 + 4 + 0 \times 2 + 1$$

$$= 1\ 1\ 1\ 0\ 1$$

$$[29]_{10} = [11101]_2$$

Similarly, $[25.375]_{10} = 16 + 8 + 1 + 0.25 + 0.125$

$$= 2^4 + 2^3 + 0 + 0 + 2^{-2} + 2^{-3}$$

$$[25.375]_{10} = [11011.011]_2$$

This is a laborious method for converting numbers. It is convenient for small numbers and can be performed mentally, but is less used for larger numbers.

Double-Dabble Method

A popular method known as double-dabble method, also known as divide-by-two method, is used to convert a large decimal number into its binary equivalent. In this method, the decimal number is repeatedly divided by 2, and the remainder after each division is used to indicate the coefficient of the binary number to be formed. Note that the binary number derived is written from the bottom up.

Example 4.8 Convert 199\textsubscript{10} into its binary equivalent.

Solution:

- $199 \div 2 = 99 + \text{remainder } 1$ (LSB)
- $99 \div 2 = 49 + \text{remainder } 1$
- $49 \div 2 = 24 + \text{remainder } 1$
- $24 \div 2 = 12 + \text{remainder } 0$
- $12 \div 2 = 6 + \text{remainder } 0$
- $6 \div 2 = 3 + \text{remainder } 0$
- $3 \div 2 = 1 + \text{remainder } 1$
- $1 \div 2 = 0 + \text{remainder } 1$ (MSB)
The binary representation of 199 is therefore, 11000111. Checking the result, we have
\[ [11000111]_2 = 1 \times 2^7 + 1 \times 2^6 + 0 \times 2^5 + 0 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 \]
\[ = 128 + 64 + 0 + 0 + 0 + 4 + 2 + 1 \]
\[ \therefore [11000111]_2 = [199]_{10} \]
Notice that the first remainder is the LSB and the last remainder is the MSB. This method will not work for mixed numbers.

**Decimal Fraction to Binary**

Conversion of decimal fraction to binary fractions may be accomplished by using several techniques. Again, the most obvious method is to subtract the highest value of negative power of 2, which may be subtracted from the decimal fraction. Then, the next highest value of negative power of 2 is subtracted from the remainder of the first subtraction, and this process is continued until there is no remainder or till the desired precision is obtained.

**Example 4.9** Convert the decimal 0.875 into its binary number.

**Solution:**
\[ 0.875 - 1 \times 2^{-1} = 0.875 - 0.5 = 0.375 \]
\[ 0.375 - 1 \times 2^{-2} = 0.375 - 0.25 = 0.125 \]
\[ 0.125 - 1 \times 2^{-3} = 0.125 - 0.125 = 0 \]
\[ \therefore [0.875]_{10} = [0.111]_2 \]

A much simpler method of converting longer decimal fractions to binary consists of repeatedly multiplying by 2 and recording any carriers in the integer position.

**Example 4.10** Convert 0.6940\(_{10}\) into its binary number.

**Solution:**
\[ 0.6940 \times 2 = 1.3880 = 0.3880 \text{ with a carry of 1} \]
\[ 0.3880 \times 2 = 0.7760 = 0.7760 \text{ with a carry of 0} \]
\[ 0.7760 \times 2 = 1.5520 = 0.5520 \text{ with a carry of 1} \]
\[ 0.5520 \times 2 = 1.1040 = 0.1040 \text{ with a carry of 1} \]
\[ 0.1040 \times 2 = 0.2080 = 0.2080 \text{ with a carry of 0} \]
\[ 0.2080 \times 2 = 0.4160 = 0.4160 \text{ with a carry of 0} \]
\[ 0.4160 \times 2 = 0.8320 = 0.8320 \text{ with a carry of 0} \]
\[ 0.8320 \times 2 = 1.6640 = 0.6640 \text{ with a carry of 1} \]
\[ 0.6640 \times 2 = 1.3280 = 0.3280 \text{ with a carry of 1} \]
We may stop here as the answer would be approximate.
\[ \therefore [0.6940]_{10} = [0.101100011]_2 \]
If more accuracy is needed, continue multiplying by 2 until you have as many digits as necessary for your application.

**Example 4.11** Convert $14.625_{10}$ into its binary form.

**Solution:** First, the integer part 14 is converted into the binary form, followed by the fractional part 0.625:

<table>
<thead>
<tr>
<th>Integer part</th>
<th>Fractional part</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 ÷ 2 = 7 + 0</td>
<td>0.625 × 2 = 1.250 with a carry of 1</td>
</tr>
<tr>
<td>7 ÷ 2 = 3 + 1</td>
<td>0.250 × 2 = 0.500 with a carry of 0</td>
</tr>
<tr>
<td>3 ÷ 2 = 1 + 1</td>
<td>0.500 × 2 = 1.000 with a carry of 1</td>
</tr>
<tr>
<td>1 ÷ 2 = 0 + 1</td>
<td></td>
</tr>
</tbody>
</table>

$\therefore$ The binary equivalent is $[1110.101]_2$.

**Binary to Decimal Conversion**

A binary number can be converted into a decimal number by multiplying the binary 1 or 0 by the weight corresponding to its position and adding all the values.

**Example 4.12** Convert the binary number 110111 into its decimal equivalent.

**Solution:**

\[
\begin{align*}
110111_2 & = 1 \times 2^5 + 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 \\
& = 1 \times 32 + 1 \times 16 + 0 \times 8 + 1 \times 4 + 1 \times 2 + 1 \\
& = 32 + 16 + 4 + 2 + 1 \\
& = 55_{10}
\end{align*}
\]

We can streamline the binary to decimal conversion by the following procedure:

**Step 1.** Write the binary, i.e., all its bits in a row.

**Step 2.** Write 1, 2, 4, 8, 16, 32, ..., directly under the binary number working from right to left.

**Step 3.** Omit the decimal weight which lies under zero bits.

**Step 4.** Add the remaining weights to obtain the decimal equivalent.

The same method is used for binary fractional number.

**Example 4.13** Convert the binary number 11101.1011 into its decimal equivalent.

**Solution:**

**Step 1:**

\[
\begin{array}{c}
1 \\
| \\
| \\
| \\
| \\
\uparrow \\
| \\
| \\
\end{array}
\]

Binary point
Step 2: 16 8 4 2 1 . 0.5 0.25 0.125 0.0625
Step 3: 16 8 4 0 1 . 0.5 0 0.125 0.0625
Step 4: 16 + 8 + 4 + 1 + 0.5 + 0.125 + 0.0625 = \([29.6875]_{10}\)
Hence, \([11101.1011]_2 = [29.6875]_{10}\)

Table 4.1 lists the binary numbers from 0000 to 10000. Table 4.2 lists the powers of 2 and their decimal equivalents and the number of K. The abbreviation K stands for \(2^{10} = 1024\). Therefore, 1K = 1024, 2K = 2048, 3K = 3072, 4K = 4096, and so on. Many personal computers have 64K memories, this means that computers can store up to 65,536 bytes in the memory section.

<table>
<thead>
<tr>
<th>Decimal</th>
<th>Binary</th>
<th>Powers of 2</th>
<th>Equivalent</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>2^0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>01</td>
<td>2^1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>2^2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>2^3</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>2^4</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>101</td>
<td>2^5</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>110</td>
<td>2^6</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>111</td>
<td>2^7</td>
<td>128</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1000</td>
<td>2^8</td>
<td>256</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1001</td>
<td>2^9</td>
<td>512</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1010</td>
<td>2^{10}</td>
<td>1024</td>
<td>1K</td>
</tr>
<tr>
<td>11</td>
<td>1011</td>
<td>2^{11}</td>
<td>2048</td>
<td>2K</td>
</tr>
<tr>
<td>12</td>
<td>1100</td>
<td>2^{12}</td>
<td>4096</td>
<td>4K</td>
</tr>
<tr>
<td>13</td>
<td>1101</td>
<td>2^{13}</td>
<td>8192</td>
<td>8K</td>
</tr>
<tr>
<td>14</td>
<td>1110</td>
<td>2^{14}</td>
<td>16384</td>
<td>16K</td>
</tr>
<tr>
<td>15</td>
<td>1111</td>
<td>2^{15}</td>
<td>32768</td>
<td>32K</td>
</tr>
<tr>
<td>16</td>
<td>10000</td>
<td>2^{16}</td>
<td>65536</td>
<td>64K</td>
</tr>
</tbody>
</table>

4.3 OVERVIEW OF CHARACTER CODING

Code is a symbolic representation of discrete information, which may be presented in the form of numbers, letters or physical quantities. The symbols used are the binary digits 0 and 1, which are arranged according to the rules of codes. These codes are used to communicate information to a digital computer and to retrieve messages from it. A code is used to enable an operator to feed data into a computer directly, in the form of decimal numbers, alphabets and special characters. The computer converts these data into binary codes and after computation, transforms the data into its original format, such as decimal numbers, alphabets and special characters.
When numbers, letters, or words are represented by a special group of symbols, this is called encoding, and the group of symbols is called a code. In Morse code, a series of dots and dashes represent alphabet, numerals and special characters.

Codes are broadly classified into five groups, viz., (i) Weighted Binary Codes, (ii) Non-weighted Codes, (iii) Error-detecting Codes, (iv) Error-correcting Codes, and (v) Alphanumeric Codes.

**Weighted Binary Codes**

Weighted binary codes obey their positional weighting principles. Each position of a number represents a specific weight. In a weighted binary code, the bits are multiplied by the weights indicated; the sum of these weighted bits gives the equivalent decimal digit.

**Straight binary coding** is a method of representing a decimal number by its binary equivalent. The codes 8421, 2421, 5421 and 5211 are weighted binary codes. Each decimal digit is represented by a four-bit binary word, the three digits for the left being weighted. Table 4.3 consists of a few weighted 4-bit binary codes with their decimal numbers and complements.

**Table 4.3 Some Weighted 4-Bit Binary Codes**

<table>
<thead>
<tr>
<th>Decimal Number</th>
<th>8421</th>
<th>5421</th>
<th>2421</th>
<th>9's Complement of 2421 Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0000</td>
<td>0000</td>
<td>0000</td>
<td>0000</td>
</tr>
<tr>
<td>1</td>
<td>0001</td>
<td>0001</td>
<td>0001</td>
<td>0010</td>
</tr>
<tr>
<td>2</td>
<td>0010</td>
<td>0010</td>
<td>0010</td>
<td>1101</td>
</tr>
<tr>
<td>3</td>
<td>0011</td>
<td>0011</td>
<td>0011</td>
<td>1100</td>
</tr>
<tr>
<td>4</td>
<td>0100</td>
<td>0100</td>
<td>0100</td>
<td>0101</td>
</tr>
<tr>
<td>5</td>
<td>0101</td>
<td>0101</td>
<td>0101</td>
<td>0100</td>
</tr>
<tr>
<td>6</td>
<td>0110</td>
<td>0110</td>
<td>1100</td>
<td>0011</td>
</tr>
<tr>
<td>7</td>
<td>0111</td>
<td>1101</td>
<td>1101</td>
<td>0010</td>
</tr>
<tr>
<td>8</td>
<td>1000</td>
<td>1110</td>
<td>1110</td>
<td>0001</td>
</tr>
<tr>
<td>9</td>
<td>1001</td>
<td>1111</td>
<td>1111</td>
<td>0000</td>
</tr>
</tbody>
</table>

**BCD or 8421 code:** The Binary-Coded Decimal (BCD) uses the binary number system to specify the decimal numbers 0 to 9. It has four bits. The weights are assigned according to the positions occupied by these digits. The weights of the first (right-most) position is $2^0 (1)$, the second $2^1 (2)$, the third $2^2 (4)$, and the fourth $2^3 (8)$. Reading from left to right, the weights are 8-4-2-1, and hence it is called 8421 code.

The binary equivalent of 7 is $[111]_2$, but the same number is represented in BCD in 4-bit form as $[0111]_2$. Also, the numbers from 0 to 9 are represented in the same way as in the binary system, but after 9 the representations in BCD are different. For example, the decimal number 12 in the binary system is $[1100]_2$, but the same number is represented as $[0001 0010]$ in BCD.
Example 4.14: Give the BCD Code for the decimal number 874.

Solution:

<table>
<thead>
<tr>
<th>Decimal number</th>
<th>BCD code</th>
<th>(874)<em>{10} = (1000 0111 0100)</em>{BCD}</th>
</tr>
</thead>
</table>

Example 4.15: Give the BCD code equivalent for the decimal number 96.42.

Solution:

<table>
<thead>
<tr>
<th>Decimal number</th>
<th>BCD Code</th>
<th>(96.42)<em>{10} = (10001101.010000010)</em>{BCD}</th>
</tr>
</thead>
</table>

2421 code: This is a weighted code; its weights are 2, 4, 2 and 1. A decimal number is represented in 4-bit form and the total weight of the four bits = 2 + 4 + 2 + 1 = 9. Hence, the 2421 code represents decimal numbers from 0 to 9. Upto 4, the 2421 code is the same as that in BCD; however, it varies for digits from 5 to 9. This code is also a self-complementing code i.e. the 9’s complement of a number ‘N’ is obtained by complementing the 0s and 1s in the code word ‘N’. For example, the 2421 code for 3 is 0011 and its natural complement 1100 gives 6 which is the 9’s complement of 3. Table 1.3 gives the 2421 code of the decimal numbers and its complement. The bit combination 1101, when weighted by the reflective digits 2421, gives the decimal equivalent of 2 × 1 + 4 × 1 + 2 × 0 + 1 × 1 = 2 + 4 + 0 + 1 = 7.

Reflective codes: A code is said to be reflective when the code for 9 is the complement of the code for 0, 8 for 1, 7 for 2, 6 for 3, and 5 for 4. While the 2421, 5211 and Excess-3 codes are reflective codes, the 8421 code is not. While finding the 9’s complement, such as in 9’s complement subtraction, reflectivity is desirable in a code.

Sequential codes: A code can be said to be sequential when each succeeding code is one binary number greater than its preceding code. This greatly helps mathematical manipulation of data. While the 8421 and Excess-3 codes are sequential, the 2421 and 5421 codes are not.

Non-weighted Codes

Non-weighted codes are codes that are not positionally weighted. This means that each position within a binary number is not assigned a fixed value. Excess-3 codes and Gray codes are examples of non-weighted codes.

Excess-3 code: As the name indicates, the Excess-3 represents a decimal number, in binary form, as a number greater than 3. An Excess-3 code is obtained by adding 3 to a decimal number. For example, to encode the decimal number 6 into
an Excess-3 code, we must first add 3 in order to obtain 9. The 9 is then encoded in its equivalent 4-bit binary code 1001. The Excess-3 code is a self-complementing code, and this helps in performing subtraction operations in digital computers, especially in the earlier models. The Excess-3 code is also a reflective code.

Example 4.16: Convert \([643]_{10}\) into its Excess-3 code.

Solution:

<table>
<thead>
<tr>
<th>Decimal number</th>
<th>6</th>
<th>4</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add 3 to each bit</td>
<td>+3</td>
<td>+3</td>
<td>+3</td>
</tr>
<tr>
<td>Sum</td>
<td>9</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

Converting the above sum into its BCD code, we have

<table>
<thead>
<tr>
<th>Sum</th>
<th>9</th>
<th>7</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCD</td>
<td>(1001)</td>
<td>(0111)</td>
<td>(0110)</td>
</tr>
</tbody>
</table>

Hence, the Excess-3 code for \([643]_{10}\) is \(1001\ 0111\ 0110\).

Table 4.4 lists the BCD, Excess-3 code and 9’s complement representations for decimal digits. Note that both codes use only 10 of the 16 possible 4-bit code groups. The excess-3 code, however, does not use the same code groups. Its invalid code groups are 0000, 0001, 0010, 1101, 1110, and 1111.

Table 4.4 Excess-3 Codes

<table>
<thead>
<tr>
<th>Decimal</th>
<th>8421 (BCD) Code</th>
<th>Excess-3 Code</th>
<th>9’s Complement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0000</td>
<td>0011</td>
<td>1100</td>
</tr>
<tr>
<td>1</td>
<td>0001</td>
<td>0100</td>
<td>1011</td>
</tr>
<tr>
<td>2</td>
<td>0010</td>
<td>0101</td>
<td>1010</td>
</tr>
<tr>
<td>3</td>
<td>0011</td>
<td>0110</td>
<td>1001</td>
</tr>
<tr>
<td>4</td>
<td>0100</td>
<td>0111</td>
<td>1000</td>
</tr>
<tr>
<td>5</td>
<td>0101</td>
<td>1000</td>
<td>0111</td>
</tr>
<tr>
<td>6</td>
<td>0110</td>
<td>1001</td>
<td>0110</td>
</tr>
<tr>
<td>7</td>
<td>0111</td>
<td>1010</td>
<td>0101</td>
</tr>
<tr>
<td>8</td>
<td>1000</td>
<td>1011</td>
<td>0000</td>
</tr>
<tr>
<td>9</td>
<td>1001</td>
<td>1100</td>
<td>0011</td>
</tr>
</tbody>
</table>

Gray code: The Gray code belongs to a class of codes called minimum-change codes, in which only one bit in the code group changes when moving from one step to the next. The Gray code is a non-weighted code. Therefore, it is not suitable for arithmetic operations but finds applications in input/output devices and in some types of analog-to-digital converters. The Gray code is a reflective digital code which has a special property of containing two adjacent code numbers that differ by only one bit. Therefore, it is also called a unit-distance code.

Table 4.5 shows the Gray code representation for the decimal numbers 0 to 15, together with the straight binary code.
NOTES

Table 4.5 Gray Code

<table>
<thead>
<tr>
<th>Decimal Numbers</th>
<th>Binary Code</th>
<th>Gray Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0000</td>
<td>0000</td>
</tr>
<tr>
<td>1</td>
<td>0001</td>
<td>0001</td>
</tr>
<tr>
<td>2</td>
<td>0010</td>
<td>0011</td>
</tr>
<tr>
<td>3</td>
<td>0011</td>
<td>0010</td>
</tr>
<tr>
<td>4</td>
<td>0100</td>
<td>0110</td>
</tr>
<tr>
<td>5</td>
<td>0101</td>
<td>0111</td>
</tr>
<tr>
<td>6</td>
<td>0110</td>
<td>0101</td>
</tr>
<tr>
<td>7</td>
<td>0111</td>
<td>0100</td>
</tr>
<tr>
<td>8</td>
<td>1000</td>
<td>1100</td>
</tr>
<tr>
<td>9</td>
<td>1001</td>
<td>1101</td>
</tr>
<tr>
<td>10</td>
<td>1010</td>
<td>1111</td>
</tr>
<tr>
<td>11</td>
<td>1011</td>
<td>1110</td>
</tr>
<tr>
<td>12</td>
<td>1100</td>
<td>1010</td>
</tr>
<tr>
<td>13</td>
<td>1101</td>
<td>1011</td>
</tr>
<tr>
<td>14</td>
<td>1110</td>
<td>1001</td>
</tr>
<tr>
<td>15</td>
<td>1111</td>
<td>1000</td>
</tr>
</tbody>
</table>

American Standards Code

American Standards Code for Information Interchange (ASCII), used in most microcomputers by its manufacturers. The ASCII code represents a character with seven bits, which can be stored as one byte with one bit unused. The extra bit is often used to extend the ASCII code to represent an additional 128 characters. The format of the ASCII code is $X_6X_5X_2X_3X_2X_1X_0$, where each bit is a ‘0’ or a ‘1’. For example, the letter A is coded as 1000001.

EBCDIC code

Another alphanumeric code used in IBM equipment is the EBCDIC or Extended Binary Coded Decimal Information Code. It differs from ASCII only in its code grouping for the different alphanumeric characters. It uses eight bits for each character and a ninth bit for parity.

Unicode

Encoding such as ASCII, EBCDIC and their variants do not have a sufficient number of characters to be able to encode alphanumeric data of all form, script and languages. As a result, these encoding do not permit multilingual computer processing. In addition, these encodings suffer from incompatibility. Two different encodings may use the same number from two different characters or different numbers for the same characters. For example, Code 4E (in hex) represents the upper-case letter ‘N’ in ASCII code and the plus sign ‘+’ in the EBCDIC code.

It is the most complete character encoding scheme that allows text of all forms and languages to be encoded for use by the computers. It not only enables
Data Presentation in Computers

The Unicode standard has been adopted by industry leaders such as HP, IBM, Microsoft, Apple, Oracle, Unisys, Sun, Sybase, SAP and many more.

Check Your Progress

1. Define base or radix.
2. What is a binary number system?
3. What is code?
4. Write a note on BCD code.

4.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The base or radix of a number is defined as the number of different digits that can occur in each position in the number system.
2. A number system that uses only two digits, 0 and 1, is called the binary number system.
3. Code is a symbolic representation of discrete information, which may be presented in the form of numbers, letters or physical quantities.
4. The Binary-Coded Decimal (BCD) uses the binary number system to specify the decimal numbers 0 to 9. It has four bits.

4.5 SUMMARY

- Base or Radix of a number is defined as the number of different digits that can occur in each position in the number system.
- The number system which utilizes ten distinct digits, i.e., 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9 is known as the decimal number system.
- A number system that uses only two digits, 0 and 1, is called the binary number system.
- Double-Dabble method, also known as divide by two method, is used to convert a large decimal number into its binary equivalent.
- A sequential code can be said, when each succeeding code is one binary number greater than its preceding code.
- Excess-3 represents a decimal number, in binary form, as a number greater than 3. An Excess-3 code is obtained by adding 3 to a decimal number.
Gray code belongs to a class of codes called minimum-change codes, in which only one bit in the code group changes when moving from one step to the next. The Gray code is a non-weighted code.

4.6 KEY WORDS

- **Binary Number System**: A number system that uses only two digits, 0 and 1, is called the binary number system.
- **Decimal Number System**: The number system which utilizes ten distinct digits, i.e., 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9 is known as the decimal number system.

4.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short-Answer Questions**

1. What is decimal number system?
2. What is weighted binary code?
3. Define mixed numbers?

**Long-Answer Questions**

1. Convert the decimal integer 29 into its binary form?
2. Convert (1011)\_2 into its decimal equivalent.
3. Explain the conversion of Binary Number into Decimal Number with an example?

4.8 FURTHER READINGS


UNIT 5  COMPUTER SOFTWARE

5.0 INTRODUCTION

A computer cannot operate without any instructions and is based on a logical sequence of instructions in order to perform a function. These instructions are known as a ‘computer program’ and constitute the computer software. The sequences of instructions are based on algorithms that provide the computer with instructions on how to perform a function. Thus, it is impossible for a computer to process without software.

5.1 OBJECTIVES

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

• Understand the features of Windows
• Define Linux
• Discuss the advantages of Linux OS
• Define system and application software

5.2 WINDOWS 10

Windows 10 is a personal computer operating system. It was developed and released by Microsoft as part of the Windows NT family of operating systems. It was officially unveiled in September 2014 after a brief demo at Build 2014. The first version of the operating system entered a public beta testing process in October. Its consumer release took place on July 29, 2015.
Versions

Windows 10 is available in different versions on the basis of editions.

1. **Home and Pro** are the two baseline editions. Home edition is chiefly designed for use in PC and tablets while Pro version includes additional features that support business environment and power users.

2. These versions are organisational editions that add features to facilitate centralized control of many installations of the OS within an organization. Enterprise, Education, Pro education, Enterprise LTSB and Mobile Enterprise are the organisational editions.

![Action Center of Windows 10](image)

*Fig. 5.1 Action Center of Windows 10*

The Windows user interface was revised to handle transitions between a mouse-oriented interface and a touchscreen-optimized interface. It was based on available input devices—particularly on 2-in-1 PCs. Both interfaces include an updated Start menu which incorporates elements of Windows 7’s traditional Start menu with the tiles of Windows 8. The first release of Windows 10 also introduces:

- A virtual desktop system
- A window and desktop management feature called Task View
- Microsoft Edge web browser
- Support for fingerprint and face recognition login
- New security features for enterprise environments
- DirectX 12 and WDDM 2.0 to improve the operating system’s graphics capabilities for games.

**Start, Shutdown, Restart and Desktop Icons**

The Windows 10 Getting Start app offers a short guided tour to Windows app. Click the Start button and click the Get Started icon (shown here) from the Start menu.

The app fills the screen, as shown.

The new Get Started app offers a short introduction to Windows 10. It also includes a short introductory video.

Like most apps, the Get Started app lists icons along the left edge. If you cannot see the icons’ labels then click the hamburger menu icon (shown in the margin) in the app’s upper-left corner. Clicking that icon in any app expands the app’s left pane, letting you see labels next to the mysterious icons.

Click the Power button at the bottom of the left column, and Windows will at the very least display options to **Shut down** and **Restart**.
Desktop Icons

Your desktop icons may be hidden. To view them, right-click (or press and hold) the desktop, select View and select Show desktop icons. To add icons to your desktop such as This PC, Recycle Bin and more:

1. Select Start > Settings > Personalization > Themes > Desktop icon settings.
2. Under Desktop Icons, check the boxes next to the icons you would like to have appear on your desktop.
3. Select Apply and OK.

4. Note: You may not be able to see your desktop icons properly if you are in tablet mode. You can find the program by searching for the program name in File Explorer. To turn off tablet mode, select action center on the taskbar (next to date and time), and then select Tablet mode to turn it on or off.

Files and Folders: Finding, Renaming, Copying

Find your files in Windows 10 using one of these methods.

- Search from the taskbar. Type the name of a document (or a keyword from it) into the search box on the taskbar, then select Find results in documents at the top of the search results pane. You will see results for documents across your PC and OneDrive.
• **Search File Explorer.** Open **File Explorer** from the taskbar or **Start** menu, then select a location from the left pane to search or browse. For example, select **This PC** to look in all devices and drives on your computer, or select **Documents** to look only for files stored there.

• To add an icon for This PC to your desktop: Select **Start** > **Settings** > **Personalization** > **Themes** > **Desktop Icon Settings**. In the pop-up window, select the check box next to **Computer** > **Apply** > **OK**

**Folders**

It is needless to say the importance of folder system. Folder Options is an important aspect in Windows operating system. Folders are the building blocks of file organization and storing. Most users are expected to know how to access Folders and open the folder option, but in case you do not know, we are there for you. You can do multiple things with folder, copy files from one folder to another, delete items from a folder, hide a folder and show that hidden folder. We are discussing some easy steps which you may find helpful.

**Opening Folder Options in Windows 10**

1. Open the File Explorer.
2. Tap on View and click on Options.

3. If you want to open folders in just a single click, then select the single click option. By default opening folders with double click is enabled.

4. Under View Tab, you can enable options by reading them. For e.g. you can hide hidden folders or show them. Similarly you can disable thumbnail views and many more. In case you want to go back to default settings, just hit Restore Defaults.
5. The search folder will help you how you would like to search items from your computer. Since search is an important and prominent feature in Windows 10, so checking right options is very important. We recommend to keep the default settings.

Renaming a Folder in Windows 10

Press Enter or click the desktop when you are through, and you are off. Or you can click the filename or folder name to select it, wait a second, and click the name again to change it.

Using shortcuts to rename files or folders

Some people click the name and press F2; Windows automatically lets you rename the file or folder.

Renaming multiple folders

1. Start Windows Explorer. To do so, click Start, point to All Programs, point to Accessories, and then click Windows Explorer.
2. Select multiple files in a folder. ...
3. After you select the files, press F2.
Type the new name, and then press ENTER.

Copying a file or folder

1. If you are using Windows 10, click or tap the Start button and choose the File Explorer button from the left-hand side. It is the one that looks like a folder.
Windows 8 users can search for This PC from the Start screen.
Tip: Both versions of Windows also support opening File Explorer or This PC with the Windows Key + E keyboard shortcut.

2. Find the folder where that the file is located by double-clicking any folders or subfolders necessary until you reach the file.

   If your file is located on a different hard drive than your primary one, click or tap This PC from the left-hand side of the open window and then choose the correct hard drive. If you don’t see that option, open the View menu at the top of the window, choose Navigation pane, and finally click or tap the Navigation pane option in that new menu.

   Note: If you’re given a permissions prompt that says you need to confirm access to the folder, just continue through.

   Tip: It’s likely that your file is located deep inside several folders. For example, you might have to first open an external hard drive or disc, and then two or more subfolders before you reach the file that you want to copy.

3. Click or tap just once on the file that you want to copy. The file will become highlighted.

   Tip: To copy more than one file at once from that folder, hold down the Ctrl key and select each additional file that should be copied.

4. With the file(s) still highlighted, access the Home menu at the top of the window and select the Copy option. Anything you just copied is now stored in the clipboard, ready to be duplicated elsewhere.

5. Navigate to the folder where the file should be copied to. Once there, open the folder so that you can see any files or folders that already exist inside (it might even be empty).

   Note: The destination folder can be anywhere; on a different internal or external hard drive, DVD, in your Pictures folder or on your Desktop, etc. You can even close out of the window where you copied the file, and the file will remain in your clipboard until you copy something else.

6. From the Home menu at the top of the destination folder, click/tap the Paste button.

   Note: If you’re asked to confirm the paste because the folder requires administrator permissions to paste files, go ahead and provide that. This just means that the folder is considered important by Windows, and that you should be careful when adding files there.

   Tip: If you chose the same folder that has the original file, Windows will either automatically make a copy but will append the word “copy” to the end of the file name (just before the file extension) or ask you to either replace/overwrite the files or skip copying them.
7. The file selected from Step 3 is now copied to the location you chose in
   Step 5.
   Remember that the original file is still located where it was when you copied
   it; saving a new duplicate did not affect the original in any way.

Directory Tree

It is a hierarchy of directories that consists of a single directory. It is called the
parent directory or top level directory, and all levels of its subdirectories.

Steps to export directory tree of a folder in Window 10

1. Navigate to the folder and select it.
2. Press Shift, right-click mouse, and select “Open command window here”.
3. In command prompt, type tree/f/a > tree.txt and press Enter.
4. Open “tree.txt” file in MS Word.
5. The dialog box “File Conversion - tree.txt” will open.
6. For “Text encoding” tick the “MS-DOS” option and press Ok.

Drives

Mounting a drive in Windows 10

Use the Windows key + X keyboard shortcut to open the Power User menu and
select Disk Management. Right-click the new empty drive you want to mount as
a folder and select New Simple Volume. Select the “Mount in the following empty
NTFS folder” option and click Browse.

Partitioning a hard drive

1. Search “hard disk partitions” at the Start Menu or Search tool. Enter into
   the Windows 10 Disk Management interface.
2. Right-click hard disk and select “Shrink Volume”. Enter the amount of space
   you want to shrink in MB as shown below then click on the Shrink button.

Disk management

1. Right-click the bottom-left corner (or Start button) on the desktop to open
   Quick Access Menu, and then choose Disk Management.
2. Use Windows+R to open Run, type diskmgmt.msc in the empty box and
   tap OK.
3. Open Disk Management in Computer Management.
Placing and Sizing of Windows 10

Right-click on the Taskbar and choose Cascade. This will put the window on the screen. Stretch the window out to the desired size and close it. It should open that size next time.

Using Shortcuts

Copy, paste, and other general keyboard shortcuts

<table>
<thead>
<tr>
<th>Press this key</th>
<th>To do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ctrl + X</td>
<td>Cut the selected item</td>
</tr>
<tr>
<td>Ctrl + C (or Ctrl + Insert)</td>
<td>Copy the selected item</td>
</tr>
<tr>
<td>Ctrl + V (or Shift + Insert)</td>
<td>Paste the selected item</td>
</tr>
<tr>
<td>Ctrl + Z</td>
<td>Undo an action</td>
</tr>
<tr>
<td>Alt + Tab</td>
<td>Switch between open apps</td>
</tr>
<tr>
<td>Alt + F4</td>
<td>Close the active item, or exit the active app</td>
</tr>
<tr>
<td>Windows logo key + L</td>
<td>Lock your PC</td>
</tr>
<tr>
<td>Windows logo key + D</td>
<td>Display and hide the desktop</td>
</tr>
<tr>
<td>F2</td>
<td>Rename the selected item</td>
</tr>
<tr>
<td>F3</td>
<td>Search for a file or folder in File Explorer</td>
</tr>
<tr>
<td>F4</td>
<td>Display the address bar list in File Explorer</td>
</tr>
<tr>
<td>F5</td>
<td>Refresh the active window</td>
</tr>
<tr>
<td>F6</td>
<td>Cycle through screen elements in a window or on the desktop</td>
</tr>
<tr>
<td>F10</td>
<td>Activate the Menu bar in the active app</td>
</tr>
<tr>
<td>Alt + F8</td>
<td>Show your password on the sign-in screen</td>
</tr>
<tr>
<td>Alt + Esc</td>
<td>Cycle through items in the order in which they were opened</td>
</tr>
<tr>
<td>Alt + underlined letter</td>
<td>Perform the command for that letter</td>
</tr>
<tr>
<td>Alt + Enter</td>
<td>Display properties for the selected item</td>
</tr>
<tr>
<td>Alt + Spacebar</td>
<td>Open the shortcut menu for the active window</td>
</tr>
<tr>
<td>Alt + Left arrow</td>
<td>Go back</td>
</tr>
<tr>
<td>Alt + Right arrow</td>
<td>Go forward</td>
</tr>
<tr>
<td>Alt + Page Up</td>
<td>Move up one screen</td>
</tr>
<tr>
<td>Alt + Page Down</td>
<td>Move down one screen</td>
</tr>
<tr>
<td>Ctrl + F4</td>
<td>Close the active document (in apps that are full-screen and let you have multiple documents open at the same time)</td>
</tr>
</tbody>
</table>
Ctrl + A
Select all items in a document or window

Ctrl + D (or Delete)
Delete the selected item and move it to the Recycle Bin

Ctrl + R (or F5)
Refresh the active window

Ctrl + Y
Redo an action

Ctrl + Right arrow
Move the cursor to the beginning of the next word

Ctrl + Left arrow
Move the cursor to the beginning of the previous word

Ctrl + Down arrow
Move the cursor to the beginning of the next paragraph

Ctrl + Up arrow
Move the cursor to the beginning of the previous paragraph

Ctrl + Alt + Tab
Use the arrow keys to switch between all open apps

Alt + Shift + arrow keys
When a group or tile is in focus on the Start menu, move it in the direction specified

Ctrl + Shift + arrow keys
When a tile is in focus on the Start menu, move it into another tile to create a folder

Ctrl + arrow keys
Resize the Start menu when it’s open

Ctrl + arrow key (to move to an item) + Spacebar
Select multiple individual items in a window or on the desktop

Ctrl + Shift with an arrow key
Select a block of text

Ctrl + Esc
Open Start

Ctrl + Shift + Esc
Open Task Manager

Ctrl + Shift
Switch the keyboard layout when multiple keyboard layouts are available

Ctrl + Spacebar
Turn the Chinese input method editor (IME) on or off

Shift + F10
Display the shortcut menu for the selected item

Shift with any arrow key
Select more than one item in a window or on the desktop, or select text in a document

Shift + Delete
Delete the selected item without moving it to the Recycle Bin first

Right arrow
Open the next menu to the right, or open a submenu

Left arrow
Open the next menu to the left, or close a submenu

Esc
Stop or leave the current task

NOTES
Computer Software
5.3 LINUX

Linux is UNIX-like computer operating system assembled under the model of free and open source software development and distribution. The kernel of this operating system was first released in 1991 by Linus Torvalds. Linux system distributions may vary in terms of system operation, configuration and software package selections. Linux runs on a wide variety of computer hardware including mobile phones, tablet computers, network routers, televisions, video game consoles, desktop computers, mainframes and supercomputers. Linux is a leading server operating system. This operating system is packaged in a format known as a Linux distribution for desktop and server use. Some popular Linux distributions include Debian, Ubuntu, Fedora and openSUSE. Linux distributions include the Linux kernel supporting utilities and libraries and usually a large amount of application software to fulfill the distribution’s use. A distribution oriented toward desktop use may include the X Window System, the GNOME and K Desktop Environment or KDE Plasma desktop environments. A distribution intended to run as a server may omit any graphical environment from the standard install and instead include other software, such as the Apache HyperText Transfer Protocol or HTTP Server and a Secure Shell or SSH server like OpenSSH. Because Linux is freely redistributable, it is possible for anyone to create a distribution for any intended use. Commonly used applications with desktop Linux systems include the Mozilla Firefox Web browser, the OpenOffice.org or LibreOffice office application suites, and the GNU Image Manipulation Program or GIMP image editor. The main supporting user space system tools and libraries from the GNU Project are the foundation for the Free Software Foundation’s preferred name GNU/Linux. The other features of Linux operating system are discussed in subsequent sections:

History of Linux

After its first launch, a number of people worked for the development of UNIX and as a result, UNIX variants are available for all types of computers. From personal computers to mainframe and also super computers, UNIX is available in one or more variants, such as HP-UX, SCO UNIX, Minix, etc. Linux was developed with the help of many UNIX programmers and wizards across the Internet allowing anyone with enough know-how and ability to develop and change the system. An important point to note is that the Linux kernel uses no code from American telephone & Telegraph AT&T or any other proprietary source. Linux is developed by the GNU project at the Free Software Foundation in Cambridge, Massachusetts. Therefore, programmers all over the world have been able to contribute to the growing pool of Linux software. The very early development of Linux dealt mostly with task-switching features of the 80386 protected-mode interface, all written in assembly code as quoted by Linux. It is also a fact that there was no announcement for the Linux Version 0.01. The 0.01 sources were
not even executable, they contained only the bare rudiments of the kernel source and assumed that you had access to a Minix machine to compile and play along with them. It was on October 5, 1991 that Linus Torvalds announced the first ‘official’ version of Linux, Version 0.02. At this point, Linus was able to run bash (the GNU Bourne Again Shell) and gcc (the GNU C compiler). At that time the primary focus was kernel development, none of the issues of user support, documentation, distribution, and so on had been addressed. Even today, the Linux community still seems to treat these ergonomic issues as secondary to the ‘real programming’, i.e., kernel development. Soon after version 0.03, there were versions numbering up to 0.10, as more people started to work on the system. After several further revisions, Linus increased the version number to 0.95, to reflect his expectation that the system was ready for an ‘official’ release very soon. Today, Linux is a complete UNIX clone, capable of running X Windows, TCP/IP, Emacs, UUCP (UNIX to UNIX Copy Protocol), mail and news software. Almost all of the major free software packages have been ported to Linux, and supported commercial software is becoming available. Much more hardware is supported than in the original versions of the kernel. Many people have executed benchmarks on 80486 Linux systems and found them comparable with mid-range workstations from Sun Microsystems and Digital Equipment Corporation. This ‘little’ UNIX clone have grown up to take on the entire world of personal computing.

Basics of Linux Operating System

After its first launch, thousands of programmers and users got attracted towards Linux. Today, we can say that Linux is the first choice of millions of people all over the globe. It is different from other operating systems as it comes with a host of positive developments. This is because of what Linux offers to users and programmers, such as scalability, security, consistency, user friendliness, freedom and non-pirated enterprise software. Many of the advantages of Linux are an aftermath of its origins, deeply rooted in UNIX.

Linux is Free: Linux is a freely distributable operating system. Here, free implies the freedom to work. You can download the Linux for free from Internet, without registration and without going into per user per year kind of licensing. You are free to use, free to customize, free to modify, free to distribute and also free to brand your modified variant. Modification is possible because its source code is freely available. This makes the Linux free. It has already been explained that no licensing is required for Linux. Again, this does not mean that there is no license. Like any other software Linux also has a license. Linux comes with GNU Public License (GPL). The license states that anybody who may want to use and apply Linux can do so. Anybody has the right to change Linux and eventually redistribute a changed version, on the condition that he makes available the code after redistribution. In other words, we can say that you are always free to grab a kernel image for any of your functionality as long as your client can still have a copy of that code.
Linux is Hardware Independent: Linux is compatible with nearly all available hardware. As mentioned in the previous section, its source code is freely downloadable and that also comes with the GPL license, you are free to follow the documentation available and customize so as to work with your unsupported hardware. This makes the Linux hardware independent.

Linux is Secure: Linux has proven, beyond doubt, the sound security level it offers. This security aspect is the key feature of Linux and its security model is entirely based on UNIX which we all know is very robust and of proven quality. In Linux, security is not only restricted to the security from Internet threats but it is also very much secure from other system related breaches or malpractices. Linux offers security at all levels, such as User level, Application level, System level, Device level, Inner threats and External threats.

Linux is Scalable: When Linux was in early phase, its creators wanted to make an operating system that was extensively suitable for any application, any hardware and any process. They wanted it to work with computers with high power and capacities like of super computers, mainframes, and with computers for personal use like PCs, laptops and even with computers of limited resources like Palmtop, Personal Digital Assistant or PDAs, etc., so that Linux fits everywhere.

Linux as Multi-user System

The term multi-user system denotes operating system or application software in which concurrent access is possible by many users on a computer system. This is also known as time-sharing. There are many systems for batch processing in mainframe computers that can also be termed as 'multi-user'. The concept has come from the fact that CPU is much faster than any peripheral device and CPU remains idle when certain input/output operations are awaited. This multi-user concept combined with multi-tasking ensures maximum utilization of CPU. Thus, a multi-user operating system provides an infrastructure for many users for using the same computer simultaneously and/or at different times. UNIX and Linux are such operating systems that are multi-user. Linux is used as a generic term that refers to UNIX-like operating systems having Linux kernel. An operating system contains a set of software packages for managing interactions with hardware parts of the operating system. The three essential elements are, Kernel for performing the basic functions of managing process, memory, files, inputs/outputs as well as functionality for communication; shell that allows communication with OS using a language for control by which user is able to control the computer hardware without knowledge of hardware and file system that allows information to be recorded as files in a tree-like structures. In a multi-user environment, a Linux PC can be connected to many terminals such that every user gets an impression that he/she using is a standalone computer. During start up, a UNIX/Linux initializes and booting process first and comes to a single user mode and then it goes to multi-user mode. In Linux, control flows from Basic Input/Output System or BIOS to boot loader and then to kernel. It is kernel that starts the scheduler that in turn starts a process
to enable multi-tasking and runs first userland program ‘init’ that lies outside the kernel space. This program (init) sets up user environment allowing users to interact with computer after logging on. Then, kernel becomes idle but becomes active only when called by user externally. Following actions are done in the start up and moving to multi-user environment:

1. BIOS, takes startup tasks that are specific to hardware-platform.
2. After recognizing the hardware BIOS loads and then executes the code for partition boot from the boot device that is designated and it contains first phase of the Linux boot loader. This loads the second phase that contains boot loader code.
3. This boot loader presents a menu for the user for booting options. Operating system is then loaded into memory, setting up essential hardware and memory paging and then calls start_kernel().
4. This called function start_kernel() performs main system setup. This starts the ‘init’ process.
   In Linux, init (initialization) is a program for UNIX-based computer operating systems that generates all other processes. It runs as a Daemon. The init process is the last step in the boot procedure and identified by Process ID or PID 1. This (init) process is never shut down.
5. After this, scheduler takes over the control for managing the system and multi-user functionality is given. Kernel becomes idle and wakes up only on call.
6. The ‘init’ process has responsibility of executing scripts as may be needed to set up all services and structures that are non-operating and allows creating user environment giving them a login screen in a multi-user environment.

Linux as Multitasking Operating System

Multitasking is, in fact, considered as the logical extension of multiprogramming. It maintains to control the operating system infrastructure in various levels. The levels in Linux OS perform task management in which multitasking process runs in server environment. Many applications can be opened up at the same time as requested by various clients. The data management keeps track of disk, tape and other storage devices in level of Linux OS. The operating system decides where the system files are physically stored in memory that can be sometimes accessed by programming interfaces. Levels also decide the device management by sending the commands. Each device can have a driver. If new peripheral is added to the OS at this level, the device driver is positively installed into the Linux OS. This OS might support optional interfaces both graphical and command line. The shell part of OS gives variations in functionality. Security feature is also decided to protect from unauthorized user. The recovery in system crashing and backup of files are gained over in this design technique. Various modules are decided in the levels of
designing interface. Multitasking use two or more than two CPUs assembled in single system unit. It refers the execution of various software processes concurrently. Cache coherency issue is solved by multitasking systems. The processors, for example Pentium Pro II, Power PC 603 and 604, digital Alpha keep cache in multitasking to solve the problem of cache coherence. These processors contain two, four and even eight processors within memory bus to share the memory problems. Large multitasking share a single bus to transmit the data directly from cache so that modified data aborts transaction to write back the system memory for next transaction whereas original requester of data re-arbitrates data from the memory. The two types of multitasking are known as shared memory type multitasking and distributed memory type multitasking. The main memory is directly accessed by the assembled processors in multitasking system is known as shared memory multitasking in which the shared portion belongs actually to main memory referred to as global memory. Cache is used for this and known as high speed buffer at exist with almost each processor. In fact, data and instructions are accessed from local memory and global memory that is used by Internetworking facility. Distributed memory type has own private memory. Various processors involved in shared memory type access the same variables at a time that can be referenced for data integrity. But in distributed memory a computational task is distributed for multiple processors involving distinct memory stack to reassemble the produced result. Multitasking uses large caches but limited processors that shares single memory bus. The examples of OS supporting multitasking are UNIX, Linux, Windows 2000, etc. The various functions are performed in multitasking as follows:

**Speed:** Multitasking supports fast processing to perform the task. Speed is decided in multiprocessor by a large number of components, for example, Pre-shared Key PSK1, or Set Storage Key or SSK, PSK etc. These systems components are connected with every serial system bus maintain the consistency of cache for high speed bus (SB1, SBn-1, SBn) etc.

**Memory Organization:** Multitasking manages the memory organization which is actually centralized in which bus uses large cache and effective way of scaling the memory bandwidth. It uses shared and distributed memory organization using at least 2-8 processors.

**Efficient System-on-Chip:** Multiprocessor includes embedded processors, mixed signal circuits and digital logic techniques to make an efficient system-on-chip because all together are combined to make heterogeneous multiprocessors.

**Thread-Level Parallelism:** The multitasking process executes reentrant programs for multiple processes known as multithreading. These programs are necessary to run the thread. Basically, it refers to two threads that execute the same code simultaneously. The programs are not thread-safe if programs with embedded data are not reentrant. The programs can be made as reentrant by
removing the embedded data and allocated it for each execution in the multiprocessors. The most versions of MS DOS are not reentrant but in the object oriented programs, the data area of each object is allocated heap store. Therefore, they are automatically thread-safe and hence reentrant.

Running Preemptive Task: The multitasking OS runs with preemptive tasks. These tasks support it to access the I/O devices, memory management and kernel services.

In the multitasking operating system, the arrangement of memory modules is as follows:

- The system unit contains $m$ memory modules and $p$ processors.
- Each processor sends requests so that they can get information from memory module.
- Memory modules are synchronized that means two modules can get requests at the same time because memory access performs task in one time unit, i.e., one complete memory cycle.
- Memory module can work one request at a time. If more than one request is tagged with at a time, they are to be queued when memory cycle starts.

Multitasking works with a number of processors in which virtual storage space is assigned for redundant execution. Each processor is assembled to write the data. The memory is allotted with each processor which keeps the address of its own memory and full bandwidth of local memory without involving interference of the other processor. There is no limit for number of processors. The memory capacity in system is constrained because the connecting processors are used in network. The distributed memory multitasking do not encounter cache coherency problems. Each processor is worked with its own data. It keeps the data in local cache because data can be referenced by other processors. One main drawback of this type of multitasking is that inter-processor communication task becomes very complex because if one processor needs other processor memory the message must be exchanged with each other which introduces two types of overhead. First overhead takes time to prepare and construct the message from one processor to other and second overhead refers to receiving processor that is in fact interrupted if one message is shared from one processor to other processors. Concurrent programming, semaphore monitoring, etc., are various techniques which are not directly applicable because they are implemented by a layered software approach. For example, if message is passed from one processor to other, it uses semaphore programming. The need of mutual exclusion in the operating system is to implement the semaphores but few machine instructions are busy to accept it. The process blocking is required in operating system calls at this design phase. The name servers are expensive to broadcast in a network if name resolves to this but at this level, name servers and global names use hierarchy that are basically local unique names. The solution for mutual exclusion is simple that generalizes to $N$ number of processes.
Multiple Processes and Multitasking

Multitasking means multiple processes (tasks). The processes can be referred to as e-mail, Web server, antivirus, running Word processor, etc.

E-mail and Linux

E-mail is an electronic medium through which the message can be sent or received from one user to another. A small edit area is provided to write the message. To send an e-mail you need to log in as root and type the name of user to whom you want to send e-mail message. You can type the following command:

```
mail richa
```

The Linux OS prompts you with Subject: then you need to press ENTER key to type the message. The Ctrl+D key combination is used to send the message. The ENTER key is pressed to get a new line. Screen shows the sample session of e-mail message.

Word Processor and Linux

WordPerfect for Linux requires a powerful workstation to run on that recommends at least 64-MB of RAM along with 450-MB of hard disk space.
Antivirus and Linux

Viruses are frequently transmitted through e-mail attachments, peer-to-peer downloads, phishing (a fraudulent process to obtain a user’s credentials) and instant messages. Among these, e-mail attachments carry and spread virus the fastest in an address book or a random combination of such address books. If these viruses are not controlled quickly, they can negate the functioning of servers and hence disrupt the e-mail services to all systems. The antivirus software available in the market to deal with virus-related issues are Symantec Antivirus (used to check the security of foreign programs and applications), Windows Vista Antivirus Spyware Antivirus Norton Antivirus (used to catch worms, rootkits, spywares, viruses etc.), Avast Antivirus, and Kaspersky Antivirus (used for HTTP traffic-checking and for providing a security wizard).

These antiviruses are useful for those types of viruses that are downloaded from the Internet or from e-mail attachments. The most popular antivirus programs are Data Fellows F-Prot, EliaShim VinuSafe, ESaSS ThunderBYTE, IBM Antivirus, McAfee Scan, Microsoft Anti Virus, Symantec Norton Antivirus and S&S Dr Solomon's AVTK.

Web Server and Linux

The Web follows the client-server mechanism for the purpose that a client program gets required information from the server. Then the server sends the requested data to the Internet through the browser. The requested data is then interpreted and displayed on the screen. The process can be explained in the following steps:

- The very first step is to open a Web browser, for example Netscape or IE.
- The requested page is opened on the Web if you type the corresponding URL in the address bar.
- The URL then extracts the necessary information for the requested page via transfer protocol, for example HTTP.
- The Web server then transmits the requested pages sent by the clients and displays the information.

The Web browser receives the HTML text as per the page that has been requested.
In Figure 5.2, you can find that multitasking uses dual core systems in which multitasking operating system uses two tasks simultaneously.

**Fig. 5.2 Features of Multitasking Operating**

### 5.4 SYSTEM AND APPLICATION SOFTWARE

A computer cannot operate without any instructions and is based on a logical sequence of instructions in order to perform a function. These instructions are known as a computer program and constitute the computer software. The sequences of instructions are based on algorithms that provide the computer with instructions on how to perform a function. Thus, it is impossible for a computer to process without a software, a term attributed to John W. Tukey in 1958.

Different kinds of software designs have been developed for particular functions. Popular computer software include interpreter, assembler, compiler, operating systems, networking, word processing, accounting, presentation, graphics, computer games and so on. The computer software is responsible for converting the instructions in a program into a machine language facilitating their execution.

**Fig. 5.3 Interaction of Software between User and a Computer System**

Software engineers develop computer software depending on basic mathematical analysis and logical reasoning. Before implementation, the software
undergoes a number of tests. Thus, the programming software allows you to develop the desired instruction sequences, whereas, in the application software the instruction sequences are predefined. Computer software can function from only a few instructions to millions of instructions; for example, a word processor or a Web browser. Figure 5.3 shows how software interacts between user and computer system.

Types of Computer Software

On a functional basis, software is categorized as follows:

- **System Software**: It helps in the proper functioning of computer hardware. It includes device drivers, operating systems, servers and utilities.
- **Programming Software**: It provides tools to help a programmer in writing computer programs and software using various programming languages. It includes compilers, debuggers, interpreters, linkers, text editors and an Integrated Development Environment (IDE).
- **Application Software**: It helps the end-users to complete one or more specific tasks. The specific applications include industrial automation, business software, computer games, telecommunications, databases, educational software, medical software and military software.

Types of Computer Software

Today, software is a significant aspect of almost all fields including business, education, medicine and various others. The basic requirement for software is a distinct set of procedures. Thus, software can be used in any domain that can be described in logical and related steps, and every software is developed with the aim of catering to a particular objective, such as data processing, information sharing and communication. Software is based on the type of applications that are as follows:

- **System Software**: This type of software is involved in managing and controlling the operations of a computer system. System software is a group of programs rather than one program and is responsible for using computer resources efficiently and effectively. Operating system, for example, is system software, which controls the hardware, manages memory and multitasking functions, and acts as an interface between applications programs and the computer.
- **Real-Time Software**: This is based on observing, analysing and controlling real-life events as they occur. Manually, a real-time system guarantees a response to an external event within a specified period of time. The real-time software, for instance, is used for navigation in which the computer must react to a steady flow of new information without interruption. Most defence organizations all over the world use real-time software to control their military hardware.
• **Business Software:** This kind of software is functional in the domain of management and finance. The basic aspect of a business system comprises payroll, inventory, accounting and software that permits users to access relevant data from the database. These activities are usually performed with the help of specialized business software that facilitates efficient framework in the business operation and in management decisions.

• **Engineering and Scientific Software:** This software has developed as a significant tool used in the research and development of next generation technology. Applications, such as study of celestial bodies, study of undersurface activities and programming of orbital path for space shuttle, are heavily dependent on engineering and scientific software. This software is designed to perform precise calculations on complex numerical data that are obtained during real-time environment.

• **Artificial Intelligence (AI) Software:** Certain problem solving techniques are non-algorithmic in nature and primarily require this type of software. The solutions to such problems normally cannot be arrived at using computation or straightforward analysis. Such problems need particular problem solving techniques including expert system, pattern recognition and game playing. Also, it constitutes various kinds of searching techniques, such as the application of heuristics. The function of AI is to add certain degree of intelligence into the mechanical hardware to have the desired work done in an agile manner.

• **Web-based Software:** This category of software performs the function of an interface between the user and the Internet. There are various forms in which data is available online, such as text, audio or video format, linked with hyperlinks. For the retrieval of Web pages from the Internet, a Web browser is used which is a Web-based software. The software incorporates executable instructions written in special scripting languages, such as Common Gateway Interface (CGI) or Active Server Page (ASP). Apart from providing navigation on the Web, this software also supports additional features that are useful while surfing the Internet.

• **Personal Computer (PC) Software:** This software is primarily designed for personal use on a daily basis. The past few years have seen a marked increase in the personal computer software market from normal text editor to word processor and from simple paintbrush to advance image editing software. This software is used mostly in almost every field, whether it is database management system, financial accounting package or a multimedia based software. It has emerged as a versatile tool for daily life applications.

Software can also be classified in terms of the relationship between software users or software purchasers and software development.

• **Commercial Off-The-Shelf (COTS):** This comprises the software without any committed user before it is put up for sale. The software users have less or no contact with the vendor during development. It is sold through retail
Computer Software

- **Customized or Bespoke**: This software is designed for a specific user, who is bound by some kind of formal contract. Software developed for an aircraft, for example, is usually done for a particular aircraft making company. They are not purchased “off-the-shelf” like any word processing software.

- **Customized COTS**: In this classification, a user can enter into a contract with the software vendor to develop a COTS product for a special purpose, that is, software can be customized according to the needs of the user. Another growing trend is the development of COTS software components, i.e., the components that are purchased and used to develop new applications. The COTS software component vendors are essentially parts stores which are classified according to their application types. These types are listed as follows:
  - **Stand Alone Software**: A software that resides on a single computer and does not interact with any other software installed in a different computer.
  - **Embedded Software**: A software that pertains to the part of unique application involving hardware, like automobile controller.
  - **Real-Time Software**: In this type of software, the operations are executed within very short time limits, often microseconds, e.g., radar software in air traffic control system.
  - **Network Software**: In this type of software, software and its components interact across a network.

Figure 5.4 illustrates the various types of customized COTS.

![Fig. 5.4 Types of Customized COTS](image)
System Software

System software constitutes all the programs, languages and documentation provided by the manufacturer in the computer. These programs provide the user with an access to the system, so that he can communicate with the computers and write or develop his own programs. The software makes the machine user-friendly and makes an efficient use of the resources of the hardware. System software are permanent programs on a system and reduce the burden of the programmer as well as aid in maximum resource utilization. MS DOS (Microsoft Disk Operating System) was one of the most widely used systems software for IBM compatible microcomputers. Windows and its different versions are popular examples of systems software. Systems software are installed permanently on a computer system and used on a daily basis.

Classification of an Operating System

An Operating System (OS) is the main control program for handling all other programs in a computer. The other programs, usually known as application programs, use the services provided by the OS through a well-defined Application Program Interface (API). Every computer necessarily requires some type of operating system that instructs the computer about operations and use other programs installed in the computer. The role of an OS in a computer is similar to the role of the manager in an office for the overall management of the college.

Any computer system can be broadly classified in terms of four component dimensions:

(i) Hardware
(ii) Operating system
(iii) Application programs (like MS Word, Games, Calculator)
(iv) Users (people who work on the computer)

Figure 5.5 displays the various components of the computer system.

Components of an Operating System

An operating system has three primary components:

1. **Control Programs**: As the name implies, these control and maintain the operations of a computer. There Initial Program Loader (IPL) is located in
the form of firmware and is stored in the Read Only Memory (ROM) section of the Memory Unit. When the computer is switched on, the electronic chip is automatically activated and the IPL reads the Boot Sector Routine (BSR), which resides in the primary memory of the computer.

2. **System Service Programs**: These support the control programs. Each of these is divided into three portions: Linkage Editor, librarian and input/output control system.

   A linkage editor is an editor program that establishes a single module from many modules by resolving cross-references among the modules.

3. **Utility Programs**: These programs run on the operating system in order to carry out various user related commands to manage the software linking the user and the operating system. In MS DOS, for example, the utility programs are FDISK, FORMAT, ATTRIB, BACKUP, FIND and others.

   **Booting Process**: In computing, a bootstrapping process called booting (booting up) starts the OS when the computer system is switched on. The first set of operations performed by the computer when switched on is called boot sequence. The main operating system for the computer is loaded by the bootloader.

   One can boot an operating system in two conditions: (i) Where there is a single OS installed, and (ii) Where there are multiple OSs installed on the computer.

   1. **Utilities**: Utilities are useful software for the smooth working of the computer. These software will assist the user to perform activities, like editing a text file, backing up data, removing the outdated files, recovering the data and protecting the computer from virus. Most of these utilities are also available along with the operating system. Utilities are also available separately. A few utilities are discussed as follows:

      **Text Editors**: Text editors are used to text from keyboard and save in a storage media. The text stored can be retrieved, modified, and printed.

      **Antivirus Programs**: Antivirus programs are used to protect your computer from virus. Computer virus is nothing but a computer program which will rearrange the stored data or programs in such a way that the user will not be able to use it. The virus programs make the computer work abnormally. Some virus programs called friendly virus programs will not cause any damage to the data or hardware. Other viruses will cause heavy damage to the resources and the hardware.

      The antivirus program scans the storage devices checking for virus. Antivirus programs are also available to protect the computer online.

      **Language Processors**: A language processor is a system program that converts the English-like instructions used by computer programmers into the machine-readable code used by the hardware. Programs written in languages, such as C, C++, Pascal, BASIC, FORTRAN, or COBOL must be converted into the appropriate machine language.
Assembler, interpreter and compiler are language processors. An assembler converts an assembly language program into machine language. An interpreter converts a high-level language program line by line into a machine language. The machine language program is called object program. A compiler also converts an error-free high-level language program into object program, however, in one step.

Operating systems are discussed in detail in the next section of this unit.

**Application Software**

Users install specific software programs based on their requirements; for instance, accounting software (like Tally) used in business organizations and designing software used by architects. All programs, languages and utility programs constitute software. With the help of these programs, users can design their own software based on individual preferences. Software programs aid in achieving efficient application of computer hardware and other resources.

A few types of application programs that are widely accepted these days are:

1. **Word Processing**

A word processor is an application program used for the production of any type of printable text document, including composition, editing, formatting and printing. It takes the advantage of a Graphical User Interface (GUI) to present data in a required format. It can produce any arbitrary combination of images, graphics and text. Microsoft Word is the most widely used word processing system.

Microsoft Word can be used for the simplest to the most complex word processing applications. Using Word, you can write letters and reports, prepare bills and invoices, prepare office stationery, such as letterheads, envelopes and forms, design brochures, pamphlets, newsletters and magazines, and so on.

2. **Spreadsheet**

Microsoft Excel is the most commonly used spreadsheet. It is ideal for a task that needs a number of lists, tables, financial calculations, analysis and graphs. Excel is good for organizing different kinds of data, however, it is numerical data that is best suited. Thus, Excel can be used when you not only need a tool for storing and managing data, but also analysing and querying it. In addition to providing simple database capabilities, Excel also allows you to create documents for the World Wide Web (WWW).

The menus, toolbars and icons of MS Excel are very similar (though not the same) to MS Word. This is in keeping with Microsoft’s much hyped philosophy and strategy of offering users a totally integrated office suite pack. From the user’s point of view, this means less time spent in learning the second package once you know the first, and almost effortless and seamless exchange of data between various components.
3. Presentation Graphics

PowerPoint is a presentation tool that helps create eye-catching and effective presentations in a matter of minutes. A presentation comprises individual slides arranged in a sequential manner. Normally, each slide covers a brief topic. The term ‘Free’ software specifies the freedom of using the software by various computer users (private individuals as well as organizations and companies) granting them freedom and control in running and adapting the computing and data processing as per their needs. The key objective of free software is to grant freedom rights to users so that the users are free to run, copy, distribute, study, change and improve the software. For example, you can use PowerPoint software for preparing presentations and adding notes to the specific slides. Similarly, you have the option of either printing the slides—in case you want to use an overhead projector, simply attach your computer to an LCD display panel that enlarges the picture several times and shows the output on a screen.

You have three options for creating a new presentation:

(i) Begin by working with a wizard (called the AutoContent Wizard) that helps you determine the theme, contents and organization of your presentation by using a predefined outline

(ii) Start by picking out a PowerPoint Design Template which determines the presentation’s color scheme, fonts and other design features

(iii) Begin with a completely blank presentation with the color scheme, fonts and other design features set to default values

If you decide to choose the third option, PowerPoint designers have provided a wide assortment of predefined slide formats and Clip Art graphics libraries. Through these predefined slide formats, you can quickly create slides based on standard layouts and attributes.

PowerPoint shares a common look and feel with other MS Office components, and having once mastered Word and Excel, learning PowerPoint is almost like playing a game. In addition, it is also easy to pick up data from Word and Excel directly into a PowerPoint presentation and vice versa.

4. Database Management Software

Nowadays, all large businesses require database management. When managing a large customer base, it is important to examine vital information, like the busying pattern, cheap suppliers and the number of orders being received. In order to efficiently manage all these functions, MS Access is required.

As a first step, plan and create your database structure, identify the required fields based on the type of data (numbers, alphanumeric, data, and so on), and the maximum width of each field. After determining the structure, you can create a table either in the design mode (which is customized), or you can use the table wizard and any of the predefined tables, with the required modifications.
Creating the tables through the table wizard is much faster and easier than through the design mode. However, if you use wizards you are somewhat restricted with the predefined settings already available.

Once you have created the table, you can then use the form’s wizard to create user-friendly and aesthetically pleasing layouts for data entry. Creating forms for data entry also ensures that the user inputs only the right kind of information and both data entry errors as well as typing work is minimized.

Once the forms have been created and relevant data has been entered, using these you can then use the report wizard to generate any kind of report. Using reports, you can not only organize and present your data in a more meaningful manner, but also use various standard functions, like subtotals, totals and sorting, to summarize your data.

Now to really fine-tune this access application, you can create data access pages to enable people spread over a large geographical area to share and compile information using the Internet.

**Licensed and Free Domain Software**

1. **Licensed Software**

   Although, there is a large availability of open source or free software online, not all software available in the market is free for use. Some software falls under the category of Commercial Off-The-Shelf (COTS). COTS is a term used for software and hardware technology which is available to the general public for sale, license or lease. In other words, to use COTS software, you must pay its developer in one way or another.

   Most of the application software available in the market need a software license for use.

   Software is licensed in different categories. Some of these licenses are based on the number of unique users of the software, while other licenses are based on the number of computers on which the software can be installed. A specific distinction between licenses would be an Organizational Software License, which grants an organization the right to distribute the software or application to a certain number of users or computers within the organization, and a Personal Software License which allows the purchaser of the application to use the software on his or her computer only.

2. **Free Domain Software**

   To understand this, let us distinguish between the commonly used terms: Freeware and Free Domain software. The term ‘freeware’ has no clear accepted definition, but is commonly used for packages that permit redistribution without modification.
This means that their source code is not available. Free domain software is software that comes with permission for anyone to use, copy, and distribute, either verbatim or with modifications, either gratis or for a fee. In particular, this means that the source code must be available. Free domain software can be freely used, modified, and redistributed but with one restriction that the redistributed software must be distributed with the original terms of free use, modification and distribution. This is known as ‘copyleft’. Free software is a matter of freedom, not price. Free software may be packaged and distributed for a fee. The ‘Free’ here refers to the ability of reusing it — modified or unmodified — as a part of another software package. The concept of free software is the brainchild of Richard Stallman, head of the GNU project. The best known example of free software is Linux, an operating system that is proposed as an alternative to Windows or other proprietary operating systems. Debian is an example of a distributor of a Linux package.

Free software should, therefore, not be confused with freeware, which is a term used for describing software that can be freely downloaded and used but which may contain restrictions for modification and reuse.

Check Your Progress

1. What are the two versions of windows 10?
2. Write a short note on Linux OS?
3. What is the function of artificial intelligence?

5.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Home and Pro are the two baseline editions.
2. Linux is UNIX-like computer operating system assembled under the model of free and open source software development and distribution. Linux is freely redistributable and it is possible for anyone to create a distribution for any intended use.
3. The function of AI is to add certain degree of intelligence into the mechanical hardware to have the desired work done in an agile manner.

5.6 SUMMARY

- Windows 10 is a personal computer operating system. It was developed and released by Microsoft as part of the Windows NT family of operating systems.
• Folders are the building blocks of file organization and storing.
• Linux is UNIX-like computer operating system assembled under the model of free and open source software development and distribution.
• The multitasking OS runs with Pre-emptive tasks. These tasks support it to access the I/O devices, memory management and kernel services.
• Multitasking means multiple processes. The processes can be referred to as e-mail, Web server, antivirus, running Word processor, etc.
• A computer cannot operate without any instructions and is based on a logical sequence of instructions in order to perform a function. These instructions are known as a computer program.
• System software is involved in managing and controlling of the operations of a computer system.
• Booting Process in computing, a bootstrapping process called booting (booting up) starts the OS when the computer system is switched on.

5.7 KEY WORDS

• System Software: It is a type of computer program that is designed to run a computer’s hardware and application programs.
• Business Software: This kind of software or set of computer programs is used by business users to perform various business functions.

5.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions
1. What are the features of Windows 10 in its first release?
2. Write the steps for renaming a folder in Windows 10.
3. What is licensed and free domain software?

Long-Answer Questions
1. Explain the advantages of Linux OS.
2. Describe Linux as multi-user system.
3. Explain different types of application and computer software.
5.9 FURTHER READINGS


UNIT 6  FILE ORGANISATION

6.0  INTRODUCTION

In this unit, you will learn about the advantages of database over file based systems and database models. A file based system allows access to single files or tables at a time. These system stored data in set of files. It contains flat files that have no relation to other files. In DBMS, all files are integrated into one system thus making data management more efficient by providing centralized control on the operational data. Data provides a schema that describes how a database is structured and used.

6.1  OBJECTIVES

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

- Understand file based system and database management system
- Explain the different types of data models

6.2  FILE BASED SYSTEMS AND DATABASES

File-Based Systems

Conventionally, before the database systems were introduced, data in software systems was maintained using files. In this approach, the needed data is stored...
locally and programs are developed for each type of application. The following terms are related to a file processing system:

- **Data**, which is raw facts, is provided to the computer in terms of bytes.
- **Data item** is the smallest named unit of data that has meaning in the real world. Examples include employee name, address and employee code. Traditionally, the term, data item, is called **field** in data processing and is the smallest unit of data that has meaning to its users. **Record** is a set of related data items (fields) organized in a well-defined structure treated as a unit by an application program. The structure of a record depends on:
  - Items to be included: their characteristics, variability, prevalence in file
  - The intended use(s) of the information: time requirements, overlapping or conflicting requirements
  - Update characteristics, for example frequency, growth, deletion and modification, time constraints, etc.
  - Links to other records/files/systems
  - Computing environment like operating system, languages, hardware, etc.
- **File** is a collection of all occurrences (instances) of similar types of records, i.e., it is a group of records of a single type.

In file-based systems, an organization stores information as groups of records in separate files. These file-based systems consist of a few data files and many application programs. Data files are organized to facilitate access to records and ensure their efficient storage. In a file-based system, there are two types of records—logical records and physical records. A logical record is a collection of related data items treated as a conceptual unit independent of how or where the information is stored. A physical record is a contiguous area of storage space defined by the characteristics of storage devices and operating systems and includes all the bytes, which will be read/written by a single command to the I/O device. A file processing system relies on the basic access methods of the host operating system for data management.

In a file processing system, it is possible for the application program to only make a request for data from the operating system by demanding a specific logical record. The relationship between physical and logical records and the location of the physical records in a specific file is kept track of by the operating system. Location of fields within the logical records is a activity that is take care of by the application program.

In a file processing system, a program takes less time to execute than an equivalent program written in a high-level language as algorithms for sort, merge and report generation are already in-built in the file management software. Besides, the cost of software development is less.
Such file-based approaches provide an improved automated data processing than earlier manual paper record-based systems. However, in view of demand for increased efficiency and speed, a file processing system suffers some significant disadvantages, which are as follows:

- **Data Redundancy and Inconsistency:** A major drawback in the traditional file system environment is non-sharing of data. It means if different systems of an organization are using some common data, even then instead of storing it once and sharing it, each system stores data in separate files. Often, the same information is stored in more than one file. This redundancy in storing the same data in multiple places leads to several problems. First, this leads to the wastage of storage space and poses a serious problem if the file processing system has to manage a large amount of data. Second, it leads to the duplication of effort, as one needs to perform several updates. Third, data inconsistency leads to a number of problems, including loss of information and incorrect results.

- **Difficulty in Accessing Data:** A file-based system does not provide users with ad hoc information requests as most of the information retrieval possibilities are implemented based on pre-determined requests for data. In today’s competitive and fast business environment, other than such regularly scheduled requests, there is also a need for responding to unexpected queries. A new application program often requires an entirely new set of file definitions. Even though an existing file may contain some of the needed data items, the application often requires a number of other data items. As a result, the programmer has to recode definitions of the needed data items from the existing file as well as definitions of all new data items, thereby requiring excessive programming effort. Therefore, conventional file processing systems do not let needed data to be retrieved conveniently and efficiently.

- **Data Isolation:** Data are scattered in various files, in different formats. In a file processing system, it is difficult to determine relationships between isolated data in order to meet user requirements. To tackle such situations, first, the files have to be evaluated by analysts and programmers to determine the specific data requirement from each file and the relationships between the data. Then applications have to be written in a third generation language for processing and extracting the needed data. Imagine the work involved if data from several files was needed.

- **Program–Data Interdependency:** In a file-based system, data is organized in the form of file and records. Files and records are described by specific formats and access strategy, which are coded into application
program by the programmer. Such application programs are data-dependent. Consequently, in such an environment, any change of data structure or format requires appropriate changes to all the concerned application programs. This is something that makes a change very painful or problematic for the designers or developers of the system.

- **Atomicity Problem:** In many applications, which have already been implemented, it is not easy to see to it that the data is restored to the last consistent state following the detection of a failure.

- **Integrity Problem:** Data integrity means correctness or accuracy of data. Integrity ensures accuracy of data. The data values stored in a file system may have to satisfy certain types of constraints. Programmers enforce these types of constraints in the system by adding appropriate code in the various application programs. However, when new constraints are to be added, it is difficult to change the program to enforce them with small effort and time.

- **Security Problems:** In conventional systems, applications are developed in an ad hoc manner. At times, different components of the operational data are accessed by different parts of a firm. In an environment of this type, it can be quite difficult to ensure/enforce security.

- **Concurrent Access anomalies:** If the system allows multiple users to update the data simultaneously, the interaction of concurrent updates may result in inconsistent data. In the traditional file system, such concurrent access anomalies cannot be avoided without huge programming effort.

The above limitations can be attributed to the following factors:

- Definition of data is embedded in application programs rather than stored separately. In such an environment, any change in data structure or format requires appropriate changes to the application programs.

- There is no control over the access and manipulation of data beyond that imposed by application programs.

**Database Management System—A Better Alternative**

With a database management system or DBMS as is referred to in short, the scenario is totally different. Programs do not deal with stored data by its location but they are provided with a software by a DBMS. This software allows application programs to deal with data field names irrespective of the location of the fields within the records, the location of the records within a file and the file within a device. In a DBMS, all files are integrated into one system, thus making data management more efficient by providing centralized control on the operational data. Database management systems are not only used in the commercial applications, but also in many of the scientific/engineering applications.
Database

Database means a place where data can be stored in a structured manner. It is a shared collection or batch of data that is logically related, along with their descriptions designed to meet the information requirements of an organization.

A database is a complex data structure. It is stored in a system of mutually dependent files. Those files contain the following information:

1. The set of data available to the user, the so-called ‘end-user data’. Those are the real data, which can be read, connected and modified by the user (if he has the corresponding rights).
2. The so-called ‘metadata’ (the data describing the end-user data). Here, the properties (for example, their type) and the relative relations of the end-user data are described.

6.2.1 RDBMS Packages

Following are some of the RDMS tools.

1. Oracle RDBMS
2. IBM DB2
3. Microsoft SQL Server
4. SAP Sybase ASE
5. Teradata
6. ADABAS
7. MySQL
8. MS Access
9. informix

6.3 DATABASE MODELS

A database model is a specification describing how a database is structured and used. There are several data models and some common models are given below:

- Relational Model
- Network Model
- Hierarchical Model
- Object Oriented Model
- Object Relational Model
- Entity-Relationship (E-R) Model
- Semi Structured Model
- Associative Model
- Context Model
A characteristic of the database approach is that it provides a level of data abstraction by hiding superfluous details, while highlighting the details that are of interest to the application. A data model is a mechanism to provide this abstraction for different database applications.

A DBMS can choose from several approaches to manage data. Each approach constitutes a data model, which can be defined as an integrated collection of concepts or tools used to describe and manipulate data, relationships between data and semantics and constraints on data in an organization. Constraints imply a set of rules that imposes restriction on data in a database. The data model provides the necessary means to achieve the abstraction. Most DBMS provide mechanisms to structure data in the database being modelled, allow the set of operations to be defined on them and enforce certain constraints to maintain the integrity and security of data. Therefore, a data model is a mechanism for specifying the schema of a database.

**Advantages of a Data Model**

The advantages of a data model are as follows:

- It ensures that all data objects provided by the functional team are represented with accuracy and in complete form.
- It contains enough details to be used by the technical team who build the physical database.
- It can be used to communicate information within and across business organizations.

**Entity-Relationship (E-R) Analysis**

The Entity-Relationship or E-R analysis is beneficial for a database designer in various ways. The following are the features of the E-R analysis:

- The constructs used in the E-R model can easily be transformed into relational tables.
- The E-R model is simple and easy to understand and is, therefore, used by a database designer to communicate a database design to users accessing the database.
- It is used as a design plan by a database developer to implement a data model in a DBMS.

**Record-Based Logical Model**

Data at the conceptual level and view level can be described with the help of record-based logical models. Such models are also used for specifying the overall logical structure of the database and providing a higher level description of implementation. The database in record based model is prepared in a fixed format with different types of records. Each record type refers to a limited number of fields or attributes and each field regards to a fixed length. There is no mechanism
in it for the direct representation of code in the database but there are different languages related to models for expressing database queries and updates.

There are mainly three types of record based logical models: relational, network and hierarchical models. You will learn the concepts of the record based data model in the following paragraphs.

The record is maintained on the basis of existing data in a database. Data and relationship among the data is represented by a collection of tables in which every table has its own number of columns with unique names through the relational model. In the E-R model, entities and their relationships are corresponded as two-dimensional tables. The set theoretic relation that is a subset of the Cartesian product of the list of domains is the mathematical concept based on the relational model. A relation among a set of values is represented by a row in a table, where the table is a collection of such a relationship.

Relations

Given a collection of sets $H_1, H_2, \ldots, H_N$; $R$ is a relation on these $N$ sets, if it is a set of ordered $N$-tuples $< h_1, h_2, \ldots, h_N >$ such that $h_1$ belongs to $H_1$, $h_2$ belongs to $H_2$, $\ldots$, $h_N$ belongs to $H_N$. Sets $H_1, H_2, \ldots, H_N$ are the domains of $R$ and $N$ is the degree of $R$. Any subset of the Cartesian product of one or more than one domain is their relation which can be represented through a table. Characteristics of the table are a lot similar to conventional sequential file with rows of the table corresponding to records of the file and columns corresponding to the fields of the records.

Student

<table>
<thead>
<tr>
<th>Roll No</th>
<th>Name</th>
<th>House</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>108</td>
<td>BRIJESH</td>
<td>YELLOW HOUSE</td>
<td>AUSTIN</td>
</tr>
<tr>
<td>125</td>
<td>RADHIKA</td>
<td>PINK HOUSE</td>
<td>SHAWN</td>
</tr>
<tr>
<td>139</td>
<td>NEHA</td>
<td>BLUE HOUSE</td>
<td>TAKER</td>
</tr>
<tr>
<td>161</td>
<td>SUDHIR</td>
<td>PURPLE HOUSE</td>
<td>ORTON</td>
</tr>
</tbody>
</table>

Cartesian Products

Concept of product in relational algebra has also been taken from Cartesian product of set theory. The concept has been adopted in relational algebra by extending it to relations too. Cartesian product is an operation working on two sets or two relations. It is also known as Cross product or Cross Join. A Cartesian product of two relations is another relation resulting from combination of tuples of one relation with all the tuples of another relation. Product of two relations $R$ and $S$ is denoted as $R \times S$.

Example:

We take the example of same two relations $R$ and $S$ where $R = \{(A, 1), (B, 2), (D, 3), (F, 4), (E, 5)\}$ and $S = \{(A, 1), (C, 2), (D, 3), (E, 4)\}$, then $R \times S = \{(A, 1, 1), (A, 1, 2), (A, 1, 3), (A, 1, 4), (A, 1, 5), (B, 2, 1), (B, 2, 2), \ldots\}$.

relations.
2), (C, 2)), ((B, 2), (D, 3)), ((B, 2), (E, 4)), ((D, 3), (A, 1)), ((D, 3), (C, 2)), ((D, 3), (D, 3)), ((D, 3), (E, 4)), ((F, 4), (A, 1)), ((F, 4), (C, 2)), ((F, 4), (D, 3)), ((F, 4), (E, 4)), ((E, 5), (A, 1)), ((E, 5), (C, 2)), ((E, 5), (D, 3)), ((E, 5), (E, 4))}. Relation R has 5 tuples and S has 4 tuples and R \times S contains \((5 \times 4) = 20\) tuples.

The following Figure 6.1 illustrates this concept.

![Fig. 6.1 Cartesian Product](image)

Tuple
Every row of the table corresponds to one N-tuple or tuple of the relation, i.e., tuples are the members of a relation. An entity is represented by a tuple in the set of entity.

Cardinality
Cardinality of the relation, i.e., the number of rows in a table is defined by the number of tuples in a relation.

Degree or Arity
Degree means the number of attributes (columns) within a relation (table). For example, each relation that is a subset of \(M_1 \times M_2 \times \ldots \times M_N\) is said to have a degree \(N\) or arity \(N\).

Components: A tuple \((s_1, s_2, \ldots, s_N)\) is said to have \(N\) components and the \(i^{th}\) component is \(D_i\).

Attribute: Attributes are defined as the columns of a table. It is a significant feature of entity as it helps in the identification of an entity. The actual content of the attribute or quality of the attribute is called attribute value.

Domain: It is a collection of values from which the values for a given attribute should be selected.

Relation Scheme: It is the set of attribute names of a relation. If \(B_1, B_2, \ldots, B_n\) are the attributes of a relation \(V\) then the relation scheme would be written as \(V(B_1, B_2, \ldots, B_n)\); and \(V(B_1, B_2, \ldots, B_n) = \{B_1, B_2, \ldots, B_n\}\). For instance, if Name, Date Of Birth (DOB) and Token No. are the characteristics of a relation Employee, then the relation scheme for Employee will be \{Token No., Name,
DOB) and the relational schema would be written as Employee(Token No, Name, DOB). The assortment of relation scheme used to signify information is termed as relational database scheme. Relational database is the current value of the corresponding relations. 1st degree relation is called unary relation, 2nd degree is binary, 3rd is ternary and N is N-ary relations. The relational model is also known as flat file.

Properties of a Relation
The properties of a relation are as follows:
- Relation is a set of tuples and it will not have any duplicate elements and therefore, there cannot be any duplicate rows. Two identical records can only exist if the file is conventional.
- Row and column order are insignificant.
- Information would be lost if the values are split, i.e., the values are atomic.
- All values in the column are the values of the same attribute.

Various Keys
Super Key: A set of one or more attributes (columns), whose values when taken collectively can uniquely identify a tuple (a row) in a relation (table).
- Primary Key: A candidate key which is used as the principal means for identifying tuples in a relation is termed as Primary Key or PK.
- Secondary Key (Regular Key): A key which identifies a set of tuples (rows/records) in a relation (table) or tuples having a certain property or common values for the different attributes (columns or fields) of that key. A secondary key does not identify a tuple uniquely.
- Alternate Key: A candidate key that is not the primary key is called an alternate key. A relation can have only one primary key and any number of candidate keys.

Concatenated Key or Composite Key: If the primary key is formed by the combination of more than one attribute, it is termed as concatenated key.

Candidate Key: A super key for which no proper subset is a super key is called candidate key.

Foreign Key: An attribute or a set of attributes of a relation R₁ is termed as a Foreign Key or FK, if its values can be either null or values in the primary key (candidate key) of some other relation, say R₂. Consider the STUDENT table with attributes RollNo., Name, Class, Place, Sex, DOB; and the CLASSES table with attributes ClassCode and Description. RollNo is the primary key of STUDENT table and ClassCode is the primary key of CLASSES table. Class is a foreign key for the STUDENT table whose referenced key is ClassCode in CLASSES table.
Primary Domain
A domain is a primary domain, if and only if there exists a single attribute primary
key defined on that domain. For example, consider the table ITEM with attributesItemCode, ItemName, SUPPLIER with attributes - SupplierCode, SupplierName,
PURCHASE with attributes ItemCode, SupplierCode, Qty, and CUSTOMER
with attribute Name, Place, HouseName. If ItemCode is the primary key of ITEM
table, SupplierCode is the primary key of SUPPLIER table, {ItemCode,
SupplierCode} is the primary key of PURCHASE, and {Name, HouseName } is
the primary key of CUSTOMER, then the domains of ItemCode, SupplierCode
are primary domains. But the domains of Name or HouseName are not Primary
domains.

File Organisation

NOTES

Concept of Domain Tuple
A database table is made up of rows and columns. A row represents a tuple of a
relation in the table. The term ‘cardinality’ is defined as the number of tuples in a
relation. Tuples are unique. They can be arranged in any order. A relation is defined
as a set of tuples. A tuple is a finite set of sequenced objects, each of a specified
type. It might contain ‘n’ number of objects and hence called ‘n-tuple’.
The characteristics of a tuple are as follows:
 It contains object’s information.
 It is a concept that describes and presents a table in a database.
Relational database is widely and popularly used in a network era to share
various types of data. These databases contain records or tuples representing a
single, implicitly structured data item in a table whereas columns define a set of data
values containing various data types, such as string, int, etc. Types of a relation
impose attributes without order. The queries specify select operations to identify
tuples for joining relations. The insert, delete and update operations are used to
modify relations. New tuples can supply explicit values or derive it from the query.
A domain can be defined as a set of databases for the given attribute. The
attribute is defined as the combining of data with a behaviour. It works with the
attribute’s name and values which are limited to constraints. Take an example of
character data value ‘XYZ’. This value does not come in the integer domain but the
value ‘123’ satisfies the domain for a specific row within the tuple. The domain
approach in context of the tuple is basically an object representation in terms of data
and behaviour. In essence, a domain tuple resembles the data model and can have
relationships which are not available in a relational model. For example, inheritance
maintains a relationship that is unique to an object or domain tuple. A domain tuple
deals with complex databases such as domain of object oriented databases.

Relational Model
In 1970, E. F. Codd formally introduced the relational model. Predicate logic and
set theory form the basis of the relational model for database management. This

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model provides a simple, yet rigorously defined, concept of the manner in which data is perceived by users.

**Strengths**

Some of the strengths of relational models are given in Table 6.1.

<table>
<thead>
<tr>
<th>Strength</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplicity</td>
<td>End-users’ requests are formulated in terms of the information content. These requests do not reflect any complexities due to system-oriented aspects. A relational data model is what one sees, and not necessarily, what will be implemented physically.</td>
</tr>
<tr>
<td>Non-Procedural Request</td>
<td>Requests focus on ‘What is to be done’ rather than ‘How it is done’.</td>
</tr>
<tr>
<td>Data Independence</td>
<td>Removes the details of storage structure and access strategy from the user interface. Structural flexibility is provided by relational databases. It is easier to maintain applications written for those databases. It also allows retrieval of combinations of data that may not have been anticipated as required or needed when the database was designed. To be able to make use of this characteristic, however, the design of the relations must be complete and accurate.</td>
</tr>
<tr>
<td>Mathematical Backbone</td>
<td>It is based on a formal theoretical model and is not only studied extensively but proven in practice. Almost every known aspect of it is actually proven in the form of mathematical theorems.</td>
</tr>
</tbody>
</table>

**Components**

The main principle of the relational model is the information principle—all information is represented by data values in relations. The three components—structural, manipulative and integrity—make up the relational model. These components are described as follows:

- The structural component is concerned with how data is represented. A set of relations represents the conceptual view of the database.
- The manipulative component is concerned with how data is operated upon. It comprises a set of high-level operations, which produces whole tables and acts upon them.
- The integrity component is concerned with determining which states are valid for a database. It is a cluster of rules for the maintenance of the integrity of the database.

The relational data model represents a database as a collection of relation values or relations where a relation resembles a two-dimensional table of values presented as rows and columns. A relation has a heading, which is a tuple of attribute names and a body, which is a set of tuples having the same heading. The heading of a relation is also referred to as relation schema or intension and the body of the relation is referred to as extension. Thus, the intension of the EMP relation would be:

```
EMP(EmpCode, EmpName, Salary, Date_of_Join, DeptNo)
```

Intensions provide a convenient way of describing a database depicting the schema of the database. An extension refers to the rows of data values.
Relational Terminologies

**Domain:** A domain is the set of defined atomic values for an attribute. It is a pool of values from which specific relations draw their actual values. A domain is specified in terms of data type (possibly system-defined or user-defined) and, optionally, in terms of size, range, etc.

**Attribute:** Attribute is the name of a role played by a domain in the relation. Each attribute $A_i$ is defined over a domain $D_i$ (the set of values that $A_i$ can take on) and is the name of a feature of the real-world entity or relationship that the relation is representing. Formally, it is an ordered pair $(N, D)$, where $N$ is the name of the attribute and $D$ is the domain that the named attribute represents, e.g., Emp Name, M GHOSh.

**Relational Schema:** A relational schema is made up of a relation name and a list of attributes. A relation schema $R$ is denoted by $R(A_1, A_2, \ldots, A_n)$, where $R$ is the name of the relation and $A_1, A_2, \ldots, A_n$ is a list of attributes. A relation schema is used to describe a relation.

**Relational Database Schema:** It is a set of relation schema, each with a distinct name. If $R_1, R_2, \ldots, R_n$ are a set of relation schemas, then we can write the relational database schema $R$ as $R = \{ R_1, R_2, \ldots, R_n \}$.

**Relation:** A relation (or relation state) $r$ of the relation schema $R(A_1, \ldots, A_n)$ is a set of $n$-tuples, i.e.,

$$ r = \{ t_1, t_2, \ldots, t_n \}.$$

**Tuple:** Each row in a relation is a set of related data values and is called a tuple. Formally, an $n$-tuple is an ordered list of values $t = \langle v_1, \ldots, v_n \rangle$ where each $v_i$ is an element of $D_i$ where $D_i$ is the domain of $A_i$.

**Degree (of a Relation Schema):** The degree of the relation is the number of attributes ($n$).

**Cardinality (of a Relation State):** The cardinality $m$ is the number of tuples in a particular relation state.

Formally, a relation is defined as the subset of the subset of the Cartesian product of domains. In order to do so, first we define the Cartesian product of two sets and then the expanded Cartesian product. The Cartesian product of two sets $A$ and $B$, denoted by $A \times B$ is:

$$ A \times B = \{ (a, b) : a \in A \text{ and } b \in B \}$$

The expanded Cartesian product of $n$ sets $A_1, A_2, \ldots, A_n$ is defined by:

$$ (A_1 \times A_2 \times \ldots \times A_n) = \{ (a_1, a_2, \ldots, a_n) : a_i \in A_i, 1 \leq j \leq n \}$$

The element $(a_1, a_2, \ldots, a_n)$ is called an $n$-tuple.

A relation $r(R)$ is a subset of the Cartesian product of the domains $D(A)$ that define $R$. Therefore,

$$ r(R) \subseteq D(A_1) \times D(A_2) \times \ldots \times D(A_n).$$
A relation state \( r \) of the relation schema \( R(A_1, \ldots, A_n) \) is a set of \( n \)-tuples, i.e., \( r = \{ t_1, t_2, \ldots, t_m \} \).

Let us consider the following relation schema EMPLOYEE describing the employee information of a company. The relation EMPLOYEE is shown in Figure 6.2.

**Fig. 6.2 Relation Schema Employee**

### Characteristics of Relations

- A relation has a name that is distinct from all other relation names in the relation schema.
- Each attribute value of a tuple is atomic. Hence, composite and multi-valued attributes are not allowed in a relation.
- A distinct name is given to each attribute.
- In a relation, all the values of an attribute come from the same domain.
- There is no semantic significance in the order of attributes as long as correspondence between the attributes and their values in the relation is maintained.

According to this property, repeating groups or arrays should not form columns in a relational table. Such tables are said to be in the ‘First Normal Form’ (1NF). The foundation of the relational model is the atomic value property of relational tables and there it is important. The primary advantage of the one value property is that it makes the data manipulation logic simple.

This property is derived from the fact that the heading of the relation is a mathematical set (of attribute). According to this property, the ordering of the columns in the relational table is meaningless. Columns can be retrieved in various sequences and in any order. The advantage of this property is that it allows multiple users to share the same table without any concern for the manner in which it is organized. It also allows the physical structure of the database to alter without any impact on the relational tables.
- Each tuple is distinct; there are no duplicate tuples.

  This property is based on the fact that the body of the relation is a mathematical set (of tuples). In mathematics, sets do not include duplicate elements. Therefore, theoretically, this property ensures that two rows are never identical in a relational table; the values of at least one column or set of columns uniquely identify each row in the table. Such columns are referred to as primary keys.

- The order of tuples has no semantic significance.

  This property is based on the fact that in mathematics, a set is not ordered. Since the body of the relation is represented following the set theory, this property is analogous to the one mentioned earlier. However, it applies to rows rather than columns. The primary advantage is that in a relational table, the rows are retrievable in varying sequences and orders. Addition of information to a relational table becomes simple and does not impact the existing queries.

- Derived attributes are not captured in a relation schema.

  In an SQL schema, only two types of relation schema may be defined, that is VIEWS and BASE RELATION. These are called NAMED RELATIONS. Other tables, called UNNAMED RELATIONS, may be derived from these using relational operations, such as Join and Projection.

- Base Relation: This implies a named relation which corresponds to an entity in the conceptual schema whose tuples are physically stored in the database. A relational system must provide a means for creating the base relations (specifically tables) in the first place. In SQL, this function is performed by the CREATE TABLE command. Base tables have independent existence.

- View: It is a virtual or derived relation: a named relation that does not necessarily exist in its own rights, but may be dynamically derived from one or more base relations. Its purposes may be cited as follows:
  - It provides a powerful and flexible security by hiding parts of the database from certain users.
  - It permits users to access data in a way that is customized to their needs so that the same data can be seen in different ways at the same time.
  - It can simplify complex operations on the base relations.

Disadvantages of relational model are as follows:

The relational model is the most dominant. However, it suffers from certain limitations data model. Like the hierarchical and network models, the relational model has been developed to meet the requirements of business information processing. While applying the relational model to the application areas, such as Computer Aided Design (CAD), simulation and image processing, many shortcomings have been noticed in this model. It is being suggested that a more sophisticated data model should be developed. The various shortcomings of this model may be discussed as follows:
• **Difficulty in Modelling Complex Objects:** In certain circumstances, the strength of the relational model—its simple tabular data model—becomes its weakness. The reason for this is that compressing some of the complex relationships, that exist in the real-world, into tables is a cumbersome exercise. Thus, the modelling of such complex, nested entities in a relational data model is not easy.

• **Lack of Semantic Knowledge:** ‘Semantic knowledge’ refers to knowledge about the meaning of data, i.e., how to interpret data and the legitimate processes for which the data may be used. In the relational database model, this knowledge is inadequate. Only the domain, entity and referential integrity rules possess semantic information. Moreover, many RDBMS do not fully support the domain concept. In such circumstances, application programmers are left with no other option but to compensate for the inability of the basic relational model to carry semantic knowledge, by building such knowledge into application programs.

• **Limited Data Types:** This limitation is also related to the two limitations mentioned above. An RDBMS can recognize only simple atomic data types, such as integers, characters, etc. It is one of the most critical disadvantages of RDBMS.

**Network Model**

The network data model can be defined as a database model used to represent objects and the relationships among these objects. In this model, a record can have any number of parent records and it can also have multiple child records. Like the hierarchical model, the network model also supports the concept of data independence, which can be defined as the ability to change the representation of data at one level of a database system without the compulsion of changing the data representation at the next higher level. In the network data model, Data Manipulation Language (DML) is used for searching and retrieving records from the database. DML can also be used for connecting records from the set of instances, deleting and modifying records.

The network data model uses two types of data structures, records and set type, to define the data and relationship among data. Figure 6.3 represents a record type Employee that has three data items: Name, Sex and Birth Date.

<table>
<thead>
<tr>
<th>Employee</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth Date</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Fig. 6.3 Employee Record Type*
Set type is a description of a 1:N relationship between two record types. Each set type definition has the following elements:

- Name for Set Type
- Owner Record Type
- Number Record Type

Figure 2.4 represents a set type R_Dept as an arrow. This representation is known as Bachman diagram. In the Figure 6.4, Department is the owner record type and Employee is the child record type. This represents a 1:N relationship between the department of the company and the employees that are working in that department.

![Diagram](image)

**Fig. 6.4 Set Type R_Dept**

In a database, there are set occurrences, also called set instances, corresponding to a set type. Each instance is used to relate one record from owner record type, i.e., Department to the set of records of member record types, i.e., Employee. Owner serves as parent node and member serves as a child node. Each set occurrence consists of the following elements:

- One owner record from owner record type.
- A member of related member records from the member record type.

A record from the member record type cannot belong to more than one set occurrence of a particular set type. This represents a 1:N relationship. A set occurrence can be easily identified by the owner record or by any number of records. The following are the differences between the set instance of a database and the set in mathematics:

- The set instance in a database has one distinguished element called owner record, whereas in mathematics, there is no such type of distinction among set elements.
- In a database, all member records of a set instance are ordered. On the other hand, in mathematics, the elements of a set are not ordered.

The most commonly used implementation of a set type in a network model is the system-owned set. A system-owned set can be defined as a set that does not have...
any owner record type. In this set, the system can be regarded as an owner record type. It provides the following services to the network model:

- System-owned sets provide entry points into the database through the records of a specified member record type. Processing can be performed through the fields or data items of the member record type.
- System-owned sets can be used to order the records of a given record type by using set ordering specifications. By specifying the number of system-owned sets on the same record type, you can access your records in a different order.

Figure 6.5 shows a network model.

In Figure 2.5, Department, Project and Staff Members are the owner record types and Code, Qualification and Skill are the member record types.

The advantages of the network data model are as follows:

- It enables the representation of complex relationships and effect of operations, such as ADD and DELETE, on the relationships.
- It uses constructs, such as FIND, FIND OWNER and FIND NEXT, within a set that allows the users to navigate through the database.
- It can inherit the advantages of the hierarchical model.
- Many-to-Many (M:N) relationships are easier to implement in a network model as compared to a hierarchical model.
- It ensures data integrity.

The disadvantages of the network data model are as follows:

- It provides a complex array of pointers, that thread through a set of records, that are not dealt with easily.
- It provides less scope for query optimization.
Hierarchical Model

Data models can be defined as a collection of various concepts used to describe the structure of a database. Implementing a data model includes specifying data types, relationships among data types and constraints on the data. In the hierarchical model, also called hierarchical schema, data is organized in the form of a tree structure. The hierarchical model supports the concept of data independence. Data independence is the ability to change the representation of data at one level of a database system without the compulsion of changing the data representation at the next higher level.

The hierarchical model uses two types of data structures, records and parent–child relationship to define the data and relationship among data. Records can be defined as a set of field values, which are used to provide information about an entity. An entity is a collection of objects in a database, which can be described by using a set of attributes. Records that have the same type can be easily grouped together to form a record type and assigned a name. The structure of a record type can be defined by using a collection of named fields or data items. Each data item or field has a certain data type such as character, float or integer. The Parent-Child Relationship (PCR) can be defined as a 1:N relationship between two different record types. The record type on the 1-side is called the parent record type and the record type on the N-side is called the child record type. Occurrence of the PCR type, also called instance, consists of one record of the parent record type and a number of records of the child record type. Figure 6.6 shows an example of 1:N relationship between a finance department and its employees.

Hierarchical schema consists of a number of record types and PCR types. In the hierarchical schema, record types are represented by rectangular boxes and PCR types are represented by the lines, which are used to connect a parent...
record type to a child record type. Figure 6.7 represents a hierarchical schema, which has three record types and two PCR types. Department, Employee and Project are the record types in Figure 6.7.

Each record type can have a set of data items or fields. For example, the record type Department can have department name, department number and department code as the fields or data items. PCR type can be represented by listing pair in parentheses. For example, in Figure 6.7, there are two PCR types, which can be represented as (Department, Employee) and (Department, Project). In the figure, each occurrence of the (Department, Employee) PCR type relates one department record to the records of many employees, who work in that department. The occurrence of (Department, Project) PCR type relates a department record to the records of projects controlled by that department. Figure 6.8 represents the tree like structure of the hierarchical schema.

In a tree like structure, a record type is represented by the node of the tree and PCR type is represented by the arc of the tree. The following are the properties of the hierarchical schema, which contains the numbers of record types and PCR types:

- One record type, called the root of the hierarchical schema, does not participate as a child record type in any PCR type.
File Organisation

NOTES

Self-Instructional Material

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- In the hierarchical model, each record can have only one parent record but can have many child records.
- Every record type except the root participates as a child record type in only one PCR type.
- A record type can participate as a parent record type in a number of PCR types.
- A record type which does not participate as a parent record type in any PCR type is called leaf node in hierarchical schema.
- If a record type participates as a parent node in more than one PCR type, then its child record types must be in a left to right ordered sequence.

The advantages of the hierarchical data model are as follows:
- It is simple to construct and operate on data in the hierarchical model.
- It involves hierarchically organized domains such as product info in manufacturing and employee information in organization.
- It uses constructs, such as GET, GET UNIQUE and GET NEXT.

The disadvantages of the hierarchical data model are as follows:
- It requires the navigational and procedural processing of data.
- It provides less scope of query optimization.

Comparative Table showing Differences between Hierarchical Model, Network Model and Relational Model

<table>
<thead>
<tr>
<th>Factor</th>
<th>Network Model</th>
<th>Hierarchical Model</th>
<th>Relational Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Independence</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Structural Independence</td>
<td>No. Changes in the database structure require to be made in all related application programs.</td>
<td>No. Changes in the database structure require to be made in all related application programs.</td>
<td>The Relational database model is based on the Relational Algebra. The basic data structure of the relational model is a table, where information about a particular entity (say, an employee) is represented in columns and rows.</td>
</tr>
<tr>
<td>Programming</td>
<td>Extensive programming required, as network model is implemented using linked list.</td>
<td>Difficult to design, as you need to implement it using a tree.</td>
<td>The relational model has strong mathematical foundation with set theory and predicate logic to define data.</td>
</tr>
<tr>
<td>Data Definition Network</td>
<td>Network Data Definition Language (NDSDL) is used to define data in network models.</td>
<td>Hierarchical Data Definition Language (HDDL) is used to define data in hierarchical models.</td>
<td>Relational model is considered as the most flexible model of the database models.</td>
</tr>
<tr>
<td>Data Manipulation Network</td>
<td>Network Data Manipulation Language (NDML) is used to modify data in network models.</td>
<td>Hierarchical Data Manipulation Language (HDML) is used to define data in network models.</td>
<td>Certain fields may be designated as keys, which mean that searches for specific values of that field will use indexing to speed them up. Where fields in two different tables take values from the same set, a join operation can be performed to select related records from the two tables by matching values in those fields.</td>
</tr>
<tr>
<td>Constraint</td>
<td>A link depends on its start node and end node. If a start node or an end node is deleted, the link is also deleted.</td>
<td>A record can only be inserted if it is related to a parent record and not to a root record.</td>
<td>A relational database allows the definition of data structures, storage and retrieval operations and integrity constraints. In such a database the data and relations between them are organized in tables. A table is a collection of records and each record in a table contains the same fields.</td>
</tr>
</tbody>
</table>
1. Define database. It is a shared collection or batch of data that is logically related, along with their descriptions designed to meet the information requirements of an organization.

2. A database model is a specification describing how a database is structured and used.

3. Cardinality of the relation, i.e., the number of rows in a table is defined by the number of tuples in a relation.

4. Super key is a set of one or more attributes (columns), whose values when taken collectively can uniquely identify a tuple (a row) in a relation (table).

6.5 SUMMARY

- Data is raw facts, which is provided to the computer in terms of bytes.
- File is a collection of all occurrences (instances) of similar types of records. It is a group of records of a single type.
- Database means a place where data can be stored in a structured manner.
- A candidate key which is used as the principal means for identifying tuples in a relation is termed as Primary Key.
- An attribute or a set of attributes of a relation R1 is termed as a Foreign Key.
- A domain is a primary domain, if and only if there exists a single attribute primary key defined on that domain.
- Data models can be defined as a collection of various concepts used to describe the structure of a database. The hierarchical model supports the concept of data independence.
• The network data model can be defined as a database model used to represent objects and the relationships among these objects.
• View is a virtual or derived relation: a named relation that does not necessarily exist in its own rights, but may be dynamically derived from one or more base relations.
• RDBMS stands for relational database management system. A relational database has following major components: Table, Record / Tuple, Field & Column / Attribute.

6.6 KEY WORDS

• **Super Key:** A set of one or more attributes (columns), whose values when taken collectively can uniquely identify a tuple (a row) in a relation (table).
• **Alternate Key:** A candidate key that is not the primary key is called an alternate key. A relation can have only one primary key and any number of candidate keys.

6.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short-Answer Questions**

1. Define database.
2. What are the benefits of using database over file based systems?
3. Discuss the properties of relation.

**Long-Answer Questions**

1. Explain the relational and network model.
2. What are the services of network model?
3. Explain hierarchical model.

6.8 FURTHER READINGS


UNIT 7 DATABASE SYSTEM

7.0 INTRODUCTION

In the previous unit, you have learned that the database means a place where data can be stored in a structured manner. It is a shared collection or batch of data that is logically related, along with their descriptions designed to meet the information requirements of an organization. In this unit, you will learn about the services offered by the DBMS and features of WINISIS and MS Access.

7.1 OBJECTIVES

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

- Discuss the significance of DBMS
- Explain the different types of database languages
- Understand the features of WINISIS and MS Access

7.2 DATABASE SYSTEM: DEFINITION, SCOPE, NEED AND PURPOSE

It is a software system that allows users to not only define and create a database but also maintain it and control its access. A database management system can be called a collection of interrelated data (usually called database) and a collection or set of programs that helps in accessing, updating and managing that data (which form part of a database management system).

The primary benefit of using a DBMS is to impose a logical and structured organization on data. A DBMS provides simple mechanisms for processing huge
The two basic operations performed by the DBMS are as follows:

- Management of data in the database.
- Management of users associated with the database.

Management of the data means specifying how data will be stored, structured and accessed in the database. This includes the following:

- **Defining**: Specifying data types and structures, and constraints for data to be stored.
- **Constructing**: Storing data in a storage medium.
- **Manipulating**: Involves querying, updating and generating reports.
- **Sharing**: Allowing multiple users and programs to access data simultaneously.

Further, the database management system must offer safety and security of the information stored, in case unauthorized access is attempted or the system crashes. If data is required to be shared among many users, the system must ensure that possible anomalous results are avoided.

Management of database users means managing the users in such a way that they are able to perform any desired operations on the database. A DBMS also ensures that a user cannot perform any operation for which he is not authorized.

In short, a DBMS is a collection of programs performing all necessary actions associated with a database. There are many DBMSs available in the market such as Access, dBase, FileMaker Pro, Foxpro, ORACLE, DB2, Ingress, Informix, Sybase, etc.

**A database application** is a program or a set of programs that interacts with the database at some point in its execution. It is used for performing certain operations on data stored in the database. These operations include inserting data into a database or extracting data from a database based on certain conditions, updating data in a database, producing data as output on any device such as screen, disk or printer.

**A database system** is a collection of application programs that interacts with the database along with DBMS and database itself (and sometimes the users who use the system). Database systems are designed in a manner that facilitates the management of huge bodies of information.

A database clearly separates the physical storage of data from its use by an application program to attain program-data interdependence. For using a database system, the user or programmer is unaware of the details of how the data are stored. Data can be changed or updated without making any effect on other components of the system.
A DBMS is mainly used for data or database management. The processes of database management and data management are complementary. The responsibility of data management includes data and its structure as well as the integration of data and processes. On the other hand, database management, covers the security, physical implementation, and maintenance of the physical databases. It is the responsibility of database management to manage and enforce the enterprise’s policies related to individual databases. Almost all the additional utilities and services outlined here are provided by most database management systems:

- **Enforcement of Integrity**: It is necessary for the data values stored in a database to be consistent in a certain way. The balance of a bank account, for instance, may never be below a specific amount, say £1000. Integrity can be maintained by centralized control of database. It also allows the DBA to define validation procedures that need to be carried out whenever an attempt is made to update, that is, modify, create or delete.

- **Transaction Management**: At times, a single logical unit of work is formed by numerous operations on the database. Transaction is an action that is used to perform some manipulation on data stored in the database. A DBMS is responsible for supporting all the required operations on the database; it also manages the execution of transactions so that only the authorized and allowed actions are performed. The execution of transactions requires ACID properties (Atomicity, Consistency, Isolation, and Durability). All operations of a transaction will be executed or none of the operations will take effect (atomicity). As a result of a transaction, data records are accurate (consistency). When two or more transactions run concurrently, their effects must be isolated from one another. If a transaction has completed its operations, its effect should not be lost even if the system fails immediately after the transaction completes (durability). In case of failure, abandoning the partial transaction and re-applying it becomes necessary. Also, in the event of failure, the database should be able to restore itself to a consistent state.

- **Backup and Recovery**: To ensure the restoration of the previous state in case of logical or physical corruption or data loss, a DBMS keeps back-up copies of the database. It keeps a log of all the operations performed in the database so that the database can be restored up to the last consistent state after the system’s failure. In such case, following the logs, operations can be re-done to make the database up to date.
• **Security Management**: Security management done by a DBMS is as follows:
  o Preventing unauthorized database users from accessing the database.
  o Preventing unauthorized users from accessing a part of the database information or manipulating data. This control is normally done using sub-schemas and user views or by applying access rights.
  o Protecting data to prevent unauthorized users from reading or understanding the content of the database. Data encryption is used for protecting information stored on disk as well as information exchanged on a network.

• **Concurrency Control**: Simultaneous accessing of a single database by multiple users and/or programs is possible. Some of the major issues addressed by the concurrent access to data include the following:
  o A wrong view of the database state by one user while the database is being updated by another user.
  o Updation by multiple users, concurrently, may lead to an inconsistent state or result.

  DBMS must ensure avoidance of such concurrent anomalies.

File Processing System versus Database Management System (DBMS)

<table>
<thead>
<tr>
<th>DBMS</th>
<th>File-processing system</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is a shared set of data that is logically related. It describes the data designed to meet the information requirements of an organization.</td>
<td>It is a set of application programs that serves the end-users in various ways, such as by producing reports. Each program defines and manages its own data.</td>
</tr>
<tr>
<td>Redundancies and inconsistencies in data are reduced due to single file formats and duplication of data is eliminated.</td>
<td>Redundancies and inconsistencies in data exist due to single file formats and duplication of data.</td>
</tr>
<tr>
<td>Data is easily accessed due to standard query procedures.</td>
<td>Data cannot be easily accessed due to special application programs needed to access data.</td>
</tr>
<tr>
<td>Isolation/retrieval of the required data is possible due to common file format and there are provisions to retrieve data easily.</td>
<td>Data isolation is difficult due to different file formats, and also because new application programs have to be written.</td>
</tr>
<tr>
<td>It provides program and data independence.</td>
<td>There is a dependency between application program and data. Because, definition of data is embedded in the application program rather than stored separately.</td>
</tr>
<tr>
<td>Integrity constraints, whether new or old, can be enforced as per need. Data integrity is determined on the data itself.</td>
<td>Introduction of integrity constraints is tedious and new application programs have to be written in order to determine data integrity in each application.</td>
</tr>
<tr>
<td>Atomicity of updates is possible. Atomicity of updates may not be maintained.</td>
<td>Atomicity of updates may not be maintained.</td>
</tr>
<tr>
<td>Several users can access data at the same time i.e. concurrently without problems.</td>
<td>Concurrent accesses may cause problems such as inconsistencies.</td>
</tr>
<tr>
<td>Security features can be enabled in a DBMS easily. It may be difficult to enforce security features.</td>
<td>Security features can be enabled in a DBMS easily. It may be difficult to enforce security features.</td>
</tr>
<tr>
<td>Cost of the system depends on application. It involves high cost as additional hardware is needed and conversion of the existing one is required.</td>
<td>Cost of the system is small as compared to the DBMS.</td>
</tr>
<tr>
<td>A DBMS is usually a large piece of software adding to an overhead.</td>
<td>A DBMS is usually a large piece of software adding to an overhead.</td>
</tr>
</tbody>
</table>
• **Storage Management**: Data has to be externally stored on a high-speed, random access device. The users do not have to worry about where data is stored and in which manner. This is because they can rely on the DBMS to do that. These details are simplified by the DBMS. The effectiveness of a DBMS can be measured on the basis of its efficiency and speed in storing and retrieving data. Efficiency can be measured in two ways—space and speed. Under normal circumstances, you can have either one of them, not both. *Database manager* or DBMS is a component of DBMS which addresses such problems. All storage and retrieval related are dealt with by this component.

• **Restructuring**: Any change in the database schema may result in inconsistency in the database. Restructuring is a utility for transferring the old database into a new instantaneous database under a new schema.

### Basics of Database Management System

#### Data Abstraction

A DBMS must have some means of representing the data in a way that user can easily understand. A DBMS provides users with the conceptual representation of data. The system hides certain details regarding data storage and maintenance and data is retrieved efficiently. This is performed by defining levels of abstraction at which the database may be viewed.

#### Logical and Physical View of Data

Separating the logical and physical structures of data clearly is one of the main features of the database approach. The term, ‘logical structure’, indicates the manner in which the programmers view it whereas the physical structure refers to the manner in which data is actually stored on the storage medium.

A logical view of data expresses the way a user thinks about data. Usually, it is expressed in terms of a **data model**.

A physical view of data is the way data are handled at low level, i.e., the storage and retrieval of it. Specifically stated, it is expressed in terms of specific locations on storage devices plus techniques used to access it.

A set of logical constructs that can help describe the structure of a database, that is, its data types, constraints and relationships, is referred to as a **data model**. It is also a set of basic operations that specify updates and retrievals on the database.

A data model is used to refer to a set of general principles for handling data (Tsitschizris and Lochovsky, 1982). The set of principles that defines a data model may be divided into the following three major parts:

• **Data Definition**: A set of principles concerned with how data is structured
• **Data Manipulation**: A set of principles concerned with how data is operated upon

• **Data Integrity**: A set of principles concerned with determining which states are valid for a database

**Schemas, Subschema Instances or State of a Database**

The overall description of a database is called **database schema**, which is specified during database design and is expected not to be changed very frequently. The values of a data item can be fitted into a framework. A database schema includes such information as:

- Characteristics of data items
- Logical structure and relationship among those data items
- Format for storage representation
- Integrity parameters, authorization and backup policies

A **subschema** is its proper subset designed to support ‘views’ belonging to different classes of users in order to hide or protect information. It refers to the same view as schema but for the data types and record types, which are used in a particular application or by a particular user.

Database changes over time, as information is inserted, deleted or updated. The collection of data or information stored in the database at a particular moment of time is called an **instance**, **state** or an **snapshot of the database**. Database schema and database state are two different things. While a new database is being defined, only the database schema is specified to the DBMS. The existing state of the database, with no data, is the **empty state**. We get the initial state of the database when data in the database is first inserted. The DBMS is responsible for ensuring that every state is a **valid state** satisfying the structure and constraints specified in the schema. Sometimes, the schema is referred to as the **intension**, and a database state as an **extension** of that schema.

**Data Dictionary**

A data dictionary can be treated as a special file, which stores the information about the organization and usage of data contained in the database. This information is called metadata (which means data about data). It is sometimes termed as system catalog that documents the data in the database. In a DBMS, the detailed structure and organization of each file are stored in the system catalog. Two terms, system catalog and data dictionary, are used interchangeably. A system catalog is a repository that integrates metadata. A data dictionary is a repository that manages metadata. It is a part of the system catalog that is generated for each database. A data dictionary can function in a variety of ways, which are as follows:

- **Active (Integrated)**: This is always consistent with the current structure and definition, maintained automatically by the system itself.
• Passive (Non-integrated): It is used only for documentation purpose and is not used by the DBMS software. It is simply a self-contained application and a set of files used for documenting the data processing environment. It is not consistent and managed by users of the system and modified whenever the structure of the database is changed.

Database Languages

These languages are used to define and query a database.

Data Definition Language

A database scheme is specified by a set of definitions, which are expressed by a special language called Data Definition Language (DDL). The data definition language allows the creation and deletion of structures of database objects as well as provides facilities for defining and altering defined physical data structures. CREATE, DROP and ALTER statements are the most frequently used DDL statements. The definition also includes any constraints that are set of rules to be maintained for the integrity of a database.

A DDL statement

```
CREATE TABLE EMPLOYEE
(FNAME VARCHAR(15),
LNAME VARCHAR(15),
ECODE CHAR(5) PRIMARY KEY ,
DATE_JOIN DATE,
SEX CHAR,
SALARY NUMBER (10,2),
DNO VARCHAR (5) REFERENCES DEPARTMENT
(DNUMBER));
```

In most DBMSs, the DDL also defines user views and sometimes, storage structures; in other DBMSs, separate languages such as View Definition Language (VDL), Storage Definition Language (SDL), etc., may exist for specifying views and storage structures.

In databases where there is a separation between the conceptual and internal schemas, the DDL is used to specify the conceptual schema, and the SDL is used to specify the internal schema.

An SDL statement in ORACLE

```
CREATE TABLESPACE payroll
DATAPFILE 'c:/ACTS/payroll.tsp' SIZE 10M
DEFAULT STORAGE (
INITIAL 10K
NEXT 50K
MAXEXTENTS 999
PCTINCREASE 10);
```
For true three-schema architecture, View Definition Language (VDL), is used to specify the user views and their mappings to the conceptual schema.

An Example of a VDL statement is as follows:

```
CREATE VIEW sales AS SELECT * FROM employee WHERE dno = 'D04';
```

However, in most DBMSs, the DDL is used to specify both the conceptual and external schemas.

**Data Manipulation Language**

Once the schemas are compiled and the database is populated with data, users need to manipulate the database. Data Manipulation Language or DML is a language that allows users to access as well as manipulate data. Retrieving data from the database, inserting new data into the database and deleting or modifying the existing data, are activities that comprise data manipulation. A query refers to a statement in the DML that is used for data retrieval from the database. A query language is a subset of the DML, used to pose a query. However, the terms, DML and query language, are used synonymously.

Example of DML statements are as follows:

```
SELECT ECODE, ENAME, DNO, SEX FROM EMPLOYEE;
DELETE FROM EMPLOYEE WHERE ECODE = 'E01';
UPDATE EMPLOYEE SET DNO = 'D04' WHERE ECODE = 'E03';
```

DML can be used in an interactive mode or embedded in conventional programming languages such as Assembler, COBOL, C, C++ Pascal or P/LI. Whenever DML statements are embedded in a general-purpose programming languages, that language is called host language and the DML is called data sublanguage.

There are two types of DML, which are as follows:

- **Low-level or Procedural**: This requires a user to specify what data is needed and how to get it. Examples are SQL, Quel.
- **High-level or Non-procedural**: Here, the user is required to specify the data needed without specifying the manner of retrieval, for example, datalog, QBE.

In most existing DBMSs, the external view of data is defined outside the application program or interactive session. Data is manipulated by procedure calls to subroutines provided by a DBMS or through preprocessor statements. A uniform collection of constructs forming part of the user’s programming environment, is used to define and manipulate, in an integrated environment.

**Note**: In most DBMSs, VDL, DDL and DML are not considered separate languages but a comprehensive integrated language for conceptual schema definition, view definition and data manipulation. Storage definition is kept separate to fine-tune the performance, usually done by the DBA staff.

An example of a comprehensive language is SQL, which represents a VDL, DDL, DML as well as statements for constraint specification, etc.
When DML commands are embedded in a general-purpose programming language, the programming language is called host language and the DML is called data sublanguage.

**DBMS Architecture**

Database Management Systems are very complex systems. To understand general database concepts and the structure and capabilities of a DBMS, it is useful to examine the architecture of a typical database management system.

There are two different ways to interpret the architecture of a typical database management system: the logical DBMS architecture that deals with the way data is stored and presented to users and the physical DBMS architecture that is concerned with the software components that make up a DBMS.

**Logical DBMS Architecture**

The logical architecture of a DBMS is known as the three-level architecture. It was suggested by ANSI/SPARC (American National Standards Institute/Standards Planning and Requirements Committee).

The logical architecture describes how users perceive data in a database. A DBMS provides the user with an abstract view of data. Users can access and manipulate data without worrying about where it is located or how it is actually stored and maintained. This is done by defining levels of abstraction. There are three levels of abstraction, which are as follows:

- **Physical or internal level** is the lowest level of abstraction. It describes how data is actually stored on physical media. It provides a low-level description of the physical database.
- **Logical or conceptual level** is the next higher level of abstraction. It describes what data is stored and how data is interrelated.
- **External or view level** is the lowest level of abstraction as seen by a user. It provides a window on the conceptual view, which allows the user to see only the data of interest to them. That is, this level of abstraction describes only a part of the entire database or a subset of the database.
Figure 7.1 shows the logical architecture for a typical DBMS.

![Logical Architecture of DBMS](image)

The three-level database architecture allows a clear separation of data representation as the users see it and the physical data structure layout. This separation of different views of data is flexible and adaptable. This flexibility and adaptability is known as data independence.

Since a schema defines each view, there exist several schemas in the database partitioned according to the levels of abstraction. The internal view is expressed by the internal schema, which contains the definition of the stored record, the method of representing the data fields and the access aids used. The conceptual schema defines this conceptual view. There is only one conceptual schema per database. Each external view is described by means of a schema called an external schema or a subschema. Any number of external schemas can be defined and they can overlap each other.

**Mapping between the Levels**

Mapping is the transformation of requests and results between different levels of abstraction.

Mapping can be conceptual/internal or external/conceptual mapping.

The conceptual/internal mapping exists between the conceptual and internal levels. It defines the correspondence between the records and the fields of the conceptual view and the files and data structures of the internal view.

If a modification is made to the structure of the stored database, then accordingly, a change must be made in the conceptual/internal mapping to ensure that the view from the conceptual level remains as it is. In other words, if the physical structure of the database gets modified, the DBMS has knowledge of these modifications and continues to provide the same logical view as before the changes. This is called physical data independence.
Conceptual/external mapping exists between the external and conceptual levels. This defines the correspondence between a particular external view and the conceptual view. If the structure of the database is modified at the conceptual level, then the external/conceptual mapping must also change accordingly so that the view from the external level remains constant. This mapping provides logical data independence for the database.

Two types of data independence can be defined with respect to the three-level architecture, that is, logical data independence and physical data independence. The ability to modify the conceptual scheme without modifying the external schemas or application programs is called logical data independence. At this level, changes are usually made to improve performance.

The ability to modify the internal scheme without changing the conceptual schemas or external schemas is known as physical data independence. If the conceptual view is separated from the internal view, it allows the provision of a logical description of the database without any need for specifying physical structures.

Modifications to the internal schema may be required because some physical files needed reorganization. This is usually done when the logical database structure is modified. Sometimes, it is needed to make a change in the logical structure of the data.

Physical DBMS Architecture

The related and interconnected software components of a DBMS are described by the physical architecture. At an extremely basic level, the physical DBMS architecture can be split into two parts: the back end and the front end. Management of the physical database and provision of relevant support and mappings for the internal, external and conceptual levels is the responsibility of the back end. In addition, the back end is also responsible for the other advantages of a DBMS, such as access control, security and integrity.

The front end is really just any application that runs on top of the DBMS and acts as a user interface. These may be applications provided by the DBMS vendor, the user or a third party.

The back end can be further divided into the functional software components, which are as follows:

DML Precompiler: It converts DML statements embedded in an application program to normal procedure calls in a host language. Through the DML precompiler, DML commands and application programs written in host language are separated. DML commands are sent to the DML interpreter for translating into object code for database access and the rest of the program is sent to the compiler of the host language. Object codes for the commands and the rest of the program are combined together through linking and sent to the DBMS engine (also called database manager) for execution. The precompiler must interact with
the query processor in order to generate the appropriate code. The precompiler interacts with the query processor.

**DML Compiler:** It translates DML statements into low-level instructions that a query processor understands.

**DDL Interpreter or Compiler:** It interprets DDL statements and records definitions into data dictionary.

**Query Evaluation Engine:** It executes low-level instructions generated by the DML compiler.

It mainly deals with solving all problems related to queries and query processing. It helps the database system simplify and facilitate access to data.

**Database Manager:** A program module providing an interface between low-level data (stored in the database) and the application programs and queries which are submitted to the system.

The Functions of the Database Manager Include:

- Efficient storage, retrieval and updation of data
- Interaction with the file manager
- Ensuring a state of consistency in the database irrespective of system failures
- Maintenance of integrity controls and user authority for data accession

**File Manager:** It manages allocation of disk space and data structures used to represent information on disk.

In addition, several data structures are required for the physical system implementation.

- Data are stored in **data files**, which store the database itself.
- Data dictionary: Actually, this is a critical element in the DBMS.
  - The results of compilation of DDL statements are a set of tables that is stored in a special file called data dictionary, which documents data in a database. A data dictionary contains metadata (data about data). Metadata is data about the storage details of a database.
  - Indices: To improve the performance of a DBMS, a set of access aids in the form of indexes are usually provided in the database systems. An index is a data structure that helps access data through a given part of their value. It provides fast access to data. There are several indexes and for implementing indexes, several techniques are used; however, each technique is specific to a particular database application. ADBMS provides commands to build, maintain and destroy such indexes.
  - Statistical data file: The query processor uses statistical data to optimize queries.
  - Log file: Each log record comprises the values for database items before and after a modification and it can be utilized for the purpose of recovery.
7.3 BASIC FEATURES OF WINISIS AND MS ACCESS

NOTES

Features of WINISIS

WINISIS is a Windows application and provides a graphical user interface (GUI). WINISIS uses the same database structure as CDS/ISIS for DOS. Databases created by using the DOS versions of the CDS/ISIS do not require any changes to be processed by the Windows version. Moreover, if display and print formats as well as FST tables do not use new features of the formatting language of WINISIS, a database created by the Windows version of the CDS/ISIS27 system can be processed by its DOS version.

Many databases can be opened simultaneously; in particular the same database can be opened several times maximum record size has been increased almost 4 times (30 KB in the Windows version as compared with 8 KB in the DOS versions) when greatly simplifies processing of full-text databases global record processing operations (add a field, delete a field and replace text in a field contents) are available from the system utilities menu.

MS Access Features

Following are the features of MS access.

1. Ideal for individual users and smaller teams
2. Easier than client-server database to understand and use
3. Import and export to other Microsoft Office and other applications
4. Ready templates for regular users to create and publish data
5. Allows building and publishing Web databases effortlessly
6. A user friendly feature ‘Tell Me’ for assistance
7. Allows developers to create custom solutions using VBA code
8. Hide/Show option for Ribbon
9. Allows users to Report View Eliminates Extra Reports
10. Allows output Reports in PDF format

Check Your Progress

1. What is logical view of data?
2. What is data dictionary?
3. Which database language specifies the database scheme?
7.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. A logical view of data expresses the way a user thinks about data. Usually, it is expressed in terms of a data model.
2. A data dictionary can be treated as a special file, which stores the information about the organization and usage of data contained in the database.
3. A database scheme is specified by a set of definitions, which are expressed by a special language called Data Definition Language (DDL).

7.5 SUMMARY

- A database management system is a collection of interrelated data (usually called database) and a collection or set of programs that helps in accessing, updating, and managing that data.
- A database system is a collection of application programs that interacts with the database along with DBMS and database itself.
- A data dictionary can be treated as a special file, which stores the information about the organization and usage of data contained in the database.
- Logical or conceptual level is the next higher level of abstraction. It describes what data is stored and how data is interrelated.
- A program module providing an interface between low-level data and the application programs and queries which are submitted to the system known as Database Manager.
- File Manager manages allocation of disk space and data structures used to represent information on disk.
- Microsoft Access forms provide a quick and easy way to modify and insert records into your databases.
- Access queries provide the capability to combine data from multiple tables and place specific conditions on the data retrieved.
- WINISIS is a Windows application and provides a graphical user interface (GUI). WINISIS uses the same database structure as CDS/ISIS for DOS.

7.6 KEY WORDS

- **Logical view**: A logical view of data expresses the way a user thinks about data. Usually, it is expressed in terms of a data model.
- **Physical view**: A physical view of data is the way data are handled at low level, storage and retrieval of it.
7.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

NOTES

Short-Answer Questions
1. Define the term database schema.
2. Give some examples of DDL and DML languages.
3. What are the three levels of abstraction?
4. Discuss the features of WINISIS and MS Access.

Long-Answer Questions
1. What are the services that are offered by the DBMS?
2. Differentiate between DBMS and file processing system.
3. Explain the logical architecture of DBMS.

7.8 FURTHER READINGS


UNIT 8 INFORMATION SYSTEM ANALYSIS AND DESIGN

Structure
8.0 Introduction
8.1 Objectives
8.2 Business System Concepts: Overview and Components
  8.2.1 System Boundary
  8.2.2 Business System
8.3 Project Selection
8.4 Sources of Project Requests
  8.4.1 Requests from Department Managers
  8.4.2 Requests from Senior Executives
  8.4.3 Requests from Systems Analysts
  8.4.4 Requests from Outside Groups
8.5 Preliminary Investigation
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8.6 Systems Development Life Cycle
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8.0 INTRODUCTION

In this unit, you will learn about business system concepts. Besides studying the different sources of project requests, you will also get to understand what project selection is and how it is done. At the same time, this unit will also discuss the concept of preliminary investigation. In addition, you will learn about systems development life cycle, its different stages and other related aspects.

8.1 OBJECTIVES

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

- Understand business system concepts
- Understand what project selection is
8.2 BUSINESS SYSTEM CONCEPTS: OVERVIEW AND COMPONENTS

A system is a set of organized principles, tasks, activities and procedures that defines the working of a particular establishment to achieve an objective. It is logically arranged and governed by rules, regulations and policies. Thus, a system is a process or a set of processes taking one or more inputs to produce outputs. These outputs are according to the objectives set by the policy makers. Thus, the fundamental components of a system are input, process and output which are depicted in Figure 8.1.

![Fig. 8.1 Input Process and Output](image)

A system is defined and determined by its boundaries and objectives. It is an arrangement of smaller systems in a logical order. When many smaller systems together make a larger system, the smaller systems are called the subsystems of the larger system and the larger system is called a super system.

The functioning of coordinated systems (process) includes receiving inputs from one system and giving output to other systems. A big system may have many subsystems and sub subsystems synchronized to produce the desired objectives, which are outputs from the system. For example, an information system is a system that accepts data resources as input and processes them into information products as output. It provides information when a set of organized procedures is executed.

Take the example of a garment manufacturing system where the inputs are fabric, thread, labour and utilities like electricity, etc. The process consists of taking measurements, cutting, sewing, etc. The output is in the form of shirts, trousers, jackets, etc., depending on products in which the organization is dealing. The whole business system related to the garment business has other subsystems like recruitment and training system, accounting system, procurement system, marketing system, etc. The bigger the business, the more the number of subsystems.

8.2.1 System Boundary

Things directly controlled by the system falls within the system boundary. Things falling outside the system boundary form the environment of the system. A system may be a closed system or an open system. In an open system, you can go on...
adding subsystems and it grows bigger and bigger. In a closed system, it is not so. Environment of a system means other systems that influence the system under consideration. This includes market, political systems and financial guidelines or statutes.

8.2.2 Business System

Business comprises a set of activities pertaining to commerce; manufacturing or services resulting in producing economic output intended to make a profitable gain. A business system is a system with profit objectives or non-profit objectives. It can be private as in the case of a corporation or it may be public as in the case of a government unit. The manager is the control element in the system, keeping it on course as it moves towards its goals. The business firm is a physical system which is tangible. A conceptual system is a system that represents a physical system. The managers use a conceptual system to manage the physical one. The physical system is important for what it is, the conceptual system is important for the representation of the physical system.

A system in which the inputs, process and outputs are known with certainty is called a deterministic system. For example, when one condition is processed, a certain resultant condition will always occur. An accounting system is also an example of a deterministic system. A system is called probabilistic when the output can only be predicted in probabilistic terms. The nature and working of stock control and cash flow systems can be estimated; however, few of the financial elements are variable and can be considered within the estimation of that system. These can be predicted in terms of probability of occurrence. A demand forecasting system can be called a probabilistic system.

A system, which is influenced by environmental changes and has an exchange with the environment, is called an open system. For example, any business organization can be considered an open system, as it is constantly affected by the changes in its environment. Its functions, development and results affect the environment in the same manner.

Feedback and Control

Irrespective of the way a system works, control is essential for it, and without proper feedback, no control system can work. A system produces some output that goes to a market or to another process. It is not difficult to control the quality of output if there is no feedback. For example, a garment manufacturing system produces garments of a particular quality in a competitive environment. The manufacturer of garments must get market feedback otherwise it will be difficult to improve on quality needed to compete with other manufacturers. Thus, for a system to work smoothly, its output needs appraisal by its consumers. Depending on the feedback, analysis should be carried out and control should be exercised to improve the process. This is so with a business system. Figure 8.2 illustrates this fact.
Thus, the meaning of a system in the context of business is related to a set of business processes that produces the output of the overall business activities. A business system thus consists of many subsystems, each performing a particular set of functions to achieve the overall task of producing meaningful output. Functionally, every business system has a few subsystems mainly planning, product generation, customer delivery and customer service. Each of these systems has key business processes. This is shown in Table 8.1.

Table 8.1 Subsystem of a Business System

<table>
<thead>
<tr>
<th>Business System</th>
<th>Business Planning System</th>
<th>Product Generation System</th>
<th>Customer Delivery System</th>
<th>Customer Service Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Business Processes</td>
<td>Corporate governance Information gathering Analysis Strategic planning Technology acquisition Strategic alliance</td>
<td>Market research Product design Process design Materials management Production Product launch</td>
<td>Channel management Financial management Sales management Collection process Market feedback</td>
<td>Customer training After sales services Preventive maintenance Unplanned services Reliability assessment</td>
</tr>
</tbody>
</table>

As per the nature of a business system, it is a set of three subsystems. These are as follows:

(i) **Physical subsystem**: This comprises people, infrastructure, materials and technology to convert raw material into finished products.

(ii) **Decision subsystem**: This controls the physical subsystem.

(iii) **Information subsystem**: This serves as a link between physical and decision subsystem.

The basic concepts of a business are very clear. A business runs for profit. Every investment must have a return in a finite time. With growth in technology, various business activities have been systematized and this has made a remarkable shift in business philosophy. Market is an important place for any business. With the growth of computer systems, business systems have been modernized and
now efficient systems are being used for business processes, such as planning, material procurement, manufacturing, and customer delivery and services.

<table>
<thead>
<tr>
<th>Check Your Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Define a system.</td>
</tr>
<tr>
<td>2. What is a business system?</td>
</tr>
<tr>
<td>3. How does the project selection process add strategic value to organizations?</td>
</tr>
</tbody>
</table>

### 8.3 PROJECT SELECTION

In System Analysis and Design, *project selection* is undertaken for various reasons. You may like to install a new system or may like to modify the existing system. There should be a clear justification of methods to define their value. The justification of methods, to a great extent, depends on the organizational strategy and market needs. They also depend on the need to gain an edge over present as well as potential competitors in order to enter the local or international market. Moreover, technological advancement, profitability of the project and sponsorships too play a key role in project selection. There must be enough information to take correct decisions. This information should be related to all the factors affecting a project. You should make a selection keeping in mind the benefit that you can derive out of it. The methods adopted may be Benefit Measurement Methods (BMMs) on the basis of comparative study or Constrained Optimization Method (COM) that uses a mathematical approach to justify and arrive at a conclusion for selecting the project.

BMM is the most popular method used to measure the benefits of taking up a project and comparing other projects by setting a strategic benchmark. Various models, such as cost-benefit analysis, scoring models, economic models, discounted cash flow, net present value and internal rate of return come under BMM. COM works on complex mathematical calculations based on the probable outcome that helps to select a project on best results. Methods of operations research are used in making decision models. Figure 8.3 shows the methods of project selection. The project selection process adds strategic value to many organizations. It helps them to:

- Adopt an approach to gain profit or reduce cost on resources
- Receive funds from financial institutions

These financial institutions also make systematic analyses (adopting certain criteria) to judge the suitability of financing these organizations.
There are two main activities—identification of unit and prioritization—that translate the need for project selection into a well-developed schedule. The selection of a project determines the way in which resources are allocated to the project. This helps optimal utilization of resources. Project selection also requires a number of decision-making approaches at each step to reach a final outcome. Figure 8.4 shows the sample project selection decision tree, which depicts such steps.

![Sample Project Selection Decision Tree](image)

**Fig. 8.4 Sample Project Selection Decision Tree**
The decision model, shown in Figure 8.5 is used to select a project after its simulation and evaluation. Project data is presented for simulation and evaluated to take a decision.

Decision models are also used for other purposes. You may use it to provide a way to estimate the value of additional effort and project cost. The project team leader uses these decision models to illustrate the marginal range of project cost.

Decision models give important indicators to those who give project proposals and manage projects. These decision models indicate to professionals (engineers and others) about the project characteristics and attributes that are valued in the funding process. It helps managers to know the agency that executes funded projects and the performance that is expected if the project is to create the value that motivated its funding.

8.4 SOURCES OF PROJECT REQUESTS

A project starts only when there is a request from some agencies, organizations or business establishments who want a system to be installed for them. There are, in general, four primary sources from where project requests come. Three of these sources are from within the organization. They are: departmental managers, senior executives and systems analysts. The fourth source is an outsider. It may be government agencies outside the organizational structure asking for information systems projects.

8.4.1 Requests from Department Managers

Department managers, who deal with day-to-day business activities, look for assistance within their departments. They make project requests when they are not satisfied with the time taken by their staff to complete a given job. Sometimes, it is found that there is duplication of work which gives rise to conflicts. In such cases, they discuss with other managers and administrators the clerical as well as
processing work regularly performed by them and then put forward proposals to their higher authorities to approve the installation and subsequent development of a computer-based system for office administration.

8.4.2 Requests from Senior Executives

Senior executives who are above departmental managers have a broader base than their managers and are required to take many tactical as well as strategic decisions. Chief Executive Officer (CEO), presidents, vice presidents, etc., are exposed more to the outside world in their activities and have more information about the organization as compared to departmental managers. They take the responsibility of the entire organization and their decisions affect more people in the organization. They contemplate over many issues that may affect their present business and accordingly plan future strategies. Therefore, they need various data related to the sensitive area of their business activities. This data is secret and critical to their business. There are many instances when this data gets leaked which results in the failure of their strategic business plan. These executives need a computer-based working system so that they can collect critical data, keep it secret and work on it. Thus, project requests submitted by them carry more weight and have a broader scope.

8.4.3 Requests from Systems Analysts

Many systems analysts feel it essential to have a system that eases their work. Systems analysts undertake many system development jobs, and they want a package of system and utility software that might help them carry out analysis to do their job in a better way. They also require some Computer Aided Software Engineering (CASE) tools. In such cases, systems analysts explore areas to develop projects. They prefer to either write a systems proposal themselves or persuade a manager to write a proposal for them. For example, in an organization, an analyst observes that the library information system is inefficient and takes more time in processing information. He may resort to preparing a project proposal seeking approval for a new library information system. Guided by the analyst who has enough idea on the new technology for improving the existing library information system, the concerned librarian may initiate the development of information system to the higher authority for approval.

8.4.4 Requests from Outside Groups

Apart from the three groups just discussed, there is a fourth group that requests for installing or developing a system. This group is from outside the organization. Sometimes, statutory bodies make project requests. There may be external agencies whose work is linked with the organization, and it becomes essential to maintain compatibility with the system of the organization with whom they are dealing. Project request can also come from them as well. Government contractors are bound by certain statutory obligations to use special cost accounting systems
and request comes from them as well. In general, new demands from external groups are also considered project requests. These demands may be for new systems or may require some modifications in the existing. Project requests originating from such sources are also very important.

8.5 PRELIMINARY INVESTIGATION

Preliminary investigation is the first step in SDLC. It begins once a project request is made. The purpose of this preliminary investigation is to evaluate the project request. However, this investigation does not completely lead to the description of the business system. Such investigation only helps in the collection of information for committee members to evaluate the merits of the project requests leading to an informed decision about the feasibility of the proposed project.

Systems analysts carry on the work of preliminary investigation with an aim to achieve the following objectives:
- Clarification and understanding of the project request
- Determination of the size of the project
- Cost assessment and decision on benefits of alternative approaches
- Determination of the technical and operational feasibility of alternative approaches
- Report of the investigation to management
- Recommendations on the acceptance or rejection of the proposal

During the preliminary investigation, a systems analyst gathers data through the following three primary methods:
- Reviewing organization documents
- On-site observations
- Conducting interviews

8.5.1 Reviewing Organization Documents

This is the first approach that a systems analyst adopts. He first learns about the organization involved in the project. For example, while reviewing an inventory system proposal, he gathers information to know about the working of the existing system in the department and about the people directly associated with the inventory system. The analyst obtains details by examining the organization’s charts and also carries out studies of written operating procedures. These procedures define important steps involved in receiving, managing and dispensing stock.

8.5.2 On-Site Observations

After gathering information at the first step, the analyst moves on to actual locations to collect data by on-site observation. Thus, the analyst or a group of analysts
directly observe the activities of the system. The purpose of this on-site observation is to get a close feel of the real system being studied. During this phase of observation, the analyst is able to observe the office environment, the workload of the system, the users involved in the operation, the methodology adopted for work, and the facilities provided by the organization to the users.

8.5.3 Conducting Interviews

The two techniques of investigation discussed till now reveal to the analyst the way a system operates, but these may not provide enough details to take a decision on the merits of a system’s proposal. Also, they do not reveal the users’ views on the current operations. These details can be gathered only by personal interaction with the users. The analyst then resorts to interviews to gather these details. Interviews give more information to the analyst about the nature of the project request; whether it is technically, economically and operationally correct.

When a request for an information system arrives, the preliminary investigation, which is the first activity, begins. This comprises of three parts:

(i) Clarification of request
(ii) Feasibility study
(iii) Approval of request

(i) Clarification of Request: Requests that come from employees and users in the organizations are not clear and it is difficult to decide the scope of work. This warrants the need to examine and clarify properly before carrying out system investigation.

(ii) Feasibility Study: It is an important outcome of the preliminary investigation which determines whether the system, for which the request has been made, is feasible or not. Feasibility study has three aspects as follows:

(a) Technical Feasibility: This is related to the technicality of the project. This ponders over the question whether the work for the project can be done with the existing equipment, the current software package and the available human resources. In case, a new technology is required, it is essential to know whether it is possible to develop it further.

Technical issues, which are generally pointed out during the feasibility stage, are as follows:

- Availability of necessary technology
- Technical capability to procure data and to use a new system equipment
- Possibility of future upgradation if developed
- Technical guarantees for accuracy and reliability over and above the factors like ease of access and security of data.

(b) Economic Feasibility: Every organization wants to develop a system that gives it some benefit in terms of financial return and that too at a reasonable
A system developed technically and installed properly must be profitable for the organization. Financial benefits should be equal to or more than the cost of the system. The analysts ponder over various queries of financial and economic nature during the preliminary investigation to estimate the following:

- The cost of full systems investigation
- The cost of hardware and software
- The benefits in the form of reduced costs of operation or fewer costly errors
- The cost if the proposed system is not developed

(c) Operational Feasibility. This feature of feasibility study is related to its operational aspect wherein the working of the hardware, the software and the human resource is to be taken into account. So, the question of whether the system will work if it is developed and implemented comes naturally. Another aspect related to human resource is whether there will be resistance from users who may not agree to accept the changes.

Proposed projects can be beneficial if turned into information systems meeting the requirements of operation for the organization. Important aspects of assessing the operating feasibility are as follows:

- Enough support for the project from the management as well as users. There may be resistance if people are accustomed to the present system and are not ready to think of any alternative system and resist a change.
- If an existing business methodology does not suit the users, a change takes place. This brings about a better and useful system in operation.
- Users’ involvement in the planning and development of the new system as a project is very much required. Involvement from the early stages, i.e., from the start of the project and during the development stage too, reduces the chances of resistance to a great extent.

If users feel that the proposed new system is not in their interest or may not produce the desired results, or is feared that it will have an adverse effect on the overall working personnel, then, there will be a sharp reaction and resistance to the installation of a new system.

Issues that appear minor in the beginning may grow and assume major proportions later on when the system is implemented. This warrants a careful consideration of the system’s operational aspects.

Feasibility studies are carried out by a selected group of people having expertise in information systems techniques. They have the ability to
understand the parts of the business or organization involved or affected by the project, and have enough skill in the systems analysis and design process.

To be judged feasible, a proposal for the specific project must pass all these tests. Otherwise, it is not considered a feasible project.

(iii) Approval of Request: Teams carrying out feasibility studies may not find all requested projects feasible. Out of so many project requests, only a few may be found worth pursuing. Projects found feasible and considered as desirable get listed in a schedule. Development work, in some cases, may start immediately if systems staff members are not busy with other ongoing projects. In case systems personnel are not available and are busy with other projects, management decides on setting priorities and then projects are scheduled accordingly. The estimation of cost, priority, completion time, and personnel requirements is made post approval. These projects are queued up and later on, when the other projects are completed, the proposed application development which is next in queue, is initiated.

Check Your Progress

4. What are the main sources of project requests?
5. What are the methods used by the systems analyst to gather data?
6. What are the technical issues that arise during the feasibility stage?

8.6 SYSTEMS DEVELOPMENT LIFE CYCLE

The constant need to make accurate and efficient software has led to the formalization of certain stages and phases in the process of program creation. Systems Development Life Cycle (SDLC) is a series of steps agreed upon by software developers in creating special software. Developers adhere to certain steps to ensure that they have the right software for the right demand.

SDLC is an approach and a set of activities carried out by systems analysts and systems designers to develop an information system. It consists of the following activities, which are to:

- Identify problems, opportunities and objectives
- Determine information requirements
- Analyse the system needs
- Design the recommended system
- Develop and document software
Remember that all subsystems in organizations are interrelated. A system cannot be implemented without considering its effect on the rest of the organization. Possible questions to be raised during project selection are as follows:

- Do we have support from management?
- Is this an appropriate time for project commitment?
- Does the project help the organization to achieve its goal?
- Do we have adequate resources and expertise?
- Is the development of the project worthwhile?

These requests are scrutinized by a committee to determine the orders that have to be approved. The approved system request is called planned system initiative. The requests that are not approved are called backlogged requests. A planned system initiative leads to the activities of SDLC.

8.6.1 Phases of the Systems Development Life Cycle

In many business organizations, all the phases and activities of software development are closely related. When a system owner or a user makes a request for a new system or some modifications in an existing system, the first system activity, i.e., identifying problems in the existing system, begins. Consider a scenario of a banking organization currently working in a manual working system. Now, the organization wants to computerize the entire working system. For this, the organization needs to follow all the phases of SDLC. The following are the steps that the organization needs to follow to implement the new system in the organization:

- Identify the problems in the existing manual system and the objectives of the proposed system.
- Determine the information required to implement the proposed system.
- Analyse the proposed system requirements.
- Develop the design to implement the proposed system.
- Implement and prepare the documentation of the proposed system.
- Test and maintain the working of the proposed system.
- Evaluate the performance of the proposed system.
Figure 8.6 shows the phases in the SDLC.

**Fig. 8.6 Phases in SDLC**

**Identifying Problems, Opportunities and Objectives**

Problems are undesirable situations that prevent an organization from attaining its goals, objectives and purposes completely. The steps that help in avoiding a variety of problems in an organization are as follows:

- Keeping a check on the behaviour of employees
  - High turnover
  - High absenteeism
  - High job dissatisfaction
- Listening and adhering to external feedback, e.g., customers, suppliers, vendors, etc.
  - Suggestions
  - Lowering or loss of sales
  - Complaints
Checking performance criteria against output

- Multiple errors
- Work not completed efficiently
- Work done either incorrectly or incompletely or slowly

For problem detection, it is important to observe the behavior of employees and listen to external feedback. When accounting and reacting to problems, the systems analyst plays the role of consultant, supporting expert and change agent. The systems analyst should be able to detect where processes can be improved.

An opportunity is a chance to improve a business system even if no problem exists. Directives are the requirements imposed by management or by the government agencies. A problem for a manager might be turned into an opportunity for improvement by an alert systems analyst. Improvement can be defined as changes that result in benefits. Opportunities for improvement include the following processes:

- Speeding up a process
- Eliminating unnecessary steps
- Reducing errors in input by changing forms and screens
- Combining processes
- Reducing redundant output
- Improving users’ satisfaction
- Improving integration of systems or subsystems

The systems analyst should know what is happening in a business, and together with other organizational members, should identify the problems. According to the systems analyst, opportunities are situations that can be improved by using computerized information systems. The systems analyst must be aware of what the business is trying to do, i.e., the objective of the business, and then find those suitable aspects of information systems applications, which can help the business to fulfill its objectives.

An important outcome of this stage is the determination of the feasibility of the proposed system. Feasibility study has four aspects, which are economic feasibility, technical feasibility, operational feasibility, etc.

Economic feasibility is the measure of the effectiveness of a project or solution in terms of cost. It is also known as the cost–benefit analysis. Technical feasibility measures whether the solution can be supported by existing technology or not. The systems analyst must find out whether current technical resources can be upgraded or added to in a manner that fulfills the request under consideration. Operational feasibility measures whether the system will be used if it is developed and implemented or whether there will be resistance from users that will affect the possible system benefits. The people involved in this phase are users, analysts and systems managers coordinating the project. Activities in this stage involve...
Information System
Analysis and Design

NOTES
interviewing user management, summarizing the knowledge obtained, estimating
the scope of the project and documenting the results. The output of this phase is a
feasibility report containing a problem definition and a summary the objectives.
The management must then take a decision on whether or not to proceed with the
proposed project.

Determining Information Requirements
The systems analyst tries to comprehend the information that is required by the
users to execute their work. Information requirement determination involves studying
the current business system to find out how it works and where improvements
should be made. System study results in an evaluation of how current methods are
working and whether adjustments are possible or not.

Sampling and analysing data, interviewing, questionnaires, etc., can serve
as tools to define information requirements. Sampling can be defined as the process
of systematically selecting representative elements of a population. Analysing the
documents helps to understand how organizational members are engaged in the
process of organizing.

Interviewing is a common method used by systems analysts for collecting
data on information requirements. An interview is a directed conversation with a
specific purpose that uses a ‘question and answer’ format. Questionnaires are a
technique for gathering information from the people in the organization who may
be affected by the current and proposed systems. By using questionnaires, you
can quickly gather huge amounts of data about how users feel about the current
system, what problems they are experiencing with their work and what they expect
from a new or modified system.

An observation is another method used for gaining information on how things
are actually done. Observations must be structured and systematic in order to
correctly interpret the findings. The analyst must know what is being observed.

The people involved in this phase are the systems analysts, users and
operation managers. By the time this phase is about to come to an end, the analyst
must be in a position to comprehend how the business works and have complete
information regarding the goals, people, data and processes involved.

Analysing System Needs
The determination of information requirements is a critical stage in the systems
development process. The question of the ‘right system’ to be developed, and
which ‘work in right direction,’ is settled at this stage. If the defined system is
‘wrong’ during the determination of system requirements, then the subsequent
processes are of no use.

Statistics prove that addition of features or changes in the developed system
will cost fifty to hundred times more than it will cost to change during the analysis
and design stage.
James Withered identifies the following are the common mistakes that usually occur in the determination of system requirements:

- Systems analysts assume that managers know what information they need.
- Systems analysts do not determine the requirements for all the decision-makers. They focus only on the business functions requesting a new information system.
- Systems analysts tend to determine requirements for managers one at a time whereas they should do it as a group process. The disadvantage of this method is that sometimes managers cannot think of everything they need when individually asked to, but a group process can settle down this issue.
- Systems analysts sometimes ask the wrong questions to determine information requirements. An obvious question to the managers is ‘What information do you need from the new system?’ Sometimes analysts act as an ‘order taker’ than a ‘problem solver.’ The problem solver must have creatively determined how to obtain answers to requirements determination questions through less frequently asked indirect questions.
- Systems analysts expect managers to analytically determine their exact detailed requirements and get it right the first time.

In this phase, the systems analyst analyses the system needs and also the structured decisions. In systems analysis, various tools and techniques are used to plan for the future system by analysing and recording the performance of the current system. The main tools that are used in structural systems analysis include data flow diagrams (DFD), data dictionary, decision trees, decision tables, etc.

DFD can be used in this stage as a tool to chart the input, processes and output of the business functions in a structured graphical form. It is a graphical method that illustrates the flow of information and the transformations that are applied as data travels from input to output. Data dictionaries are an integral part of structured analysis because data flow diagrams themselves do not fully describe the system data elements. Data dictionaries provide additional information about a system and store details and descriptions of data flows, data stores and processes.

A decision tree approach represents a method for depicting alternative actions and conditions within a horizontal tree framework. These are used when complex branching occurs in a structured decision process. A decision table is an excellent tool for expressing complex logical relationships in a highly understandable and precise manner. A decision table is a matrix containing rows and columns that are used to define relationships.

Finally, the systems analyst prepares a system proposal that summarizes what has been found, provides cost–benefit analysis of alternatives and makes recommendations on what should be done. The system proposal represents the
summary of the systems analyst’s work up to that point. A systems proposal should include:

- A covering letter
- The project’s title page
- Table of contents
- Executive summary
- Documentation including the outline of systems study
- Exhaustive results of the systems study
- Systems options
- Systems analysts’ recommendations
- Proposal summary
- Appendices

If one of the recommendations is acceptable to the management, then the systems analyst proceeds along that course.

8.6.2 Feasibility Analysis

Preliminary investigations examine the feasibility of the software project under study. In the preliminary investigation and feasibility study, the analyst collects information about what the end-user expects from the new system. The feasibility study provides enough information so that an alternative can be selected for the development of the new system. Feasibility study helps management to make a decision about whether the system under study is feasible. Since it is not possible to implement all proposed projects, feasibility study should be completed within a short period of time. Some possible objectives for requesting projects are as follows:

- Improving accuracy of data input (reducing errors)
- Eliminating unnecessary reports (duplicate reports, etc.)
- Integrating business subsystems
- Upgrading customer services
- Shortening data processing time

The foundation for the project effort, in totality, is set by a project team at the very beginning of the SDLC. While initiating a project, it is very important to justify it, that is, to determine whether it should be built or not. However, the unfortunate part is that it is never justified properly. It will be beneficial if the non-feasible projects are discarded at this stage. This will prevent unnecessary investments from being made. The primary objective of the feasibility or justify stage is to define the best solution for implementing the project and to justify its need and appropriateness.
Steps involved in Feasibility Analysis

Figure 8.7 depicts the justify stage process pattern. There are several activities involved in justifying a project. Creation of a feasibility study involves the following steps:

- Determination of the alternatives of implementation
- Assessment of each alternative economic feasibility
- Assessment of each alternative technical feasibility
- Assessment of the operational feasibility of each option
- Selection of an alternative
- Identification of potential risks

Fig. 8.7 The Justify Stage Process Pattern (Selection of a Feasible Solution)

The first phase of the feasibility study is to identify the possible implementation alternatives for a project. Contrary to what is popularly believed, there are many options available for implementation of a project, including the following:

- Doing nothing
- Implementing using a variety of technologies
- Buying a similar system or outsourcing its development

What is important is to identify many alternatives for a project that are viable. This facilitates their easy comparison and assessment, which in turn, facilitates the selection of the best option for an organization.

Technical, economical and operational areas of the feasibility study must be addressed for the further development of the system. The following steps are involved in feasibility analysis:

- Decision regarding feasibility of the project should be made by the management and not the systems analyst.
- Feasibility data gathered by experts and professionals forms the basis of these decisions, and it is presented by the analyst.
- The systems analyst must address the three areas—technical, economic and operational feasibility—in the preliminary study of the system under development.
- The requested system project must be studied quickly.
The study should result in a reasonable information output.
Following the preliminary study, the projects that successfully fulfill the three feasibility criteria should be selected for a detailed system study.
At this juncture, the systems analyst suggests the most suitable system project to the management.
At this point, a commitment from the management implies that only the systems studied can proceed.

The following are the steps involved in conducting the feasibility analysis:

- **Step 1:** Form a project team and appoint a project leader
- **Step 2:** Develop system flowcharts
- **Step 3:** Enumerate candidate solutions
- **Step 4:** Identify, analyse and describe the features of candidate systems
- **Step 5:** Evaluate performance and cost effectiveness of each candidate solution
- **Step 6:** Choose the best solution
- **Step 7:** Prepare a formal feasibility report and submit it to the management

### 8.6.3 Design

Design is a blueprint to define the tasks that need to be performed to build a system. It forms the most creative and challenging phase of SDLC that describes the final system and at the same time the process to develop the final system. During the design phase, the technical specifications of the proposed system are specified. It also includes the development of programs and program testing.

The design process of a software system involves two important phases—logical design and physical design. During logical design, the dataflow diagrams developed during the structured analysis phase are converted into a design that reveals various kinds of quality attributes supported by a structured design. However, during the physical design phase, necessary changes are made to the logical design to incorporate the changes in end-user requirements.

The following are the stages involved in the design process of a software system:

- Developing a preliminary design for the problem model
- Improving the initial design to include required features
- Evaluating and fine-tuning the features of the design
- Modifying the design to incorporate implementation limitations
- Developing detailed system documentation
- Obtaining approval of the design from the top management
- Testing the developed design if the design is accepted
In this phase, the systems analyst develops the logical design of the information system. He designs accurate data entry procedures to ensure that the data going into the information system is correct. He has to decide about the logical design of the user interface. This phase also includes designing files or databases that will contain the data required by the decision makers of the organization. The systems analyst works with users to design output either on-screen or printed that meets their information needs.

Finally, the systems analyst designs the controls and backup procedures to protect the system and the data. He produces program specification packets for programmers, that contain input and output layouts, file specifications, processing details. The following are the points that should be kept in mind at this stage:

- Functions performed by the system
- Interaction between functions
- Information to be transported by the system
- Input transferred to produce output
- The type of work performed by the system
- The source from where the system gets information to perform the task
- The destination where the result is given by the system

**Developing and Documenting Software**

The analysts along with the programmers work towards developing the necessary software. They also work with users to develop effective documentation such as manuals, online help, etc., for the software. Software developers may install purchased software or they may write new, custom designed programs. The choice depends on the various factors, such as cost and the time available to write the software.

In organizations, programmers perform tasks such as documentation of programs. They also explain why procedures are coded in specific ways. In some organizations, programmers are a part of their personal staff. In other firms, outsourcing may be done. Documentation is essential to test the program and carry on maintenance once the application has been installed.

**8.6.4 Testing and Evaluation**

The program testing is utilized to showcase the existence of bugs, and never to prove their non-existence.

If the results delivered by the system are different from the expected ones in just one case, this shows that the system is incorrect. This phase involves systems analysts and programmers. The information system, which is developed, is tested before being used in this phase. It is much less costly to identify and rectify the problems before the system is handed over to users. Testing is a direct responsibility
(i) **Program Testing**: Program testing tests individual programs for syntax error and logic error. A syntax error is a program statement that violates one or more rules of the language or package in which it is written. Logic error deals with the incorrect data fields, out of range items and invalid combinations.

(ii) **String Testing**: Each program is tested with other programs to see that they interact well. Each portion of the system is tested against the entire module with test and live data.

(iii) **System Testing**: System testing includes the forced system failure and validation of the system. The whole system is tested to verify that the backup and recovery procedures are effective and efficient.

(iv) **User Acceptance Testing**: User motivation and knowledge are crucial for the successful implementation of an information system. User acceptance test has the objective of selling the user the validity and reliability of the system.

The maintenance of the system begins in this phase and is carried out on a routine basis throughout the life of the information system. Maintenance may include updates also. Maintenance of the systems is an important issue. Those systems should be installed or modified which have a reasonable useful life. Well-designed software reduces the maintenance cost. Auditing is the way of assuring the quality of the information contained in the system. Both internal and external auditors are used to determine the reliability of the systems information.

### 8.6.5 Implementation

In this phase, the systems analyst helps to implement the information system. The process of ensuring that the information system is operational and then allowing users to take over its operation for use and evaluation is called implementation. This involves training the users to handle the system. The systems analyst needs to plan for a smooth conversion from the old system to the new one by converting files from old formats to new ones.

The total evaluation of the system is done in this final phase. After the system is installed, it must be maintained for the following two reasons—to correct the software errors and enhance the software’s capabilities. The approaches to implementation are:

- Using different strategies for training users and personnel and making sure that each user understands any new role that he/she must take on
- Choosing a conversion strategy
- Evaluating the new or modified information system
Training

Systems analysts are engaged in educational processes with users through training. The trainer and the trainee determine training strategies. The systems analyst ensures that anyone whose work is affected by the new information system is properly trained. Possible training sources include the following:

- Vendors
- Systems analysts
- External paid trainer
- In-house trainers
- Other system users

Guidelines for training are as follows:

- Establishing measurable objectives
- Using appropriate training methods
- Selecting suitable training locations
- Employing understandable training materials

The objectives of a training program are as follows:

- To enhance communication among the members of the development team
- To provide knowledge about the new system to the employees of a company
- To increase user awareness
- To obtain support for the new system from the top management
- To provide information to the employees and the top management about the problems and issues that can be handled by the new system

Conversion

To convert the old system of information into the new or customized system, there are five strategies which are as follows:

- Parallel conversion
- Direct changeover
- Distributed conversion
- Modular prototype conversion
- Gradual (phased) conversion

Security of computer facilities, stored data and information generated is part of a successful conversion. The three interrelated aspects of security are as follows:

- Physical security
- Logical security
- Behavioural security
Evaluation

Many different evaluation approaches are available for evaluating information systems, including the revised decision evaluation approach, user involvement evaluations and cost-benefit analysis. The information system utility approach is a broad and helpful method to determine the accomplishment of a system that is fully developed.

(i) **Form Utility**: It answers all questions regarding the type of output allocated to the decision-maker.

(ii) **Possession Utility**: It answers all questions as to the receiver of the output.

(iii) **Time Utility**: It answers all questions regarding the time of information delivery.

(iv) **Place Utility**: It answers questions regarding information that is distributed.

(v) **Goal Utility**: It answers questions on whether the output has value in achieving organization objectives.

(vi) **Actualization Utility**: This process involves introduction of information and utilization by the decision-maker.

8.6.6 Project Review

Project review does the job of scrutinizing the set of steps included in SDLC. This checks the work progress, its status as on date, its effectiveness, efficiency, completion status and specific problem areas. The required steps are reviewed by the following themes:

**Project Initiation and Planning**

This is the first phase in the project in which business problems are analysed and objectives are identified. A project can start only when it is found feasible. For this, a feasibility study is carried on with an objective to investigate the possible solutions for problems and decide among the various alternative solutions and give final recommendations. A project is selected or initiated to deliver the approved solution only after this.

Planning means setting out the steps required to complete a project in a finite framework of time. Accordingly, activities, tasks and timeframe are decided and resources are allocated to each task. A financial plan decides phasing of expenditure on materials, equipment and human resources to meet the quality targets along with measures to be taken to control these expenditures. Planning also includes identification of potential risks and ways and means to handle them.

This also requires a communication plan, taking in consideration, the criteria to interact with a client’s expectations and acceptance. A procedure has to be adopted to inform stakeholders and finally handle the procurement plan.
Project Execution, Monitoring and Control

A project plan contains activities and tasks that are to be executed to deliver the project to the client. Execution requires timely allocation of resources. Project plan is also made on a network that is a pictorial view of all the activities linked together in a particular fashion. This gives a clear view of activities that help timely allocation of resources.

A network model, typically a Program Evaluation Review Technique (PERT) chart and a Critical Path Method (CPM) chart, are used to see a coordinated view of each and every activity. A bar chart or Gantt chart is also used to monitor project activities. Every activity must end in some event. Thus, you can monitor the output of each activity checking its quality and ensuring that it meets the criteria of acceptance. After all the activities are completed, the project becomes ready for closing.

Project Audit and Effectiveness Review

Audit means a formal investigation of a project, following some strict guidelines.

In this step, a complete review is made to judge the effectiveness of the project. Some statutory obligations are also required to be fulfilled and certain well-defined procedures are to be adopted. Effectiveness of the completed project is judged against some standard.

Project Success and Monetary Review

Success of the project is judged on the basis of predefined success criteria. In the field of software projects, the success criteria may be entering a particular number of lines of codes and performing a particular function before putting it for further test.

The stage to which the work has progressed and the extent to which the assets are being improved is reviewed at this stage.

Project Closing

Once all project activities are completed and an audit is made, it is ready to be finally handed over to the client. After this, the suppliers’ contracts are terminated and documents are handed over and resources are released. Stakeholders are informed and finally post implementation executions are made. On closing the project, further testing and trial may be carried out to convince the client about the quality of deliverables.

Despite the project and governance team’s best efforts, projects established with appropriate processes and controls may find it difficult to deliver the benefits envisaged in the original business plan before the start of the project. Moreover, often the client demands some features even after the completion of the project. Common vision can perform a review of all elements of a project that covers
Different phases of a project review are shown in Figure 8.8.

Table 8.2 shows the checklist of the project review phenomena. This is a checklist containing some points for review. Figure 8.9 shows a standard review flow chart.

**Table 8.2: Ten Point Project Review Checklist**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Reviewed Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review the objective of the project in the review session to focus on the problem.</td>
<td>Revisit the problem statement.</td>
</tr>
<tr>
<td>Have any invited reviewers pointed out loopholes in the project?</td>
<td>Focus first on the issues by invited reviewers.</td>
</tr>
<tr>
<td>Review the status of project against the plan.</td>
<td>PERT chart used by Project team to plan the project.</td>
</tr>
<tr>
<td>Check on necessity of mid-course correction.</td>
<td>See the problem statement as defined in the scope.</td>
</tr>
<tr>
<td>Issues on old project, if any.</td>
<td>Think of planned action taken to review the issues of old project.</td>
</tr>
<tr>
<td>Are any new issue?</td>
<td>Collection of raw data is needed for each new issue?</td>
</tr>
<tr>
<td>Criteria for next project milestone.</td>
<td>Check for the project milestone.</td>
</tr>
<tr>
<td>Decide on next review sessions.</td>
<td>Set date, time and location of the project.</td>
</tr>
</tbody>
</table>
7. What is SDLC?
8. What is program testing?

**8.7 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS**

1. A system is a set of organized principles, tasks, activities and procedures that defines the working of a particular establishment to achieve an objective.

2. Business comprises a set of activities pertaining to commerce; manufacturing or services resulting in producing economic output intended to make a profitable gain. A business system thus consists of many subsystems, each performing a particular set of functions to achieve the overall task of producing meaningful output. Functionally, every business system has a few subsystems mainly planning, product generation, customer delivery and customer service.
3. The project selection process adds strategic value to many organizations. It helps them in several ways such as to:
   - Adopt an approach to gain profit or reduce cost on resources
   - Receive funds from financial institutions

4. There are, in general, four primary sources from where project requests come. Three of these sources are internal. These are from within an organization and are made by the departmental managers, senior executives and systems analysts. The fourth source is external. It may be government agencies outside the organizational structure asking for information systems projects.

5. During the preliminary investigation a systems analyst gathers data through three primary methods which are as follows:
   - Reviewing organization documents
   - On-site observations
   - Conducting interviews

6. The technical issues that are generally pointed out during the feasibility stage are as follows:
   - Availability of necessary technology.
   - Technical capability to get data for using a new system for new equipment.
   - Possibility of future upgradation if developed.
   - Technical guarantees for accuracy and reliability over and above the factors like ease of access and security of data.

7. SDLC, which stands for Systems Development Life Cycle, is an approach and a set of activities carried out by systems analysts and system designers to develop an information system.

8. Program testing tests individual programs for syntax errors and logic errors. A syntax error is a program statement that violates one or more rules of the language or package in which it is written. Logic error deals with the incorrect data fields, out of range items and invalid combinations.

8.8 SUMMARY

- A system is a set of organized principles, tasks, activities and procedures that defines the working of a particular establishment to achieve an objective. It is logically arranged and governed by rules, regulations and policies.
- A system is defined and determined by its boundaries and objectives. It is an arrangement of smaller systems in a logical order. When many smaller systems together make a larger system, the smaller systems are called the subsystems of the larger system and the larger system is called a super system.
- A system, which is influenced by environmental changes and has an exchange with the environment, is called an open system.

- In system analysis and design, project selection is undertaken to modify the existing system. The project selection process adds strategic value to many organizations.

- There are, in general, four primary sources from where project requests come. Three of these sources are from within the organization. They are: departmental managers, senior executives and systems analysts. The fourth source is an outsider. It may be government agencies outside the organizational structure asking for information systems projects.

- Preliminary investigation is the first step in SDLC. It begins once a project request is made. The purpose of this preliminary investigation is to evaluate the project request.

- Feasibility study is an important outcome of the preliminary investigation which determines whether the system, for which the request has been made, is feasible or not.

- Systems Development Life Cycle (SDLC) is a series of steps agreed upon by software developers in creating special software. Developers adhere to certain steps to ensure that they have the right software for the right demand.

- Problems are undesirable situations that prevent an organization from attaining its goals, objectives and purposes completely.

- The systems analyst should know what is happening in a business, and together with other organizational members, should identify the problems. According to the systems analyst, opportunities are situations that can be improved by using computerized information systems.

- The systems analyst tries to comprehend the information that is required by the users to execute their work. Information requirement determination involves studying the current business system to find out how it works and where improvements should be made.

- In the preliminary investigation and feasibility study, the analyst collects information about what the end user expects from the new system. The feasibility study provides enough information so that an alternative can be selected for the development of the new system.

- Design is a blueprint to define the tasks that need to be performed to build a system. The design process of a software system involves two important phases—logical design and physical design.

- Project review does the job of scrutinizing the set of steps included in SDLC. This checks the work progress, its status as on date, its effectiveness, efficiency, completion status and specific problem areas.
8.9 KEY WORDS

- **System:** It is a set of organized principles, tasks, activities and procedures that defines the working of a particular establishment to achieve an objective. It is logically arranged and governed by rules, regulations and policies.

- **Preliminary investigation:** Its purpose is evaluation of the project request. Such investigation only helps in the collection of information for committee members to evaluate the merits of the project requests leading to an informed decision about the feasibility of the proposed project.

- **System development life cycle:** It is an approach and a set of activities carried out by systems analysts and system designers to develop an information system.

8.10 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short-Answer Questions**

1. What is meant by a business system?
2. Why is project selection undertaken?
3. What do you understand by preliminary investigation?
4. Differentiate among problems, opportunities and directives.
5. How do you determine the user requirements for a system?
6. Mention the different types of feasibility measurements used in a system.
7. Define the terms economic feasibility, operational feasibility and technical feasibility.
8. What are the different types of testing?

**Long-Answer Questions**

1. What are the sources of project requests? Explain.
2. Explain preliminary investigation with the help of example.
3. Explain the software development life cycle.
4. “Program testing can be used to show the presence of the bugs, but never to show their absence.”
5. Discuss. What does testing mean? Explain.
6. Discuss the activities carried out during the implementation stage.
8.11 FURTHER READINGS


UNIT 9 HARDWARE AND SOFTWARE MANAGEMENT

Structure
9.0 Introduction
9.1 Objectives
9.2 Server Configuration and Managing the Server
  9.2.1 Managing the Server
  9.2.2 RAID Application
9.3 Software Licensing and AMC Issues
9.4 Answers to Check Your Progress Questions
9.5 Summary
9.6 Key Words
9.7 Self Assessment Questions and Exercises
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9.0 INTRODUCTION

In this unit, you will learn about the various activities required for server configuration and software licensing. The term configuration can be referred to either software or hardware or their combination. Whenever you install a new device, you have to configure it for proper functioning. Software licensing promotes the use and redistribution of software and removes the issues related with software piracy.

9.1 OBJECTIVES

After going through this unit, you will be able to:
- Discuss the activities in server network configuration
- Discuss the RAID application
- Understand the software licensing and AMC issues
9.2 SERVER CONFIGURATION AND MANAGING THE SERVER

Server network configuration includes the following activities:

1. Enabling protocols
2. Modifying the port or pipe used by a protocol
3. Configuring encryption
4. Configuring the SQL Server Browser service
5. Exposing or hiding the SQL Server Database Engine on the network
6. Registering the Server Principal Name

Most of the time you don’t need to change the server configuration but configure the network protocols. Network configuration for SQL Server is done using SQL Server Configuration Manager. For earlier versions of SQL Server, use the Server Network Utility that ships with those products.

Protocols

For enabling or disabling the protocols used by SQL server, you can use SQL server configuration manager. You can also use this manager to configure the options available for protocols. All protocols have equal access and must be enabled all protocols that you want clients to use. For information about which protocols you should use, see Enable or Disable a Server Network Protocol and Default SQL Server Network Protocol Configuration.

Changing/Modifying a Port

You can configure the TCP/IP protocol to listen on a designated port. By default, the default instance of the Database Engine listens on TCP port 1433. Named instances of the Database Engine and SQL Server Compact are configured for dynamic ports. This means they select an available port when the SQL Server service is started. The SQL Server Browser service helps clients identify the port when they connect.

When configured for dynamic ports, the port used by SQL Server may change each time it is started. When connecting to SQL Server through a firewall, you must open the port used by SQL Server. Configure SQL Server to use a specific port, so you can configure the firewall to allow communication to the server. For more information, see Configure a Server to Listen on a Specific TCP Port (SQL Server Configuration Manager).

Changing a Named Pipe

The named pipe protocol can be configured to listen on a designated named pipe. The default instance of SQL Server Database Engine listens on pipe \\pipe\sql\query...
for the default instance and `\pipe\MSSQL$<instancename>`\sql\query for a named instance. The Database Engine can only listen on one named pipe. You can change the pipe to another name. The SQL Server Browser service helps clients to identify the pipe when they connect. You can see Configure a Server to Listen on an Alternate Pipe (SQL Server Configuration Manager) for more information.

**Force Encryption**

You can configure the database engine to require encryption while communicating with client applications. You can see Enable Encrypted Connections to the Database Engine (SQL Server Configuration Manager) for more information.

**Extended Protection for Authentication**

This option is available for OS that support extended protection using service binding and channel binding. Connect to the database engine using extended protection is available for more information.

**Authenticating by Using Kerberos**

Kerberos authentication is supported by the SQL server. You can see Register a Service Principal Name for Kerberos Connections and Microsoft Kerberos Configuration Manager for SQL Server for more information.

**Registering a Server Principal Name (SPN)**

The Kerberos authentication service uses an SPN to authenticate a service. You can use Register a Service Principal Name for Kerberos Connections.

When connecting with NTLM, SPNs may also be used to make client authentication more secure. You can use Connect to the Database Engine Using Extended Protection.

**SQL Server Browser Service**

The SQL Server Browser service helps client computers to find instances of SQL Server. It doesn’t need to be configured, but must be running under some connection scenarios. You can use SQL Server Browser Service (Database Engine and SSAS) for more information.

**Hiding SQL Server**

SQL Server Browser responds to queries, with the name, version, and connection information for each installed instance. The Hide Instance flag of SQL server indicates that Server Browser should not respond with information about this server instance. You can use Hide an Instance of SQL Server Database Engine for more information.
9.2.1 Managing the Server

Server management involves system administration duties. It encompasses initial server setup tasks, service monitoring, regular server maintenance and optimization, and security. Whilst a larger corporation can staff an IT department, pay salaries and manage employees who complete these tasks, it is usually not a viable option for a smaller business. Using a server management company instead is a great way to alleviate the headaches that come with the growth of your business. Your systems will be monitored for health and serviced on a regular basis without having to find and pay for full time employment of an onsite systems administrator.

Backups

It refers to the making copies of data for the purpose of recovery in case of data loss. Secondarily, it also refers to making copies for historical purposes, such as for longitudinal studies, statistics or for historical records or to meet the requirements of a data retention policy.

9.2.2 RAID Application

RAID stands for Redundant Array of Independent Disks. It was originally named as Redundant Array of Inexpensive Disks. It is a data storage virtualization technology which combines multiple physical disk drive components into one or more logical units for the purposes of data redundancy, performance improvement, or both. This technology is basically used to increase the reliability and performance of data storage. There are various levels of RAID which you have studied earlier in this book.

9.3 SOFTWARE LICENSING AND AMC ISSUES

A software license is a legal contract that provides the rights to redistribution or use of software. There are two categories of licenses i.e. perpetual and term license. Perpetual license have unlimited validity to use the software because the user owns the license. The term license has limited validity usually one or two years. Microsoft provides three types of license as follows:

1. **OEM license**: it is provided to the PC manufacturers.
2. **Retail license**: it is given for products that can be bought off the shelf.
3. **Volume license**: it is given to users whose requirement is large and spend a minimum of Rs.5 lakh on a specific product.

**AMC Issues**

A computer AMC is a contract that assure periodic upkeep and maintenance of hardware and software of your computer, and fixing any related problems which arise during the tenure of the contract. Another advantage of having an Annual Maintenance Contract AMC is the comparatively low cost for repairing a PC.
Annual Maintenance Contract Issues

In terms of maintenance of software, conventional software support and maintenance typically involves bug fixes and security updates, technical assistance and access to upgrades. Most businesses opt for AMCs for the software that they use. However, AMCs suffer from various issues such as:

- There is a lack of clarity over legal rights in the software maintenance market.
- There is also confusion among businesses over whether they could terminate a software maintenance contract, and if it was possible to then continue support at a later date.
- Businesses also fear penalties and so-called back maintenance while contemplating renewing support maintenance agreements.
- There is also a lack of accountability in the software business.

Check Your Progress

1. What is the full form of RAID?
2. What is software license?

9.4 ANSWERS TO CHECK YOUR PROGRESS

1. RAID stands for Redundant Array of Independent Disks.
2. A software license is a legal contract that provides the rights to redistribution or use of software.

9.5 SUMMARY

- The term configuration can be referred to either software or hardware or there combination. Whenever you install a new device, you have to configure it for proper functioning.
- For enabling or disabling the protocols used by SQL server, you can use SQL server configuration manager.
- Server management involves system administration duties. It encompasses initial server setup tasks, service monitoring, regular server maintenance and optimization, and security.
- A software license is a legal contract that provides the rights to redistribution or use of software.
- AMC is a contract that assure periodic upkeep and maintenance of hardware and software of your computer, and fixing any related problems which arise during the tenure of the contract.
9.6 KEY WORDS

- **Database**: It is a data structure that stores organized information.
- **SQL**: It is structured query language used for storing, manipulating and retrieving data in the database.

9.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short-Answer Questions**

1. List the various activities in network configuration.
2. What is server management?

**Long-Answer Questions**

1. Explain the activities in network configuration.
2. What are AMC issues? Discuss.

9.8 FURTHER READINGS


UNIT 10 NETWORKING:
TECHNOLOGICAL
DEVELOPMENT IN
COMMUNICATION

Structure
10.0 Introduction
10.1 Objectives
10.2 Transmission Media
   10.2.1 Bounded Media
   10.2.2 Unbounded Media
10.3 Digital Networks
10.4 Answers to Check Your Progress Questions
10.5 Summary
10.6 Key Words
10.7 Self Assessment Questions and Exercises
10.8 Further Readings

10.0 INTRODUCTION

In this unit you will learn about the Transmission media, Digital Network, LAN, MAN, WAN, PSTN, ISDN, Networking. The successful transmission of information to others, very clearly, is considered of a great increased value. The guided media includes all wired media, also referred to as conducted or bounded media. The main limiting factor of a twisted pair cable is caused by a phenomenon known as the skin effect. Satellite radio is a non-terrestrial microwave transmission system utilizing a space relay station. Infrared light transmissions have existed for many years but their use has been limited to TV remote controls and wireless slide projector remote controls. A digital signal can be transmitted through a broadband and narrow band medium. A metropolitan area network (MAN) covers larger geographic areas such as cities or districts. ISDN is a network architecture in which digital technology is used to convey information from multiple networks to the end user. This information is end-to-end digital.

10.1 OBJECTIVES

After going through this unit, you will be able to:
- Understand the digital network
- Discuss about the satellite communication
- Discuss about Noisy channel
• Define the Satellite cellular telephone
• Describe the Microwave transmission

10.2 TRANSMISSION MEDIA

The successful transmission of information to others, very clearly, is considered of a great increased value. This is a basic principle that is well understood in the IT age of today. The transmission of information across a distance necessarily involves some form of transmission medium. The selection of physical transmission media that serve to transport the information is critical to its successful conveyance. In interactive communication, the medium can be critical to the message. The transmission of an electrical signal requires the use of a transmission medium, which normally takes the form of a transmission line. There are various ways to transmit the signal. These can be broadly categorised into:

- guided media
- unguided media

Guided Media

The guided media includes all wired media, also referred to as conducted or bounded media.

Unguided Media

The second category includes all traditional wireless media, also referred to as radiated, or unbounded.

In the transmission of signal the data is encoded to energy and then energy is transmitted. Similarly, at the receiving end the energy is decoded back to data. This energy can be electrical, light and radio, etc. Therefore this transmitted energy is carried through a medium, which depends upon the type of energy being transmitted. The energy in different forms have different properties and therefore cannot be transmitted using the single media. They have different requirements for transmission including standard specified hardware for data encoding and creating links to transmission medium. Media can be copper, glass and air as bounded and unbounded media respectively.

Transmission Concepts and Terms

Before discussing the different kinds of transmission medium, it becomes necessary to know about the basic concepts and terminologies associated with the transmission of a signal.

Frequency Spectrum

The symbols in Table 10.1 have the following meanings:

- \( K \) (Kilo) = 1,000,
- \( M \) (Mega) = 1,000,000 (1 million),
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G (Giga) = 1,000,000,000 (1 billion)
T (Tera) = 1,000,000,000,000 (1 trillion)
cm = centimeter (1/100 metre)
mm = millimeter (1/1,000 metre)
µ = micron (1/1,000,000 metre)

In the transmission of data the range of carrier frequencies is based on the nature of the medium and the requirements of the applications supported. Therefore, frequency spectrum may be defined as the range of frequencies being supported by a particular transmission medium. The actual range of frequencies supporting a given communication is known as a pass band. These are given in Table 10.1.

Bandwidth

In a very general way bandwidth may be defined as the range of frequencies, which a channel is allowed to pass through the signals between that frequency ranges. In other words we may say that bandwidth is the difference between the highest and the lowest frequencies of a band and is expressed in Hertz. In general, the greater the bandwidth, the higher will be the data transmission rate or throughput. It should be noted that bandwidth and data transmission rate are very closely interrelated to each other. Clearly, any transmission system becomes more attractive if the available bandwidth is greater, introduced errors are fewer, and the maximum distance between various network elements (amplifiers, repeaters, and antennae) is greater.

Distances

The higher frequency signals offer greater bandwidth; they also generally suffer to a greater extent from signal attenuation than lower frequencies. This fact results in more errors in transmission, unless the amplifiers/repeaters are spaced more closely together. It clearly demonstrates the close and direct relationship between bandwidth, distance, and error performance.

<table>
<thead>
<tr>
<th>Name of Band</th>
<th>Frequency Range</th>
<th>Wavelength</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audible</td>
<td>20 Hz–20 kHz</td>
<td>&gt;100 km</td>
<td>Voice</td>
</tr>
<tr>
<td>Extremely Very Low Frequency (ELF/VLF) Radio</td>
<td>3 kHz–30 kHz</td>
<td>100–10 km</td>
<td>Radio Navigation, Weather, Submarine Communications</td>
</tr>
<tr>
<td>Low Frequency (LF) Radio</td>
<td>30 Hz–300 kHz</td>
<td>1–10 km</td>
<td>Radio Navigation, Maritime Communications</td>
</tr>
<tr>
<td>Medium Frequency (MF) Radio</td>
<td>300 kHz–3 MHz</td>
<td>1 km–300 m</td>
<td>Radio Navigation, AM Radio</td>
</tr>
<tr>
<td>High Frequency (HF) Radio</td>
<td>3 MHz–30 MHz</td>
<td>100–10 m</td>
<td>Citizen Band (CB) Radio</td>
</tr>
<tr>
<td>Very High Frequency (VHF) Radio</td>
<td>30 MHz–300 MHz</td>
<td>10–100 m</td>
<td>Maritime (MAR), VHF TV, FM Radio</td>
</tr>
<tr>
<td>Ultra High Frequency (UHF) Radio</td>
<td>300 MHz–3 GHz</td>
<td>1–10 cm</td>
<td>Maritime, Satellite, UHF TV</td>
</tr>
<tr>
<td>Super High Frequency (SHF) Radio</td>
<td>3 GHz–30 GHz</td>
<td>10–10 cm</td>
<td>Maritime, Satellite</td>
</tr>
<tr>
<td>Extremely High Frequency (EHF) Radio</td>
<td>30 GHz–300 GHz</td>
<td>10–100 cm</td>
<td>Microwave, Satellite</td>
</tr>
<tr>
<td>Infrared Light</td>
<td>103–105 GHz</td>
<td>300–30 µm</td>
<td>Infra-red</td>
</tr>
<tr>
<td>Ultraviolet Light</td>
<td>105–105.5 GHz</td>
<td>30–300 µm</td>
<td>UV Vision, Holography</td>
</tr>
<tr>
<td>X-rays</td>
<td>1055–3000 GHz</td>
<td>100–300 µm</td>
<td>X-ray Vision, Nuclear Medicine</td>
</tr>
<tr>
<td>Gamma and Cosmic Rays</td>
<td>1013–1022 Hz</td>
<td>100–1000 µm</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 10.1 Frequency Spectrums
Bandwidth, in this context, refers to the raw amount of bandwidth the medium supports. Error performance refers to the number or percentage of errors, which are introduced in the process of transmission. Distance refers to the minimum and maximum spatial separation between devices over a link, in the context of a complete, end-to-end circuit.

**Propagation Delay**

Propagation delay is the time taken by a signal to travel from transmitter to receiver across a data communication system. The speed of the electromagnetic energy is roughly the speed of light (30,000 km per second) in free space. The speed of propagation for twisted pair or coaxial cable is a fraction of this figure. The nature of the data communication system will have considerable influence on the level of propagation delay. In other words, the total length of the circuit directly influences the length of time it takes for the signal to reach the receiver.

**Security**

Security, in the context of transmission systems, addresses the protection of data from interception as it transverses the network. Particularly in the case of data networking, it is also important that access to a remote system and the data resident on it be limited to authorised users; that so, methods of authentication must be employed to verify that the access request is legitimate and authentic.

**Resistance to Environmental Conditions**

Resistance to environmental conditions applies specially especially to wired systems. Twisted pair, coaxial, and fibre optic cables are manipulated physically as they are deployed and reconfigured. Clearly, each has certain physical limits to the amount of bending and twisting (flex strength) it can tolerate, as well as the amount of weight or longitudinal stress it can support (tensile strength), without breaking (break strength). Fibre optic cables are notoriously susceptible in this regard. Cables hung from poles expand and contract with changes in ambient temperature; while glass fibre optic cables expand and contract relatively little, twisted pair copper wire is more expansice.

The issue of resistance to environmental conditions also applies to airwave systems, as reflective dishes, antennae, and other devices used in microwave, satellite, and infrared technologies must be mounted securely to deal with wind and other forces of nature. Additionally, the towers, walls and roofs on which they are mounted must be constructed and braced properly in order to withstand such forces.

**Physical Dimensions**

The physical dimensions of a transmission system must be considered as well. This is true, in the case of wired systems. The weight of a cable system must be considered as one attempts to deploy it effectively. Additionally, the bulk (diameter) of the cable is of importance, as conduit and raceway space often is at a premium.
The physical dimensions of airwave systems also must be considered, as the size and weight of the reflective dish and mounting system (e.g., bracket and tower) may require support.

**Cost and Ease of Installation**

Cost issues abound in the selection of an appropriate transmission medium. Such issues include the cost of acquisition, deployment, operation, and maintenance (O&M), and upgrade or replacement. Without a lengthy discussion of each cost issue, it is particularly noteworthy to compare the costs of deployment of wired versus wireless media.

Wired transmission systems require a right-of-way and this should be secured. Wired transmission involves a cost component in the form infrastructure. The infrastructure includes digging of trenches and boring of holes so that cable can be pulled and poles may be mounted. In addition, amplifiers or repeaters may be placed. Such costs are not trivial. Unlike wired system, wireless systems require secured right-of-way and antennae. It may be inferred that the deployment of wired systems certainly speak of a set of cost issues that often can be more problematic.

**Selection Criteria**

When choosing the most effective transmission media, consider the above mentioned transmission characteristics which are listed below:

- Bandwidth/Transmission rate
- Distances
- Propagation delay
- Security
- Resistance to environmental conditions
- Physical dimensions
- Cost and ease of installation

**10.2.1 Bounded Media**

Bounded media or wired transmission systems employ physical media, which are tangible. Also known as conducted systems, wired media employs a metallic or glass conductor which serves to conduct, electromagnetic energy. The twisted pair and coaxial cable systems conduct electrical energy through a copper medium. Fibre optic systems conduct light or optical energy, generally using a glass conductor. The term bounded or guided media means that the signal is contained within an enclosed physical path. It also refers to the fact that some form of shield, cladding, and/or insulation is employed to bind the signal within the core medium, thereby improving signal strength over a distance and enhancing the performance of the transmission system in the process. Twisted pair as unshielded and shielded, coaxial and fibre optic cable systems fall into this category.
Twisted Pair (Copper Conductors)

A twisted pair as shown in Fig. 10.1 is a pair of copper wires in which each wire has diameter in the range of 0.4-0.8 mm is used. They are twisted together and wrapped with a plastic coating. The twisting improves the electrical noise immunity and decreases the error rate of the data communication system. Each conductor is separately insulated by some low smoke and fires retardant substance. Polyethylene, polyvinyl chloride, fluoropolymer resin and Teflon are some substances that are used for insulation purposes.

This twisting process serves to improve the performance of the medium by containing the electromagnetic field within the pair. Thereby, the radiation of electromagnetic energy is reduced and the strength of the signal within the wire is improved over a distance. Clearly, this reduction of radiated energy also serves to minimise the impact on adjacent pairs in a multiple cable configuration. This is especially important in high-bandwidth applications, as higher frequency signals tend to lose power more rapidly over distance. Additionally, the radiated electromagnetic field tends to be greater at higher frequencies, impacting adjacent pairs to a greater extent. Generally speaking, the more twists per foot, the better the performance of the wire.

These are popular for telephone network. The energy flow is in guided media. Metallic wires were used almost exclusively in telecommunications networks for the last 90 years, until the development of microwave and satellite radio communications systems. Therefore, copper wire has established itself as a well proven mature technology with ruggedness and cost effective way. In certain applications, copper-covered steel, copper alloy, nickel- and/or gold-plated copper and even aluminum metallic conductors are employed.

The maximum transmission speed is limited in this case. The copper conductor that carries analog data can be used to carry digital data also in association with the modem. Modem is a device to convert digital signal into analog signal and vice versa. The data rate in this category is found to be approximately 28 Kbps. The widespread use of the Integrated Services Digital Network (ISDN) enabled to the use of improved modulation and coding schemes and data rate up to 128 Kbps. Local Area Networks (LANs) also use twisted pairs. These networks also upgraded to support for high bit rate real time multimedia. The Asymmetric Digital Subscriber Lines (ADSL) technology is designed to use 2-wire copper loops at data rates of 1.544 Mbps from Internet to subscribers and about 600 Kbps from the subscribers to the Internet. The twisted pair cable may be defined in two categories based upon the shielding and without shielding.
Unshielded Twisted Pair (UTP)

UTP as depicted in Fig. 10.2, the copper media, is commonly used in telephone lines. This is also being used increasingly at higher data rates. The UTP has become the de facto standard for horizontal wiring. Horizontal wiring specifies the connection between the outlet and the termination in the communication closet. The horizontal wiring can span to a maximum of 90 meters. The communication closet does not depend on media type and is therefore common to all media types.

![Unshielded Twisted Pair (UTP)](image)

A UTP cable normally may enclose about up to 4200 twisted pairs. The UTP offers advantages that include flexibility, cost-effective transmission medium and they are subtly used for both voice and data communications. However, the limited bandwidth offered by UTP is its greatest weakness and therefore it does not find deployment for long distance transmission and low error rates.

Shielded Copper or STP

Shielded twisted pair (STP) differs from UTP in that a metallic shield or screen surrounds the pairs, which may or may not be twisted. As illustrated in Fig. 10.3, the pairs can be individually shielded. A single shield can surround a cable containing multiple pairs or both techniques can be employed in tandem. The shield itself is made of aluminum, steel, or copper. This is in the form of a metallic foil or woven meshes and is electrically grounded. Although less effective, the shield sometimes is in the form of nickel and or gold plating of the individual conductors.

![Shielded Twisted Pair (STP) Configuration](image)
Advantages

Shielded copper offers the advantage of enhanced performance for reasons of reduced emissions and reduction of electromagnetic interference. Reduction of emissions offers the advantage of maintaining the strength of the signal through the confinement of the electromagnetic field within the conductor. In other words, signal loss is reduced. An additional benefit of this reduction of emissions is that high-frequency signals do not cause interference in adjacent pairs or cables. Immunity from interference is realized through the shielding process, which reflects electromagnetic noise from outside sources, such as electric motors, other cables and wires, and radio systems.

Disadvantages

Shielded twisted pair, on the other hand, has several disadvantages. First, the raw cost of acquisition is greater as the medium is more expensive to produce. Second, the cost of deployment is greater as the additional weight of the shield makes it more difficult to deploy. Additionally, the electrical grounding of the shield requires more time and effort.

General Properties of Twisted Pair

- **Gauge:** Gauge is a measure of the thickness of the conductor. The thicker the wire, the lesser the resistance, is the stronger the signal over a given distance, and the better the performance of the medium. Thicker wires also offer the advantage of greater break strength. The gauge numbers are retrogressive. In other words, the larger is the number, the smaller is the conductor.

- **Configuration:** In a single pair configuration, the pair of wires is enclosed in a sheath or jacket, made of polyethylene, polyvinyl chloride or Teflon. Usually, multiple pairs are so bundled in order to minimise deployment costs associated with connecting multiple devices (e.g., electronic PBX or KTS telephone sets, data terminals, and modems) at a single workstation.

- **Bandwidth:** The effective capacity of twisted pair cable depends on several factors, including the gauge of the conductor, the length of the circuit and the spacing of the amplifiers/repeaters. One must also recognise that a high-bandwidth (high frequency) application may cause interference with other signals on other pairs in close proximity.

- **Error Performance:** Signal quality is always important, especially relative to data transmission. Twisted pair is especially susceptible to the impacts of outside interference, as the lightly insulated wire act as antennae and, thereby, absorbs such errant signals. Potential sources of Electro Magnetic Interference (EMI) include electric motors, radio transmissions and fluorescent light boxes. As transmission frequency increases, the error performance of copper degrades significantly with signal attenuation increasing approximately as the square root of frequency.
Distance: Twisted pair is distance limited. As distance between network elements increases, attenuation (signal loss) increases and quality decreases at a given frequency. As bandwidth increases, the carrier frequency increases, attenuation becomes more of an issue, and amplifiers/repeaters must be spaced more closely.

Security: Twisted pair is inherently an insecure transmission medium. It is relatively simple to place physical taps on UTP. Additionally, the radiated energy is easily intercepted through the use of antennae or inductive coils, without the requirement for placement of a physical tap.

Cost: The acquisition, deployment and rearrangement costs of UTP are very low, at least in inside wire applications. In, high-capacity, long distance applications, such as inter-office trunking, however, the relative cost is very high, due to the requirements for trenching or boring, conduit placement, and splicing of large, multi-pair cables. Additionally, there are finite limits to the capacity and other performance characteristics of UTP, regardless of the inventiveness of technologists. Hence, the popularity of alternatives such as microwave and fibre-optic cable.

Applications: UTP’s low cost including recently developed methods of improving its performance has increased its application in short-haul distribution systems or inside wire applications. Current and continuing applications include the local loop, inside wire and cable, and terminal-to-LAN. Generally speaking, UTP no longer is deployed in long haul or outside the premises transmission systems.

The additional cost of shielded copper limits its application to inside wire applications. Specifically, it generally is limited to application in high-noise environments. It also is deployed where high frequency signals are transmitted and there is concern about either distance performance or interference with adjacent pairs. Examples include LANs and image transmission.

Coaxial Cable

The main limiting factor of a twisted pair cable is caused by a phenomenon known as the skin effect. As the frequency of the transmitted signal increases, the current flowing in the wires tends to flow only on the outer surface of the wire, thus using the less of the available cross section. This increases the electrical resistance of the wires for higher frequency signals leading to higher attenuation. In addition, at higher frequencies, more signal power is lost as a result of radiation effects. Hence for applications that demand higher frequencies, another type of transmission medium must be used. Coaxial cable minimizes both these effects.

Coaxial Cable as shown in Fig. 10.4 is a very robust shielded copper wire two-conductor cable in which a solid centre conductor runs concentrically (coaxial) inside a solid outer circular conductor. This forms an electromagnetic shield around the former that serves to greatly improve signal strength and integrity.
The two conductors are separated by insulation. A layer of dielectric (nonconductive) material, such as PVC or Teflon, then protects the entire cable.

![Coaxial Cable Configurations](image)

**Fig. 10.4 Coaxial Cable Configurations**

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It comes under the category of a bounded media and is still an effective medium to use in data communication. Coaxial cable includes shield for improved performance and therefore is expensive. Cable TV networks use coaxial cable. Local Area Networks can operate over coaxial cable to the 10BASE5, 10BASE2, and 10BASET specifications. In general, coaxial cable enables longer distance transmission at higher data rates than twisted pair cable but is more expensive.

There are two types of coaxial cables:

**Baseband**

It transmits a single signal at a time at very high speed. The signal on baseband cable must be amplified at a specified distance. It is used for local area networks.

**Broadband**

It can transmit many simultaneous signals using different frequencies.

**General Properties of Coaxial Cable**

- **Gauge:** The gauge of coaxial cable is thicker than the twisted pair. While this increases the available bandwidth and the distance of transmission, it also increases the cost. Traditional coaxial cable is quite thick, heavy and bulky of which Ethernet LAN 10Base5 is an example. Ethernet LAN 10Base2 is of much lesser dimensions but offers less in terms of performance.

- **Configuration:** Coaxial cables consist of a single, two-conductor wire, with a centre conductor and an outer shield/conductor, which is of solid metal. Sometimes braided or stranded metal is used. Twin axial cables contain two such configurations within a single cable sheath. As the centre conductor carries the carrier signal and the outer conductor generally is used for electrical grounding. Coaxial cable connectivity can be extended through the use of twisted pair with a BALUN (Balanced/Unbalanced) connector serving to accomplish the interface.

- **Bandwidth:** The effective capacity of coaxial cable depends on several factors, including the gauge of the centre conductor, the length of the circuit,
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and the spacing of amplifiers and other intermediate devices. The available bandwidth over coaxial cable is very significant; hence it is used in high capacity applications, such as data and image transmission.

- **Error Performance:** Coaxial cable performs exceptionally well, due to the outer shielding. As a result, it is often used in data applications.

- **Distance:** Coaxial cable is not as limited as UTP, although amplifiers or other intermediate devices must be used to extend high frequency transmissions over distances of any significance.

- **Security:** Coaxial cable is inherently quite secure. It is relatively difficult to place physical taps on coaxial cable. Radiation of energy is also minimal hence interception of it is not easy.

- **Cost:** The acquisition, deployment, and rearrangement costs of coaxial cables are very high, compared with UTP. In high capacity data applications, however, that cost is often outweighed by its positive performance characteristics.

- **Applications:** Coaxial cable’s superior performance characteristics make it the favored medium in many short hauls, bandwidth-intensive data applications. Current and continuing applications include LAN backbone, host-to-host, host-to-peripheral and CATV.

**Optical Fibre**

We have seen in the previous section that the geometry of coaxial cable significantly reduces the various limiting effects, the maximum signal frequency, and hence the information rate that can be transmitted using a solid conductor, although very high, is limited. This is also the case for twisted lines. Optical fibre differs from both these transmission media in that it carries the transmitted information in the form of a fluctuating beam of light in a glass fibre rather than as an electrical signal on a wire. This type of transmission has become strong support for digital network owing to its high capacity and other factors favourable for digital communication.

Fibre optic transmission systems are opto-electric in nature. In other words, a combination of optical and electrical electromagnetic energy is involved. The signal originates as an electrical signal, which is translated into an optical signal, which subsequently is reconverted into an electrical signal at the receiving end. Thin glass fibre as shown in Fig. 10.5 is very clear and designed to reflect light internally for efficient transmission carries light with encoded data. Plastic jacket allows fibre to bend (some!) without breaking. Light emitting diode (LED) or laser injects light into fibre for transmission. Light sensitive receiver at other end translates light back into data.

The optical fibre consists of a number of substructures as shown in Fig. 10.6. In this case, a cladding made of glass with lower refractive index surrounds a core made of glass, which carries most of the light. This bends the light and
confines it to the core. The core is surrounded by a substrate layer (in some fibers) of glass, which does not carry light, but adds to the diameter and strength of the fibre. A primary buffer coating and a secondary buffer coating to provide mechanical protection cover all these.

The light pulse travels down the center core of the glass fibre. Surrounding the inner core is a layer of glass cladding, with a slightly different refractive index. The cladding serves to reflect the light waves back into the inner core. Surrounding the cladding is a layer of protective plastic coating that seals the cable and provides mechanical protection. This is shown in Figure 10.4. Typically, multiple fibers are housed in a single sheath, which may be heavily armored.

Light propagates along the optical fibre core in one of the following ways depending on the type and width of core material used.

**Multimode Fibre**

Here, the core diameter is relatively large compared to a wavelength of light. Core diameter ranges from 50 micrometers (µm) to 1,000 µm, compared to the wavelength of light of about 1 µm. This means that light can propagate through the fibre in many different ray paths, or modes, hence the name multimode. Multimode fibre is less expensive to produce and inferior in performance because of the larger diameter of the inner core. When the light rays travel down the fibre, they spread out due to a phenomenon known as modal dispersion. Although reflected back into the inner core by the cladding, they travel different distances and, therefore, arrive at different times. The received signal thus has a wider pulse width than the input signal with a corresponding decrease in the speed of transmission. As a
result, multimode fibre is relegated to applications involving relatively short distances and lower speeds of transmission, for example, LANs and campus environments. Two basic types of multimode fibres exist. The simpler and older type is a ‘step index’ fibre, where the index of refraction (the ability of a material to bend light) is the same all across the core of the fibre.

**Step Index Multimode Fibre**

This is shown in Fig. 10.7. With all these different ray paths or modes of propagation, different rays travel different distances, and take different amounts of time to transit the length of a fibre. This being the case, if a short pulse of light is injected into a fibre, the various rays emanating from that pulse will arrive at the other end of the fibre at different times, and the output pulse will be of longer duration than the input pulse. This phenomenon is called ‘modal dispersion’ (pulse spreading), and limits the number of pulses per second that can be transmitted down a fibre and is still recognised as separate pulses at the other end. This, therefore, limits the bit rate or bandwidth of a multimode fibre. For step index fibers, wherein no effort is made to compensate for modal dispersion, the bandwidth is typically 20 to 30 MHz over a length of one kilometer of fibre, expressed as “MHz - km”.

![Fig. 10.7 Multimode Step Index Fibre](image)

**Graded Index Multimode Fibre**

In the case of a graded index multimode fibre, the index of refraction across the core is gradually changed from a maximum at the center to a minimum near the edges, hence the name graded index. This design takes advantage of the phenomenon that light travels faster in a low-index-of-refraction material than in a high-index material. If a short pulse of light is launched into the graded index fibre, it may spread some during its transit of the fibre, but much less than in the case of a step index fibre. Therefore, dispersion can be reduced using a core material that has a variable refractive index. In such multimode graded index fibre light is refracted by an increasing amount as it moves away from the core as shown in Fig. 10.8. This has the effect of narrowing the pulse width of the received signal compared with stepped index fibre, allowing a corresponding increase in the speed of transmission. They therefore can support a much higher bit rate or bandwidth. Typical bandwidths of graded index fibers range
from 100 MHz-km to well over 1 GHz-km. The actual bandwidth depends on how well a particular fibre's index profile minimizes modal dispersion, and on the wavelength of light launched into the fibre.

Fig. 10.8 Light Propagation in Multimode Graded Index Fibre

Monomode/Singlemode Fibre
This has a thinner inner core. The core diameter of about 9 µm is much closer in size to the wavelength of light being propagated, about 1.3 µm. This limits the light transmission to a single ray or mode of light to propagate down the core of the fibre as shown in Fig. 10.9. All the multiple-mode or multimode effects described above are eliminated. However, one pulse-spreading mechanism remains. Just as in the multimode fibres, different wavelengths of light travel at different speeds, causing short pulses of light injected into the fibre to spread as they travel. This phenomenon is called ‘chromatic dispersion’.

Fig. 10.9 Light Propagation in Single Mode Step Index Fibre

It performs better than does multimode fibre over longer distances at higher transmission rates. Due to reduced core diameter all the emitted light propagates along a single path. Consequently the received signal is of a comparable width to the input signal. Although more costly, monomode fibre is used to advantage in long haul, and especially in high bandwidth, applications.

Singlemode fibres have the very broadest bandwidth, lowest cost and lowest attenuation of any available optical fibre. Therefore, they are universally used in long-distance telephony and cable television applications.
Advantages of Optical Fibres

- Immunity to electromagnetic interference and crosstalk
- No electrical ground loop or short circuit problems
- Small size and light-weight
- Large bandwidth for size and weight
- Safe in combustible areas (no arcing)
- Immunity to lightning and electrical discharges
- Longer cable runs between repeaters
- Flexibility and high strength
- Potential high temperature operation
- Secure against signal leakage and interference
- No electrical hazard when cut or damaged

General Properties of Optical Fibre

- **Configuration:** Fibre optic systems consist of light sources, cables and light detectors, as depicted in Fig. 10.10. In a simple configuration, one of each is used. In a more complex configuration over longer distances, many such sets of elements are employed. Much as is the case in other transmission systems, long haul optical communications involve a number of regenerative repeaters. In a fibre optic system, repeaters are opto-electric devices. On the incoming side of the repeater, a light detector receives the optical signal, converts it into an electrical signal, boosts it, converts it back into an optical signal, and places it onto a fibre, and so on. There may be many such optical repeaters in a long haul transmission system, although typically far fewer than would be required using other transmission media.

- **Bandwidth:** Fibre offers by far the greatest bandwidth of any transmission system, often in excess of 2 Gbps in long haul carrier networks. Systems
Networking: Technological Development in Communication

- **Error Performance**: Fibre being a dielectric (a nonconductor of direct electric current), it is not susceptible to Electro Magnetic Interference/Radio Frequency Interference (EMI/RFI). This also does not emit EMI/RFI. The light signal will suffer from attenuation, although less so than other media. Scattering of the optical signal, bending in the fibre cable, translation of light energy to heat, and splices in the cable system can cause such optical attenuation.

- **Distance**: Monomode fibre optic systems routinely are capable of transmitting signals over distances in excess of 325 km. Hence relatively few optical repeaters are required in a long-haul system. This will reduce costs, and eliminate points of potential failure.

- **Security**: Fibre is intrinsically secure, as it is virtually impossible to place a physical tap without detection because no light is radiated outside the cable. Therefore, interception of signal is almost impossible. Additionally, the fibre system supports such a high volume of traffic that it is difficult to intercept and distinguish a single transmission from the tens of thousands of other transmissions that might ride the same cable system. The digital nature of most fibers coupled with encryption techniques frequently used to protect from interception make fibers highly secure.

- **Cost**: While the acquisition, deployment, and rearrangement costs of fibre are relatively high, the immense bandwidth can outweigh that cost in bandwidth-intensive applications. At Gbps speeds, a single set of fibers can carry huge volumes of digital transmissions over longer distances than alternative systems, thereby lowering the transport cost per bit and cost per conversation to fractions of a penny per minute.

- **Applications**: Applications for fibre optic transmission systems are bandwidth intensive. Such applications include backbone carrier networks, international submarine cables, backbone LANs (FDDI), interoffice trunking, computer-to-computer distribution networks (CATV and Information Superhighway) and fibre to the desktop (Computer Aided Design).

### Bounded Media Comparison Chart

<table>
<thead>
<tr>
<th>Media</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twisted Pair</td>
<td>Low cost, well established, easy to add nodes</td>
<td>Sensitive to noise, short distances, limited bandwidth, security hazard because of easy interception</td>
</tr>
<tr>
<td>Copper Cable</td>
<td>High bandwidth, long distances, noise immunity</td>
<td>Physical dimensions, security is better in comparison to twisted pair cable</td>
</tr>
<tr>
<td>Optical Fibre</td>
<td>Very high bandwidth, noise transmutation, long distances, high security, small size</td>
<td>Connections, cost</td>
</tr>
</tbody>
</table>

NOTES
10.2.2 Unbounded Media

Wireless transmission systems do not make use of a physical conductor, or guide to bind the signal. In this case, data are transmitted using electromagnetic waves. Therefore, they are also known as unguided or unbounded systems. Energy travels through the air rather than copper or glass. Hence the term radiated often is applied to wireless transmission. Finally, such systems employ electromagnetic energy in the form of radio or light waves that are transmitted and received across space, and are referred to as airwave systems. The transmission systems addressed under this category include microwave, satellite and infrared. There are different techniques to convert the data suitable for this mode of communication. Radio waves can travel through walls and through an entire building. They can travel for long distances using satellite communication or short distance using wireless communication. Radio waves need attention and caution when this technology is used for delivery of real time applications like multimedia contents because radio links are susceptible to fading, interference, random delays, etc.

Radio

It is a technique in which data is transmitted using radio waves and therefore energy travels through the air rather than copper or glass. Conceptually radio, TV, cellular phones, etc., uses radio transmission in one form or another. The radio waves can travel through walls and through an entire building. Depending upon the frequency, they can travel long distance or short distance. Satellite relay is the one example of long distance communication. Therefore, each frequency range is divided into different bands, which has a specific range of frequencies in the radio frequency (RF) spectrum. The RF is divided in different ranges starting from very low frequencies (VLF) to extremely high frequencies (EHF). Figure 10.11 shows each band with a defined upper and lower frequency limit.

![Radio Frequency Range and Types of Transmission Media](image-url)
Two transmitters cannot share the same frequency band because of the mutual interference and therefore band usage is regulated. The International Telecommunication Union (ITU) regulates international use of the radio spectrum. Domestic use of the radio spectrum is regulated by national agencies such as Wireless Planning and Coordination (WPC) in India. WPC assigns each transmission source a band of operation, a transmitter radiation pattern, and a maximum transmitter power. The Table 7.1 shows the bands and frequency ranges. Omni directional or directional antennas are used to broadcast radio waves depending upon band. The transceiver unit, which is consisted of transmitter and receiver along with the antenna, determines the power of RF signal. Other characteristics of radio waves is that in vacuum all electromagnetic waves or radio waves travel at the same speed, i.e., at the speed of light which is equal to $3 \times 10^8$ metre per seconds. In any medium this speed gets reduced and also becomes frequency dependent. In case of copper the speed of light becomes approximately two thirds of the speed of light. The basic features of the radio waves are as follows:

- they are easy to generate
- they have the same velocity in vacuum
- they may traverse long distances
- they are omni directional
- they can penetrate building easily so they find extensive use in communication both indoor and outdoor
- they are frequency dependent. At low frequency they can pass through obstacles. However, the power falls off sharply with distance from the source because power is inversely proportional to cube of the distance from the source. At HF they travel in straight lines and bounce off obstacles.

**Very Low Frequency (VLF)**

The VLF method takes advantage of electromagnetic radiation generated in the low frequency band of 3-30 kHz by powerful radio transmitters used in long-range communications and navigational systems. At large distances from the source, the electromagnetic field is planar and horizontal and the electric component E lies in a vertical plane perpendicular to the H component in the direction of propagation and follow the ground. AM uses VLF band. This band of frequencies cannot be used for data transfer because they offer relatively low bandwidth.

**Microwave Transmission**

Microwave transmission is a form of radio transmission which uses extremely high frequencies. All the specified frequency ranges are in the GHz range and the wavelength in the millimetre range. Since these types of high frequency signals are
prone to attenuation, hence, amplification is required after a specific distance. The radio beams are highly focussed in order to increase the transmission distance of the signals. The transmit antenna is centred in a concave metallic dish which focuses the radio beam with maximum effect, as illustrated in Fig. 10.12. Similarly the receiver dish is also concave in nature which collects the maximum amount of incoming signal.

Fig. 10.12 Point-to-point Microwave

It is a point-to-point transmission system, instead of a broadcast system. Also each antenna must be within the line of sight of the next antenna. Due to the curvature of the earth, the microwave signal hops are limited to a maximum of 80 km.

General Properties of Microwave Transmission

- **Configuration**: Microwave radio consists of an antennae at the center of a reflective dish which is attached to the structure such as a tower or a building. Cables connect the antennae to the actual equipment.
- **Bandwidth**: Bandwidth in excess of 6 Gbps is common in microwave transmission.
- **Error Performance**: Assuming proper design, digital microwave performs well in this regard. However, environmental interferences such as, precipitation, haze, smog and smoke create troubles for high frequency transmission, yet microwave performs much better in this regard.
- **Distance**: At higher frequencies, microwave is distance limited, which can be overcome through complex arrays of antennae incorporating spatial diversity in order to collect more signals.
- **Security**: As is the case with all radio communication systems, microwave is inherently insecure, which can be improved through encryption.
- **Cost**: Even though the acquisition, deployment and rearrangement cost can be very high, yet, microwave compares very favourably with cabled systems, which require right-of-way, trenching and conduit and splicing.
• **Applications:** Microwave was originally used for long haul voice and data communication since it was found to be the most attractive alternative to cable system. However, the recent upsurge of fibre optic communication system is currently used in this regard. Contemporary applications include private networks, interconnections of cellular radio switches and an alternative of cabled communication system in difficult terrain.

**Satellite Communication**

Satellite radio is a non-terrestrial microwave transmission system utilizing a space relay station. Satellites have proved invaluable in extending the reach of voice, data, and video communications around the globe and into the most remote regions of the world. Exotic applications such as the Global Positioning System (GPS) would have been unthinkable without the benefit of satellites. Contemporary satellite communications systems involve a satellite relay station that is launched into a geostationary, geosynchronous, or geostatic orbit. Such satellites are called geostationary satellite. Such an orbit is approximately 36,000 kms above the equator as depicted in Fig. 10.13. At that altitude and in an equatorial orbital slot, the satellite revolves around the earth with the same speed as that of the speed of revolution of earth and maintains its relative position over the same spot of the earth’s surface. Consequently, transmit and receive earth stations can be pointed reliably at the satellite for communications purposes.

![Fig. 10.13 Satellites in Geostationary Earth Orbit](image)

The popularity of satellite communications has placed great demands on the international regulators to manage and allocate available frequencies, as well as the limited number of orbital slots available for satellite positioning are managed at national, regional and international levels. Generally speaking, geostationary satellites are positioned approximately 2 apart in order to minimise interference from adjacent satellites using overlapping frequencies. Such high frequency signals are especially susceptible to attenuation in the atmosphere. Therefore, in case of satellite communication two different frequencies are used as carrier frequencies to avoid interference between incoming and outgoing signals. These can be listed as follows.
Frequencies Used

- **Uplink frequency**: It is the frequency used to transmit signal from earth station to satellite. Table 10.3 shows the higher of the two frequencies that is used for the uplink. The uplink signal can be tailored stronger and therefore can better deal with atmospheric distortion. The antenna at transmitting side is centered in a concave, reflective dish that serves to focus the radio beam, with maximum effect, on the receiving satellite antenna. The receiving antenna, similarly, is centered in a concave metal dish, which serves to collect the maximum amount of incoming signal.

<table>
<thead>
<tr>
<th>Frequency Bands</th>
<th>Maximum Antenna Separation</th>
<th>Analog/Digital</th>
</tr>
</thead>
<tbody>
<tr>
<td>4–6 GHz</td>
<td>32-48 Km</td>
<td>Analog</td>
</tr>
<tr>
<td>10-12 GHz</td>
<td>16-24 Km</td>
<td>Digital</td>
</tr>
<tr>
<td>18-23 GHz</td>
<td>8-11 Km</td>
<td>Digital</td>
</tr>
</tbody>
</table>

- **Downlink frequency**: It is the frequency used to transmit the signal from satellite to earth station. In other words, the downlink transmission is focused on a particular footprint, or area of coverage. The lower frequency, used for the downlink, can better penetrate the earth’s atmosphere and electromagnetic field, which can act to bend the incoming signal much as light bends when entering a pool of water.

- **Broadcast**: The wide footprint of a satellite radio system allows a signal to be broadcast over a wide area. Thereby any number (theoretically an infinite number) of terrestrial antennae can receive the signal, more or less simultaneously. In this manner, satellites can serve a point-to-multipoint network requirement through a single uplink station and multiple downlink stations. Recently, satellites have been developed which can serve a mesh network requirement, whereby each terrestrial site can communicate directly with any other site. Previously, all such communications were required to travel through a centralized site, known as a head end. Such a mesh network, of course, imposes an additional level of difficulty on the network in terms of management of the flow and direction of traffic.

**General Properties of Satellite Communication**

- **Configuration**: Satellite communication systems consist of antennae and reflective dishes, much as in terrestrial microwave. The dish serves to focus the signal from a transmitting antenna to a receiving antenna. The send/receive dishes that make up the earth segment are of varying sizes, depending on power levels and frequency bands. They generally are mounted on a tripod or other type of brace, which is anchored to the earth, pad or roof, or attached to a structure such as building. Cables connect the antennae to
the actual transmit/receive equipment. The terrestrial antennae support a single frequency band for example, C-band, Ku-band or Ka-band. The higher the frequency bands the smaller the possible size of the dish. Therefore, while C-band TV dishes tend to be rather large, Ku-band DBS (Direct Broadcast Satellite) TV dishes tend to be very small. The space segment dishes are mounted on a satellite, of course. The satellite can support multiple transmit/receive dishes, depending on the various frequencies which it employs to support various applications, and depending on whether it covers an entire footprint or divides the footprint into smaller areas of coverage through the use of more tightly focused spot beams. Satellite repeaters are in the form of number of transponders. The transponders accept the weak incoming signals, boost them, shift from the uplink to the downlink frequencies, and transmit the information to the earth stations.

- **Bandwidth:** Satellites can support multiple transponders and, therefore, substantial bandwidth, with each transponder generally providing increments in bandwidth.

- **Error Performance:** Satellite transmission is susceptible to environmental interference, particularly at frequencies above 20 GHz. Sunspots and other types of electromagnetic interference affect satellite and microwave transmission. Additionally, some satellite frequency bands, for example, C-band needs careful frequency management. As a result of these factors, satellite transmission often requires rather extensive error detection and correction capabilities.

- **Distance:** Satellite is not considered to be distance limited as the signal largely travels through the vacuum of space. Further each signal travels approximately 36,000 kms in each direction.

- **Propagation Delay:** Geostationary satellites, by virtue of their high orbital altitude, impose rather significant propagation delay on the signal. Hence, highly interactive voice, data, and video applications are not effectively supported via two-way satellite communications.

- **Security:** As is the case with all microwave and other radio systems, satellite transmission is inherently not secure. Satellite transmission is especially vulnerable to interception, as the signal is broadcast over the entire area of the footprint. Therefore, the unauthorized user must know only the satellite and associated frequency range being employed. Security must be imposed through encryption (scrambling) of the signal.

- **Cost:** The acquisition, deployment, and rearrangement costs of the space segment of satellite systems can be quite high in several millions dollars. However, the satellite can be shared by a large number of users, with each user perhaps connecting a large number of sites. As a result, satellite networks often compare very favorably with cabled systems or microwave systems for many point-to-multipoint applications.
• **Applications**: Satellite applications are many and increasing rapidly as the traditional voice and data services have been augmented. Traditional international voice and data services have been supplanted to a considerable extent by submarine fibre optic cable systems. Traditional applications include international voice and data, remote voice and data, television and radio broadcast, maritime navigation, videoconferencing, inventory management and control through VSATs, disaster recovery and paging. More recent and emerging applications include air navigation, Global Positioning Systems (GPS), mobile voice and data because of Low Earth Orbit Satellites (LEOs), Advanced Traffic Management Systems (ATMS), Direct Broadcast Satellite (DBS) TV, Integrated Digital Services Network (ISDN), interactive television, and interactive multimedia.

• **Very Small Aperture Terminals (VSATs)**: VSATs or Very Small Aperture Terminals are a breed of satellite system involving terrestrial dishes of very small diameter (aperture). Operating in the C-band and Ku-band, VSATs are digital and are designed primarily to support data communications on a point-to-multipoint basis for large private networks in applications such as retail inventory management and credit verification and authorisation. While some newer systems also support mesh networks and voice communications, they are unusual at this time. Bandwidth is in channel increments of 56/64 Kbps, generally up to an aggregate bandwidth of 1.544 Mbps.

**Infrared Transmission**

Infrared light transmissions have existed for many years but their use has been limited to TV remote controls and wireless slide projector remote controls. However, they are now assuming a position of some importance. Infrared systems use the infrared light spectrum to send a focused light beam to a receiver, much, as a microwave system, although no reflective dish is used. Rather, a pair of lenses is used, with a focused lens employed in the transmitting device and a collective lens in the receiving device as shown in Fig. 10.14. Infrared is an airwave, rather than a conducted transmission system. Although generally used in short-haul transmission, they do offer substantial bandwidth, but with risks of interference.
Advantages include rapid deployment, especially as there are no licensing requirements as typically is the case with microwave. Additionally, infrared offers fairly substantial bandwidth at relatively low cost. However, infrared systems require line-of-sight and suffer from environmental interference, as do microwave systems. Error performance is also satisfactory. Additionally, infrared is distance limited. However, infrared often is an attractive alternative to leased lines or private cabled systems for building-to-building connectivity in a campus environment. Infrared transmission also is used in certain wireless LAN systems and is incorporated into some PDAs (Personal Digital Assistants).

10.3 DIGITAL NETWORKS

PSTN

Public Switched Telephone Network (PSTN) is the largest communication network that exists today on the face of the earth. It connects almost a billion telephone sets in a way that every set can be connected to every other set on the earth. Although the telephone system was originally meant to carry analog signals, the advent of computers and data communication has led to its being increasingly used for carrying computer data traffic. At the same time, telephone networks have evolved to take advantage of the digital technology made available by the computers. Modern networks are capable of carrying information in a variety of forms, such as voice, data, video. Recently, the technology for packet switching has made it possible to carry real-time conversations in packets.

Circuit Switching

It is a type of communication that uses a dedicated communications link between two devices in which it may use one or more switching nodes in intermediate stages. Most widely used example of circuit switching is public switched telephone network (PSTN), which finds extensive use in both voice and data communications today. The major disadvantage of this communication technique lies in its 100% dedicated connection that offers poor efficiency.

In setting up of circuit, a point-to-point connection is established from endpoints to node with the deployment of internal switching/multiplexing among nodes so that transfer of information can take place. Whenever sender and receiver wish to disconnect circuit, they do so. In this manner, a 100% reliable connection is set up between sender and receiver but at the cost of scarce network resources.

A circuit switching employs a circuit-switching node, which is a full duplex, digital switch. It provides transparent signal link between any pair of devices attached to the node. It maintains connection at the convenience of users and breaks down connection on completion of the transfer of message. Figure 10.15 shows a circuit switch.
Switching Techniques

Space-Division Switching

This kind of switch was specially developed for analog environment. Subsequently, it was also used for digital communication. The characteristics of this type switches are that they work on disjoint physical links for each connection. The switch uses metallic or semiconductor gates. Crossbar switches and close network switches are the examples of space division switching.

Crossbar Switch

It is the simplest possible space division switch where each packet takes a different path through the switch depending on its destination. Cross points are used to show the busy point or free point.

Figure 10.16 shows crossbar connections where a crossbar session has been illustrated. The advantages offered are that it is simple to implement and control and non-blocking, etc. Disadvantages are many cross points which acquires large VLSI space. It is also vulnerable to single faults, etc. Crossbar switch has simplest switch fabric and is very much faster than a bus-based switch. The cross-points are used to transfer a packet from an input to an output. An arrival pattern for fixed-size packets enables us in computing schedule in advance.
Time-Division Switching

This technique based on multiplexing was developed for digital transmission. Due to multiplexing all transmitted signals are time multiplexed to be carried by single transmission path. The transmission media must have a better throughput in comparison to each I/O lines.

The circuit-switched networks use hierarchical routing. Peer-to-peer trunks are also used at some places. Dynamically routed circuit switched networks are also in use more complex peer to peer trunks for all nodes. However, in circuit switching communication intended routes between two end points are predefined so as to enable the originating switch to select the best possible route for each connection. The routing paths are either fixed or dynamic.

In managing the creation, maintenance and termination of signal connections, control signaling is used which involves signaling from the called party to network and signals within network. Again signaling may be in channel signalling or common channel signalling for the same channel or independent channels respectively.

Time-space-time (TST) Switching

It allows sending message both on input and output trunk and therefore more flexible. This feature gives it to lower call blocking probability.

Local Area Network (LAN)

Local area network technology connects people and machines within a site. A local area network (LAN) is a network that is confined to a relatively small area as shown in Figure 10.17. Local area networks (LANs) are described as privately-owned networks that offer reliable high speed communication channels optimized for connecting information processing equipment in a limited geographical area, namely an office, a building, a complex of buildings, a school or a campus.

A LAN is a form of local (limited-distance), shared packet network for computer communications. LANs interconnect computers and peripherals over a common medium in order that users might share access to host computers, databases, files, applications, and peripherals. They can also provide a connection to other networks either through a computer, which is attached to both networks, or through a dedicated device called a gateway.

![Fig. 10.17 Local Area Network (LAN)](image-url)
The components used by LANs can be divided into cabling standards, hardware, and protocols. Various LAN protocols are Ethernet, Token Ring, TCP/IP, SMB, NetBIOS and NetBeui, IPX/SPX, Fibre Distributed Data Interchange (FDDI) and Asynchronous Transfer Mode (ATM).

**Metropolitan Area Network (MAN)**

A metropolitan area network (MAN) covers larger geographic areas such as cities or districts. By interconnecting smaller networks within a large geographic area, information is easily disseminated throughout the network. Local libraries and government agencies often use a MAN to connect to citizens and private industries. The geographical limit of a MAN may span a city. The following figure depicts how a MAN may be available within a city.

![Fig. 10.18 Metropolitan Area Network (MAN)](image)

In MAN, different LANs are connected through a local telephone exchange. Some of the widely used protocols for MAN are RS-232, X.25, Frame Relay, Asynchronous Transfer Mode (ATM), ISDN (Integrated Services Digital Network), OC-3 lines (155 Mbps), ADSL (Asymmetrical Digital Subscriber Line), etc. These protocols are quite different from those used for LANs.

**Wide Area Network (WAN)**

This technology connects sites that are in diverse locations. Wide area networks (WANs) connect larger geographic areas, such as New Delhi, India or the world. The geographical limit of WAN is unlimited. Dedicated transoceanic cabling or satellite uplinks may be used to form this type of network. Hence, a WAN may be defined as a data communications network that covers a relatively broad geographic area to connect LANs together between different cities with the help of transmission facilities provided by common carriers such as telephone companies. WAN technologies function at the lower three layers of the OSI reference model. These are the physical layers, the data link layer and the network layer.

Figure 10.19 explains the WAN, which connects many LANs together. It also uses switching technology provided by local exchange and long distance carrier.
Packet switching technologies such as Asynchronous Transfer Mode (ATM), Frame Relay, Switched Multimegabit Data Service (SMDS) and X.25 are used to implement WAN along with statistical multiplexing to enable devices to share these circuits.

The difference between MAN and WAN may be understood only from the services being used by them. WAN uses both the local and long distance carriers, while MAN uses only local carrier. The hardware and protocols are the same as in the case of MAN.

There is a lot of confusion between LAN technology and WAN technology. The answer lies in how data is switched. It is the LAN/WAN integration that makes the network work. After all, people and machines not only need to be accessible locally, but from different sites as well.

A network is accomplished using the following basic components:
- Hardware
- Applications (useful software)

The role of computer networks in development has many facets. In networking, computer, along with the necessary networking infrastructure is connected through either LAN or WAN or Internet or a combination of these three, thereby playing a greater role in e-governance, telemedicine, e-education, e-business, and so on. The Internet can improve life at a relatively low cost. The Government of India set up ERNET in 1986 to provide TCP/IP connections for education and research in India. ERNET established the first TCP/IP computer network in India and it offers services like e-mail, surfing Internet, FTP, Telnet, and database access, gopher, Archie, WAIS and WWW. Subsequently, the Government of India has liberalized the policies relating to the Internet. The liberalized policies initiated by the government encouraged many private players like DISHNET and Mantra online, and other government organizations like NIC, VSNL and MTNL to enter in this field, thereby making the Internet accessible to the common people.

The major network infrastructure available in the country has two types of WAN:
- Terrestrial WAN
- VSAT WAN
The following are the different options for setting up Intranet, education portal or e-commerce:

- Leased line
- Dial-up connection
- VSAT
- RADIO LINK.

**Integrated Services Digital Network (ISDN)**

ISDN is a group of CCITT/ITU standards relating to digital transmission across conventional copper wire telephone lines as also other media. This technology uses ISDN adapters in place of modems and provides very fast speed up. ISDN necessitates adapters at either end of the transmission circuit. However, in actual fact, multimedia delivery needs an extensive network that is capable of delivering data at high delivery speeds. Currently, ISDN implementation in the narrow band affords the best access and is the most appropriate delivery medium.

ISDN is seen by many in the industry as the means of ramping up that has the most potential of gaining universal acceptance. The installed base of ISDN is growing rapidly throughout the world to provide connections among different countries. The governments of various countries are coming out with plans and policies to implement ISDN as soon as possible. Conceptually, ISDN represents the integration of both voice data or analog signals and digital data transmission over a single network. ISDN effects this transmission over a medium that is, strictly speaking, designed for analog transmission, with BISDN (Broadband ISDN) holding out promise of extending the integration of both these services right across the entire spectrum of media of end-to-end paths including fibre-optic and radio media. Broadband ISDN will cover frame relay service for high-speed data that can be transmitted in sustained bursts, especially over FDDI (Fiber Distributed Data Interface) and SONET (Synchronous Optical Network). BISDN would support transmission from 2 Mbps up much higher, but as yet unknown rates.

**Definition of ISDN**

ISDN is a network architecture in which digital technology is used to convey information from multiple networks to the end user. This information is end-to-end digital.

**Features**

- Offers point to point delivery
- Network access and network interconnection for multimedia
- Different data rates from 64 kbps up to 2 Mbps are commercially available which can meet many needs for transporting multimedia and is four to many times more than today’s analog modems
Call set-up times are under one second. ISDN can dramatically speed up transfer of information over the Internet or over a remote LAN connection, especially rich media like graphics, audio or video or applications that normally run at LAN speeds.

ISDN would be feeder network in respect of broadband ISDN based on ATM standards.

Though ISDN might be less expensive, particularly in the case of prolonged usage, cheaper than even ATM connections and are likely to be more widely available for a longer length of time. This is the main reason why it is such a crucial tool for bringing multimedia applications to a wide spectrum of users.

There are two forms of ISDN service: Narrow band and broad band.

**Narrow band ISDN**

Narrow band ISDN is a digital service where the transport speeds are 1.544Mbps (T1) or less. Narrow band ISDN provides for the following services:

- **Circuit Switched Voice** – Circuit switched voice service is a digital voice service that offers many of the capabilities of a business. It is centered over a 4-wire ISDN Digital Subscriber Line (DSL).
- **Circuit Switched Data** – Circuit switched data service provides end-to-end digital service to pass data or video information over the public network. ISDN uses out-of-band signaling to establish and maintain data connections, which require special processing.
- **Low Speed Packet** – ISDN lines are equipped with a packet connection that is used to manage ISDN connections. This monitoring capability is provided by using the D channel on a DSL. The D channel is a 16kbps X.25 connection that is also capable of passing low speed packet while also relaying call processing information.
- **High Speed Packet** – ISDN lines are also equipped with two B channels. Each B channel is a 64kbps channel that can be used for circuit switched voice, circuit switched data, or high-speed packet service. To provision high-speed packet service one or two of the 64kbps B channels are connected (permanent virtual circuit) to the packet network thus providing a 64kbps X.25 connection.

**Broadband ISDN Service**

Broadband ISDN Service is a digital service in excess of 1.544Mbps. This digital service can be in the form of Frame Relay, SMDS, or ATM. Broadband ISDN is the service of the future. The higher speeds offered are required to support the many applications of the Information Super Highway. The range of speeds for the Broadband ISDN services usually range from 25Mbs up to the Gigabit range. The two speeds that are most often discussed are OC 1 that is 155Mbs and OC 3 that is 622Mbs. The speeds in the Broadband are made possible by the high...
quality of the digital facilities in place on the network. The early data protocols such as X.25 required extensive overhead to insure the delivery of data. Error correction and flow control were performed at a number of intermittent points along the way of a data connection. The new digital facilities and the introduction of fiber optics have eliminated this need up to a maximum extent. High-speed broadband services rely for the most part on the upper layer protocols to perform these functions on an end-to-end basis.

ISDN is accessed via any one of two alternative services, viz., CCITT as BRA (Basic Rate Access) and PRA (Primary Rate Access). Both these rates include a number of B channels carry data, voice and other services. The D channel carries control and signalling information.

- **Basic Rate Access (BRA)** affords an ISDN user with simultaneous access to two 64 kbps data channels utilising the conventional/existing twisted pair copper telephone cable, as illustrated in Figure 6.13. Each channel – referred to as a ‘B’ channel – is capable of carrying both voice or data.

  Another channel, known as the ‘D’ channel, functions at 16 kbps and is used for sending and receiving signals between user devices and the ISDN. The total transmission rate of BRA works out to a combined total of 144 kbps. The use of the two discrete ‘B’ channels and the lone signalling channel has resulted in the term ‘2B+D’. BRA is also sometimes called ‘I.420, as per CCITT recommended terminology. Basic rate ISDN is meant for low capacity usage, as per the normal needs of small business organizations.

- **Primary rate access** service provides up to 30 independent 64 kbps B channels and a separate 64 kbps D channel to carry the signalling. This basically provides digital access via a T1 line as shown in Figure 6.14. A T1 line provides a 1.544 bandwidth. This bandwidth is divided into 24 numbers of 64 kb channels. The ISDN PRI service uses 23 of the T1 channels to provide B channel access and uses the 24th channel for signaling purposes. ISDN call control procedures use packet messages to initiate, monitor, and release connections. In a BRI connection these messages are routed via the D channel. On the PRI service the /
connection/call control messages are routed over the 24th channel which is the D channel in this instance. Total data rate of PRA is 1.544 Mbps. Primary Rate Access is frequently referred to as 23 B+D due to the number of ‘B’ AND ‘D’ channels, or 1.421 because of the CCITT recommendation from which it is derived. This type of access is basically intended to be used in situations that call for large transmission capacity, e.g., when organizations make voice and data calls via an integrated services PBX.

![Primary rate interface](image)

**Check Your Progress**
1. Define radio?
2. Define local area network (LAN)?
3. What is Time space Time switching (TST)?

**10.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS**
1. It is a technique in which data is transmitted using radio waves and therefore energy travels through the air rather than copper or glass.
2. A local area network (LAN) is a network that is confined to a relatively small area (Limited Distance).
3. It allows sending message both on input and output trunk and therefore more flexible.

**10.5 SUMMARY**
- Physical transmission media that serve to transport the information is critical to its successful conveyance.
- The guided media includes all wired media, also referred to as conducted or bounded media.
The unguided media includes all traditional wireless media, also referred to as radiated, or unbounded.

Shielded twisted pair (STP) differs from UTP in that a metallic shield or screen surrounds the pairs, which may or may not be twisted.

Cable TV networks use coaxial cable. Local Area Networks can operate over coaxial cable to the 10BASE5, 10BASE2 and 10BASET specifications.

Broadband can transmit many simultaneous signals using different frequencies.

Optical Fibre transmission has become strong support for digital network owing to its high capacity and other factors favourable for digital communication.

Radio technique data is transmitted using radio waves and therefore energy travels through the air rather than copper or glass.

Microwave transmission is a form of radio transmission which uses extremely high frequencies.

Pagers may be considered a device that allows only one way communication.

ISDN is a network architecture in which digital technology is used to convey information from multiple networks to the end user.

10.6 KEY WORDS

- **LAN**: A LAN is a form of local (limited-distance), shared packet network for computer communications.
- **MAN**: A metropolitan area network (MAN) covers larger geographic areas such as cities or districts.
- **WAN**: Wide area networks (WANs) connect larger geographic areas, such as New Delhi, India or the world.

10.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. Define Wide area network (WAN).
2. What is Time Division Switching?
3. Describe Unbounded Media.
Long-Answer Questions

1. Describe Infrared Transmission.
2. Describe the Features of ISDN.
3. Explain Digital Network.
4. Write a Detail Note on PSTN.

10.8 FURTHER READINGS


UNIT 11 LIBRARY AUTOMATION

Structure
11.0 Introduction
11.1 Objectives
11.2 Planning of Library Automation
  11.2.1 Feasibility Study
  11.2.2 Technical Feasibility
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11.0 INTRODUCTION

In this unit, you will learn about the management of library automation. A library management system, also known as an automated library system, is software that has been developed to handle basic housekeeping functions of a library.

Library automation is the general term for Information and Communications Technologies (ICT) that are used to replace manual systems in the library. An Integrated Library System (ILS), also known as a Library Management System (LMS), is an enterprise resource planning system for a library, which is used to track items owned, orders made, bills paid and users who have borrowed.

An important aspect of library management is planning and maintaining library
facilities. Planning the construction of new libraries or remodeling those that exist is integral as user needs are often changing. To supplement their operating budget, managers often secure funding through gifts and fundraising. Some other facilities include cafes, Friends of the Library, and exhibit spaces to help generate additional revenue. These venues must be taken into account when planning for building expansions. The site for new construction must be located; the building must be designed, constructed, and then evaluated. Once established, it is important that the building is maintained on a regular basis. This can also be accomplished by delegating tasks to maintenance personnel or hiring an outside company through bids.

You will also learn about different feasibility studies. The feasibility study outlines and analyses several alternatives or methods of achieving business success. The feasibility study helps to narrow the scope of the project to identify the best business scenario(s). The business plan deals with only one alternative or scenario. The feasibility study helps to narrow the scope of the project to identify and define two or three scenarios or alternatives. The person or business conducting the feasibility study may work with the group to identify the ‘best’ alternative for their situation. This becomes the basis for the business plan.

The feasibility study is conducted before the business plan. A business plan is prepared only after the business venture has been considered to be feasible. If a proposed business venture is considered to be feasible, then a business plan is usually devised that provides a ‘roadmap’ of how the business will be created and developed. The business plan provides the ‘blueprint’ for project implementation. If the venture is considered not to be feasible, efforts may be made to correct its deficiencies, other alternatives may be explored or the idea is dropped.

Moreover, you will learn about the basics of a librarian. The library management system is developed in conjunction with librarians in order to gain first hand needs of various libraries. Finally, you will learn about Retrospective Conversion. Nowadays, libraries and information centers are automating their activities and functions to meet the users’ increasing needs efficiently and effectively. The first major bottleneck is the Retrospective Conversion of existing catalog into machine-readable form. It may take years depending upon the size of the existing collection of the libraries or information centers. Smaller and new libraries have an advantage over the larger and established libraries because of the lesser quantity of data for retrospective conversion.

11.1 OBJECTIVES

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

- Describe how to plan automation in a library
- Explain the different formats and standards of library
- Discuss the history and development of library automation software
11.2 PLANNING OF LIBRARY AUTOMATION

Automation of a library is an important step in library management. Therefore, it should be properly planned and implemented. Planning for library automation has been defined as planning for “integrated library management systems” that computerize an array of traditional library functions using a common database. As physical, spatial and temporal barriers to acquiring information continue to crumble, libraries must plan for a broader and more comprehensive approach to providing automated services. Currently, libraries find themselves confronted with a second computerization wave. The first wave took place during the 1970s and turned manual back-room activities, such as acquiring, distribution and cataloging, into computer-controlled activities. Essential in the computerization wave of the 1990s is the deployment of computer networks: campus-wide networks at universities as well as national and international networks. These networks provide access to remote electronic information by means of library information systems. Furthermore, available electronic information is no longer limited to so-called secondary information (catalogs, bibliographic databases, and so on). Also, primary information has now become electronically available. Presently, we can refer to the electronic full-text versions of scientific journals. Electronic textbooks and readers enable us to consult information outside the library, that is, at the professional and private work site of the library’s traditional customers. Thus, while planning the automation of a library, a series of steps need to be considered. These are discussed in detail in the following sections.

11.2.1 Feasibility Study

A feasibility study is carried out to know objectively and to rationally uncover the strengths and weaknesses of an existing or proposed venture, opportunities and threats present in the environment, the resources required to carry through, and ultimately the prospects for success. In its simplest terms, the two criteria to judge feasibility are the cost required and the value to be attained.

A well-designed feasibility study should provide a historical background of the project, a description of the product or service, details of the operations and management, marketing research and policies, financial data, legal requirements, and tax obligations. Generally, feasibility studies precede technical development and project implementation. A feasibility study evaluates the project’s potential for success; therefore, perceived objectivity is an important factor in the credibility of the study for potential investors and lending institutions. It must, therefore, be
conducted with an objective, unbiased approach to provide information upon which decisions can be based. A feasibility study assesses the feasibility of automation for library services and functions, and to determine the viability of implementing an integrated library management system. The study addresses the needs of the library in terms of library automation; benefits to be achieved from it, automation requirements and their costs, cost of automating in relation to potential cost savings, staffing requirements for automation of services and functions, and a recommended approach and process for automation. The report focuses on the following areas:

- Functional requirements for the application software
- System options (technical requirements, software options, computer equipment, estimated costs, and so on)
- Database creation and management (retrospective conversion of library holdings, issues affecting the decision, estimated costs, and so on)
- Management of an automated library system (staffing, training, estimated costs, and so on)
- The costs and benefits of library automation (quality of service users, networking, efficiency, accuracy and timeliness of library activities, management information, and cost-benefit analysis)
- A system development strategy and implementation plan

The aim of a feasibility study is to determine whether it is achievable or not. The benefits outweigh the disadvantages and also examines alternative solutions. It is designed to answer the following questions:

- Is the proposed system realistic?
- Is it necessary?
- What other options are available?
- Is it affordable?

The final output of the feasibility study is a report to be presented to the management.

11.2.2 Technical Feasibility

Technical feasibility is based on the design of system requirements to determine whether the organization has technical expertise to handle the completion of a project. When writing a feasibility report, the following points, which could affect the study, should be taken to consideration:

- The part of the business being examined.
- The human and economic factor.
- The possible solutions to the problem.
At this level, the concern is whether the proposal is both technically and legally feasible or not. The technical feasibility assessment is focused to get an insight understanding of the present technical resources available with the organization and their applicability to the expected needs of the proposed system. It is an evaluation of the hardware and software, and how it meets the need of the proposed system.

**Hardware**

Hardware is the primary requirement for library automation. Different types of hardware are available in the market. A hardware specification depends on the following:

- Available budget
- Size of the data to store
- Usage load
- Required speed
- Features to upgrade when it required
- Availability of servicing (maintenance)
- Compatible with operating system, what we are going to use
- Warranty period

When automating a library, the hardware to be procured should be taken into consideration. Today, different types of modern hardware are available in the market. Also, while procuring the hardware, the software, which will be installed, should be evaluated in terms of its compatibility with the hardware.

**Evaluation of the Hardware**

Evaluation may aim at choosing a single piece of equipment or a total system. The following characteristics of the hardware should be taken into consideration during evaluation:

(i) **Performance**: The performance of the hardware in terms of the speed of operation, memory size, storage capacity, and so on, for computer processors, should be considered. Moreover, the quality of display of the screen with color and graphics, the quality of results from output devices, among others, should also be taken into account. It should also be noted whether the system will be able to cope with the required number of users and with peak demand as well as average conditions.

(ii) **Compatibility**: Will the hardware work with existing or proposed systems. Does it meet the organization’s standards, if any? Can it be combined with the hardware of other manufacturers, if required?
(iii) **Reliability:** Is the manufacturer and/or supplier from a reputable organization. Will there be problems with upgrade or repairs? Is the equipment robust enough for the proposed use?

(iv) **Expandability:** Is the hardware capable of being expanded and upgraded, or is it strictly limited? Is there scope for add-ons, such as memory cards, additional processor, and so on? Can newer or more effective peripherals, for example, printers, be added easily?

(v) **Multi-user:** If the system starts as a single user, can it be easily extended to multi-user?

(vi) **Networking:** Is this possible now? Can it be provided in future without disruption?

(vii) **Software:** Is the hardware compatible with the application software which will be used now or may be needed in the future? Are graphics, color, and so on, available, if required, by the software? Is there sufficient processing capacity and storage capacity to use the software to the fullest? What systems software is supplied? Is there any choice?

(viii) **Environment:** Where will the hardware be located? Who will use it? Are there any problems of noise, heat, lighting, power supply and cabling to be considered? Does the hardware have to be moved at all or should it be portable?

(ix) **Price:** Not just purchase price, but the cost of maintenance, repair and development also need to be considered?

### Software

The term ‘software’ refers to a set of computer programs, procedures and associated documents (flow charts, manuals, and so on) that describe the program and how they are to be used. To be precise, software is a collection of programs to enhance the working capabilities of the hardware. Software is a set of programs written or developed to enable the computer to perform desired operations.

The hardware operates on the basis of a set of programs of software. Basically, software is the program that runs the computer to produce the required results. It is said that a computer without software is similar to a man without his brain or a library with neither books nor librarians. Therefore, on principle, the selection of software comes before hardware. It is one of the most important components which should be taken care while automation. Today, a number of application software are available in the market by different companies in India and abroad with distinct features. Therefore, while selecting software, it is very important to take care of the present as well as future needs of the library.

The selection of an operating system depends on the following:

- Hardware compatibility
- Further support from operating system developers
Library Automation

- To be user-friendly
- Upgrade facility (service packs)
- Library automation software
- Supporting software for library automation software

Types of Software

Although the range of software available today is vast and varied, most software can be divided into two major categories. These are as follows:

(i) System Software

System software is a set of one or more programs, designed to control the operation and extend the processing capability of a computer system. System software is a type of computer program that is designed to run a computer’s hardware and application programs. If we think of the computer system as a layered model, the system software is the interface between the hardware and user applications.

The Operating System (OS) is the best-known example of system software. The OS manages all the other programs in a computer.

In general, a computer’s system software performs one or more of the following functions:

- Supports the development and execution of other application software
- Monitors the effective use of various hardware resources, such as Central Processing Unit (CPU), memory, peripherals, and so on
- Communicates with and controls the operation of peripheral devices, such as printer, disk, tape, and so on

The programs included in a system software package are called system programs, and the programmers who prepare the system software are referred to as system programmers. Some of the most commonly known types of system software are as follows:

- Operating System (OS)
  An OS is system software that manages computer hardware and software resources, and provides common services for computer programs. The operating system is a component of the system software in a computer system. Application programs usually require an operating system to function.

- Programming Language Translators
  A translator is a computer program that performs the translation of a program written in a given programming language into a functionally equivalent program in a different computer language, without losing the
Communication Software

Communication software is used to provide remote access to systems, and exchange files and messages in text, audio and/or video formats between different computers or users. This includes terminal emulators, file transfer programs, chat and instant messaging programs, as well as similar functionality integrated within MUDs (Multi-User Dungeon, with later variants as Multi-User Dimension and Multi-User Domain). The term is also applied to the software operating a bulletin board system, but seldom to that operating a computer network or Stored Program Control exchange.

Email started in 1965 as a way for multiple users of a time-sharing mainframe computer to communicate. Basic text chat functionality has existed on multi-user computer systems and bulletin board systems since the early 1970s. In the 1980s, a terminal emulator was a piece of software necessary to log into mainframes and, thus, access email. Prior to the rise of the Internet, computer files were exchanged over dial up lines, requiring ways to send binary files over communication systems that were primarily intended for plain text. Moreover, programs implementing special transfer modes were implemented using various de facto standards, most notably Kermit.

Utility Programs

Utility programs refer to those programs that perform a very specific task, usually related to managing system resources. Operating systems contain a number of utilities for managing disk drives, printers and other devices. Utilities differ from applications mostly in terms of size, complexity and function. For example, word processors, spreadsheet programs and database applications are considered applications because they are large programs that perform a variety of functions that are not directly related to managing computer resources.

Utilities are sometimes installed as memory-resident programs. On DOS (Disk Operating System) systems, such utilities are called TSRs (Terminate and Stay Resident programs).

Application Software

Application software is a set of one or more programs, designed to solve a specific problem or perform a specific task. Application software, or simply applications, are often called productivity programs or end-user programs because they enable the user to complete tasks, such as creating documents, spreadsheets, databases, publications, doing online research, sending email, designing graphics, running businesses and even playing games. Application software is specific to the task it
is designed for and can be as simple as a calculator application or as complex as a word processing application.

When you begin creating a document, the word processing software has already set the margins, font style and size, and the line spacing for you. But you can change these settings, and you have many more formatting options available. For example, the word processor application makes it easy to add color, headings and pictures, or delete, copy, move and change the document’s appearance to suit your needs. The word ‘application’, once used as an adjective, is not restricted to the ‘of or pertaining to application software’ meaning. For example, concepts such as Application Programming Interface (API), application server, application virtualization, application lifecycle management and portable application, apply to all computer programs alike, and not just application software.

Some of the above-mentioned applications are available in the market as software packages. They are as follows:

- Word Processing Software
- Spreadsheet Software
- Database Software
- Graphic Software
- Personal Assistant Software
- Education Software
- Desktop Publishing Packages
- Library Management Software
- Expert Systems

Today, readymade software packages are available in the market for a wide range of applications. However, their capabilities differ, prices vary and their versions keep on changing. The selection of a suitable software package is an important factor in library automation system. There are not many publications or case studies discussing the criteria for selecting suitable software. The selection is based on specific needs of the institution, its environment, budget, user’s aims and objectives.

(iii) Commercial Software (CS)

Hundreds of commercial library software have been developed and they run successfully today in the world. There are also many software directories and other tools available that help librarians to select suitable software for their libraries. Commercial software typically provides solutions to particular application problems. Since they are developed on a commercial scale in a competitive market for use by a variety of customers, a great amount of skill and effort is put in their development.
Commercial software is easy to use as they come with all the necessary program features. Using commercial software is easy because of lack of limits and restrictions imposed to users. It is designed in a manner that allows easier implementation into the existing systems without using customization. Additionally, they are more reliable as compared to other types of software. Most of the requirements for using commercial software are determined by market research, thereby, providing up-to-date features and services. Businesses benefit by using commercial software due to their reliability, availability and affordability. It is disadvantageous to use commercial software because one has to pay before using them. In other cases, customers must pay an annual fee to keep and use the software. Another disadvantage of commercial software is its failure to meet the specific goals of each user, especially in terms of diverse programs, such as integration with electronic health and so on.

Getting solution to any problem requires the input of a professional service firm, which is costly in the long run. Commercial software programs typically come in a physical box, which is what you see displayed in retail stores. While it is true that the software boxes are not as big as they used to be, they still contain the software CD (Compact Disk) or DVD (Digital Versatile Disk). They also usually contain a 'getting started' manual along with a registration key used for registering the product. Most commercial software programs ask the user to register the program so that the company can keep a track of its authorized users. Some commercial software programs, such as newer versions of Microsoft and Adobe programs, require the user to register the programs in order to continue using them after thirty days.

While most commercial software programs are sold in the physical box, many software titles are now available as downloads. These downloads are typically made available from the company’s Website. The user pays for the program directly on the Website and instead of receiving the software in the mail, the user downloads it to his computer. Another popular way of purchasing commercial software online is simply by paying for a registration key, which unlocks the features of a shareware program. This upgrades the shareware program to the commercial version, which removes any feature limitations from the shareware version. Therefore commercial software is reliable, easy to use, and well-documented.

(iv) Open Source Software

Open Source Software (OSS) is an antonym for closed source and refers to any computer software that is released free of cost, and its licenses usually prohibit modifications and commercial redistribution. Source code is available under a license that permits users to study, change and improve the software, and to redistribute it in modified or unmodified form. A definition of open source is ‘free distribution and redistribution of software and source code; licenses that allow distribution of modifications and derived works and non-discrimination against
persons, groups or fields of endeavor’. Open source software is advantageous to both programmers and non-programmers. In fact, because much of the Internet itself is built on many open source technologies, such as the Linux operating system and the Apache Web server application, anyone using the Internet benefits from the open source software. Every time computer users view Webpages, check email, chat with friends, stream music online or play multiplayer video games, their computers, mobile phones or gaming consoles connect to a global network of computers that routes and transmits their data to the ‘local’ devices that the users have in front of them.

The computers that perform all these important works are typically located in faraway places that users do not see or cannot physically access—which is why some people call these computers ‘remote computers’. Moreover, people rely on remote computers when doing things they might otherwise do on their local devices. For example, they use online word processing, email management and image editing software that they do not install and run on their personal computers. Instead, they simply access these programs on remote computers by using a Web browser or mobile phone application.

Some people call remote computing ‘cloud computing’ because it involves activities (such as storing files, sharing photos or watching videos) that incorporate not only local devices but also the global network of remote computers, which form an ‘atmosphere’ around them. Cloud computing is an increasingly important aspect of everyday life with Internet-connected devices. Some cloud computing applications, such as Google Docs, are closed source programs. Others like Etherpad are open source programs.

OSS is generally free software that you can use in your business. Open source developers make the source code of their software publicly available for the good of the community and to publish their software with an open source license, meaning that other developers can see how it works and add to it. The term is most commonly applied to the source code of software that is made available to the general public with either relaxed or non-existent intellectual property restrictions. This allows users to create user generated software content through either incremental individual effort or collaboration. Open source software gained popularity with the rise of the Internet and its enabling of diverse production models, communication paths and interactive communities. There are very few cases of software that is free software but is not open source software, and vice versa. Many users prefer open source software to proprietary software for important, long-term projects. Because the source code for open source software is distributed publicly, users that rely on software for critical tasks can be sure that their tools will not disappear or fall into disrepair if their original creators stop working on them. The difference in the terms is where they place the emphasis.
Table 11.1 lists the difference between commercial and open source software.

**Table 11.1 Commercial and Open Source Software**

<table>
<thead>
<tr>
<th>Commercial Software (CS)</th>
<th>Open Source Software (OSS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial software has initial purchase fees, licensing fees as well as upgrade fees.</td>
<td>Open source software is available almost free of costs.</td>
</tr>
<tr>
<td>CS cannot be changed, modified, improved and redistributed by users.</td>
<td>OSS can study, change and improve the software, and redistribute it in modified or unmodified form.</td>
</tr>
<tr>
<td>CS is usually distributed only as a binary that will run only on a single hardware platform and single version.</td>
<td>OSS can be recompiled, or at least ported to new hardware and operating system.</td>
</tr>
<tr>
<td>CS is very difficult to preserve over the long run without developing hardware emulation.</td>
<td>OSS makes the preservation of digital objects easier and less risky.</td>
</tr>
<tr>
<td>It cannot be easily audited.</td>
<td>OSS is easily audited.</td>
</tr>
<tr>
<td>It is reliable, easy to use and in many instances, well-documented.</td>
<td>It might be difficult to use and may not be well documented.</td>
</tr>
<tr>
<td>CS provides support and maintenance.</td>
<td>OSS is often criticized for lack of support and maintenance.</td>
</tr>
<tr>
<td>Support and maintenance costs of CS are higher.</td>
<td>Support and maintenance costs of OSS are often lower.</td>
</tr>
</tbody>
</table>

### 11.2.3 Economic Feasibility

The purpose of economic feasibility assessment is to determine the positive economic benefits to the organization that the proposed system will provide. It includes quantification and identification of all the benefits expected. This assessment typically involves a cost-benefits analysis. The EFS (Economic Feasibility Study) is composed of two required forms: business case and cost-benefit analysis. These are discussed as follows:

- **Business Case**

The Business Case provides an analysis of the business environment including, but not limited to, a description of who the expected customers are, the nature of the business, how the payment is currently being processed, if applicable, and the current and expected volume and timing of transactions. The Business Case also presents the benefits of the proposed project.

The Business Case includes a description of the assumptions made in the economic feasibility analysis and the reasoning behind those assumptions. If a project includes electronic payment methods other than ACH (Automated Clearing House), the Business Case is required to explain why ACH would not be a viable option for the agency’s project.
• Cost-Benefit Analysis

The Cost-Benefit Analysis summarizes the revenues and costs involved with the proposed project. The amounts in the Cost-Benefit Analysis should reflect the amounts and assumptions in the Business Case. An analysis summarizing the impact to the agency, other state agencies and the general public is also included, as applicable.

Economic feasibility elements include, but are not limited to, the following:
- Increased agency revenue
- Decreased agency revenue
- Increased agency costs
- Decreased agency costs
- Increased revenue to other agencies and/or the general public
- Decreased revenue to other agencies and/or the general public
- Increased costs to other agencies and/or the general public
- Decreased costs to other agencies and/or the general public
- Other public benefits

These items are to be described in detail in the Business Case and the associated dollar amounts for these items are included in the Cost Benefit Analysis. The elements for the agency should be separated from those of other state agencies and the general public so that the potential funding requirements can be discerned.

11.2.4 Operational Feasibility

Operational feasibility is a measure of how well a proposed system solves the problems and takes advantage of the opportunities identified during scope definition and how it satisfies the requirements identified in the requirements analysis phase of system development.

The operational feasibility assessment focuses on the degree to which the proposed development projects fit in with the existing business environment and objectives with regard to development schedule, delivery date, corporate culture and existing business processes. To ensure success, desired operational results must be imparted during design and development. These include design-dependent parameters, such as reliability, maintainability, supportability, usability, sustainability, affordability and others. These parameters are required to be considered at the early stages of design if desired operational behaviors are to be realized. A system design and development requires appropriate and timely application of technological and management efforts to meet the previously mentioned parameters. A system may serve its expected purpose in an effective manner when its technical and operating characteristics are engineered into the design. Therefore, operational feasibility is an important aspect of systems design.
The Need for Operational Feasibility Studies

Operational feasibility studies are generally utilized to answer the following questions:

- **Process**: How do the end-users feel about a new process that may be implemented?
- **Evaluation**: Whether or not the process within the organization will work but also if it can work.
- **Implementation**: Stakeholder, manager, and end-user tasks.
- **Resistance**: Evaluate management, team and individual resistance and how that resistance will be handled.
- **In-House Strategies**: How will the work environment be affected? How much will it change?
- **Adapt and Review**: Once change resistance is overcome, how will the new process be implemented along with a review process to monitor the process change?

11.2.5 Schedule Feasibility

A project will fail if it takes too long in its competition. Typically, this means estimating how long the system will take to implement and if it can be completed in a given time period. Schedule feasibility is a measure of how reasonable the project timetable is. Given our technical expertise, are the project deadlines reasonable? Some projects are initiated with specific deadlines. It is necessary to determine whether the deadlines are mandatory or desirable. Schedule feasibility is defined as the probability of a project to be completed within its scheduled time limits, by a planned due date. If a project has a high probability to be completed on time, then its schedule feasibility is appraised as high. In many cases, a project will be unsuccessful if it takes longer than it was estimated. Besides, some external environmental conditions may change; hence, a project can lose its benefits, expediency and profitability. If a work to be accomplished at a project does not fit the time frames demanded by its customers, then a schedule is unfeasible (the amount of work should be reduced or other schedule compression methods should be applied).

If the project managers want to see their projects completed before they can lose their utility, they (project managers) need to give proper attention to controlling their schedule feasibility. They should calculate and continually re-examine whether it is possible to complete all amount and scope of work lying ahead, utilizing the given amount of resources, within required period of time. Schedule feasibility study includes the use of the following factors:

- Project Estimation
- Gantt and PERT (Program Evaluation and Review Technique) Charts
- CPM (Critical Path Method)
- Change Management
Check Your Progress
1. What are the different types of software?
2. Define utility programs.
3. What do you mean by schedule feasibility?

11.3 HISTORY OF LIBRARY AUTOMATION SOFTWARE

The library software packages did not develop at once. The study shows that it has developed generation wise which can be divided into four generations.

The first generation software was developed to run on specific hardware platform and proprietary operating systems. Low-level programming language was used and the non-standard database management systems were the common features of these software. Circulation module and cataloging module were the priority issues for these systems. Although these software packages were module-based systems, there was no or very little integration between these modules. The single user standalone structural design was used in this generation.

The second generation library software packages, with the introduction of UNIX (UNiplexed Information Computing System) and DOS based systems, become moveable between various platforms. Limited number of users and shared structural designs can be seen. The special features of these packages are the ability to shift between systems for a specific function. Command-driven or menu-driven features can be seen in this generation. The capacity of record holding has also been improved in this generation.

The third generation library software packages provide fully integrated systems. They are based upon relational database structure. These software packages introduced a range of standards which were a significant step towards Open System Interconnection (OSI). Color and Graphical User Interface (GUI) features, such as Windows, icons, menus and direct manipulation, have become standard and norms in this phase. User support was extensively increased in this generation.

Based on the improvement of the technology, the features of the fourth generation library management software are based on client-server architecture. These features facilitate access to other servers over the Internet. Object-oriented database management system and Windows operating system have been introduced in this generation. These systems allow increasing multiple sources from one multimedia interface. Customized report generation was also available in this phase.
Moreover, the latest library automation software allows customized report generation, and to manipulate data and investigate various scenarios. Therefore, they have all the potentials to be a decision support tool.

The growth of library automation can be better understood from Table 11.2.

<table>
<thead>
<tr>
<th>Year</th>
<th>Developments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940–49</td>
<td>Semi-mechanical applications including edge-notched cards, optical coincidence and peek-a-book cards.</td>
</tr>
<tr>
<td>1950–59</td>
<td>Use of punched cards, data processing equipment, early computers and micro image searching systems.</td>
</tr>
<tr>
<td>1960–69</td>
<td>Application of general purpose digital computers, feasibility studies of online interactive and advance micro image systems, experiments in library networking.</td>
</tr>
<tr>
<td>1970–79</td>
<td>Design of online systems and conversion of batch systems into online mode, growth of library network and databases.</td>
</tr>
<tr>
<td>1980–89</td>
<td>Intensive use of online systems, networks, mini and microcomputers, optical disks, CD-ROMs, FAX, and so on.</td>
</tr>
<tr>
<td>1990s</td>
<td>Use of Internet and library networks aims towards higher levels of computer application, such as recording through electronic media, artificial intelligence, and so on.</td>
</tr>
</tbody>
</table>

A comparative table of features and functionalities of software in four different generations is shown in Table 11.3.

<table>
<thead>
<tr>
<th>Features</th>
<th>1st Generation</th>
<th>2nd Generation</th>
<th>3rd Generation</th>
<th>4th Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming Language</td>
<td>Low-Level Language</td>
<td>COBOL, PASCAL, C</td>
<td>4th Generation Language</td>
<td>OOPS</td>
</tr>
<tr>
<td>Operating System</td>
<td>In-house Vendor Specific</td>
<td>UNIX, MS-DOS</td>
<td>UNIX, Windows</td>
<td>UNIX, Windows</td>
</tr>
<tr>
<td>DBMS</td>
<td>Non-Standard Hierarchical and Network Model</td>
<td>Entity Relation Model</td>
<td>Object-Oriented Model</td>
<td>Object-Oriented Model</td>
</tr>
<tr>
<td>Reports</td>
<td>None</td>
<td>Limited</td>
<td>Standard</td>
<td>Fully Integrated and Seamless</td>
</tr>
<tr>
<td>Communication</td>
<td>Limited</td>
<td>Semi-Interfaced</td>
<td>Standard</td>
<td>Fully Interoperating across the Internet</td>
</tr>
<tr>
<td>Portability</td>
<td>Hardware and Platform Dependent</td>
<td>Hardware and Platform Dependent</td>
<td>Multi-Vendor</td>
<td>Multi-Vendor and Multi-Vendor Integration</td>
</tr>
<tr>
<td>Reports</td>
<td>Fixed Format and Limited Length</td>
<td>Fixed Format And Unlimited Fields</td>
<td>Customized Report Generation</td>
<td>Customized Report Generation with Email and Interface</td>
</tr>
<tr>
<td>Color</td>
<td>None</td>
<td>None</td>
<td>Available</td>
<td>Fully Available with Multimedia</td>
</tr>
<tr>
<td>Capacity of Record Holding</td>
<td>Limited</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>Unlimited</td>
</tr>
<tr>
<td>Module Integration</td>
<td>None</td>
<td>Bridges</td>
<td>Standard</td>
<td>Standard</td>
</tr>
<tr>
<td>Architecture</td>
<td>Modular</td>
<td>Modular</td>
<td>Modular</td>
<td>Modular</td>
</tr>
<tr>
<td>User Support</td>
<td>Single User</td>
<td>Unlimited Number of Users</td>
<td>Unlimited Number of Users</td>
<td>Unlimited Number of Users</td>
</tr>
<tr>
<td>Multi-lingual Support</td>
<td>None</td>
<td>Limited through Hardware Support</td>
<td>Limited through Hardware Support</td>
<td>Limited through Hardware Support</td>
</tr>
</tbody>
</table>

Check Your Progress

4. State the objective of developing the first generation software.
11.4 CRITERIA FOR THE SELECTION
OF LIBRARY SOFTWARE PACKAGES

The criteria for the selection of library software packages are as follows:

- The hardware requirement to run the software has to be determined precisely. Moreover, it also has to be decided whether the existing hardware of the library would suffice or any modification. The software must run under the operating system available in the hardware.
- The software must be compatible with the computers on which it has to run. Some packages use special peripheral devices, such as modem, hard disk, and so on. A few others are designed to be used with DBMS (Database Management System) or spreadsheets. While buying software, the concerned library should verify whether any companion program or a special device/hardware are required or not.
- It should be user-friendly to the people with little or no knowledge of computer use.
- It should provide sophisticated online input, data management and retrieval facilities appropriate for the efficient handling of a relatively large bibliographies database.
- The software package should provide full documentation on all aspects, such as reference manual, instructions, online help, and so on, for assisting the librarian while using it.
- The vendor must support the installation aid and provide training to the operating personnel.
- It should be flexible in allowing the end-users to easily write their specification for local variations.
- It should accept machine readable files in the RM (Reference Manual), UNIMARC ((Universal Machine—Readable Cataloging) and eventual CCF (Common Communication Format) formats to directly generate bibliographic description for local use and generate an output file, from its own internal bibliographic description, which is formatted in accordance with the RM and/or UNIMARC and/or CCF specifications.
- Most important of all these criteria is the cost of package, which must be within budgeted amount. It should include vendors charge for training, installation, maintenance and update.
- The selection of a good and perfect software package is not an easy job. First make yourself clear of your short-term and long-term needs of the software which you intent to buy the software. Then develop functional specifications for each job that you want to do with the software.
11.5 LIBRARY AUTOMATION SYSTEM SELECTION GUIDELINES

The library automation software must be developed and designed based on the best practices that are internationally adopted in the library profession. These include:

- Adoption of MARC-based bibliographic record. Record can be imported, created, updated and exported using the MARC 21 and ISO 2709 standards. (MARC stands for MAchine-Readable Cataloging and ISO stands for International Organization for Standardization.)
- Bibliographic and item information must be stored separately in two different types of record so that more than one item record can be attached to one bibliographic record.
- Support of internationally adopted library standards, including ISBD (International Standard Bibliographic Description), AACR2 (Anglo-American Cataloguing Rules), subject heading scheme, classification scheme, and so on.
- Automation of library operations and activities, including circulation, public catalog searching, cataloging, ordering, serials control and reporting.

The library automation software must be supported by a team that processes library experience and qualification. This is essential to ensure that the team understands the library requirements and at the same time is able to provide professional advice to the libraries.

The software vendor (or developer) must have long-term commitment on the further development of the software. The vendor should, in particular, take the following into consideration:

- The vendor should be quick to integrate emerging library standards and new technology to the software. These include Web and the Internet-based access to the library catalog, XML and Dublin Core technology, Unicode, and so on.
- The vendor must be financially stable.
- The vendor must be specialized in library applications.
- The vendor must have periodical upgrade release with new enhancements.

The library automation software must be able to support Hong Kong school library environment. These include the following:

- Support bilingual interface and bilingual data.
- SAMS (Hong Kong Education Department’s School Administration Management System) student data can be imported to the library database.
• Support sharing of cataloging records among Hong Kong school libraries.
• The software must run on computer and networking equipment commonly used in Hong Kong school libraries.
• The initial purchase cost and the annual upgrade cost must be priced at a level affordable by Hong Kong school libraries.

11.5.1 Methods to Select the Software

Struggling with software selection process is extremely taxing on the average library professionals. In particular, technology, feature and functions, security and authentication issues, long-term cost, vendor viability, services and support, for example, maintenance considerations, as well as training and documentation are to be considered for software selection with greater attention. They are discussed in the following section.

• Technology

Here, technology refers to hardware and software. A suitable hardware and software is a must for proper functioning of any library automation package. Each software package should carefully examine the memory requirements and the required system software, taking the type of hardware into consideration. The technology should be able to determine whether additional peripheral hardware, such as speakers, scanners, earphones, and so on, will be necessary to make the program perform. Moreover, it will require regularly upgrading of the equipment. The technology should be strong and capable enough to handle current and future transaction load. The system speed should be acceptable for daily usage. Software should support multi-company, multidivisional and multi-currency environments.

It can be seen that software package written in higher order programming language, such as COBOL (Common Business Oriented Language), FORTRAN (Formula Translating System), BASIC (Beginner’s All-Purpose Symbolic Instruction Code), and so on, generally face problems in their maintenance, upgrading, customization, and so on, due to non-availability of suitable hardware.

11.5.2 Features and Functions

When reviewing potential software suppliers, many companies tend to focus only on the potential product’s functionality and features. These are discussed below.

• Features

The factors including data storage techniques used in development of software, database structure file organization, and so on, must be taken into consideration. It is also necessary to inspect the facilities of importing, exporting and downloading the data from one’s own computer to disk or CD-ROM (Compact Disc Read-Only Memory), and so on, and its compatibility with CCF/MARC standard format.

Many librarians are confronting the issue of language by identifying the programming language in which software is very important at the time of procurement.
or development of the package. This is due to the fact that many facilities, such as fixed length, variable field length, variable format, search facility, and so on, are provided in the packages by using suitable programming language. Generally, customers or users have to face problems in the maintenance, upgrading and customization due to inappropriate programming language in any library automation software.

**Functions**

A good library software package should be an integrated modular software for the entire range of library activities. The main functions of software packages can be listed as follows:

- Acquisitions
- Cataloging
- Circulation
- Online-Public Access Catalog
- Serial Management
- Report Generator
- Interlibrary Loan
- Community Information
- Import/Export
- Providing Reference Service

Besides this, some other factors also should be considered as the functional level in selecting the software. These factors are as follows:

- Does this package meet the overall requirements listing?
- The menu structure should be easy to follow and understand.
- Are the help files easily assessable and easy for users to understand?
- Can the user customize help to meet the individual needs of the organization?
- Is the product overly complex or too sophisticated for the average user?
- Are there standard reports available and are they useful?

**Cost**

The cost of commercial software package varies considerably across the range of packages available except open source and free software. Most of the library automation software is costly. Commercial software has initial purchase fees, licensing fees as well as upgrade fees. Moreover, the software designers also claim additional charges for customization, on-site training and data conversion from other DBMS/data sources, annual maintenance contract and customer support service. However, the software developed locally might be cheaper in price as compared with foreign software. Some software package developed using open
source and free software is available free of cost and offers only on the distribution charge. There are some other factors to be considered while selecting the software. These are as follows:

- Are the license costs justified given the functionality offering?
- Is the required database affordable?
- Are annual maintenance charges reasonable?
- What is the ratio of software cost to the implementation cost?

**Supplier Longevity**

Supplier longevity is also a very important factor to be considered before selecting the software. This factor generally considers the numbers of years a company has been actively engaged in the software industry, when was the product first released and what is the current release version being quoted. The reliability, customization and durability of the software depend on the stability of the software designer and supplier. If the company has been consistently profitable over the years the recent turnover has been on the management staff, there is no doubt on the company’s longevity. Similarly, the customer’s reference is also a supportive factor for taking a decision regarding the selection of the software.

**11.5.3 Services**

The most important factor is the service part of any software package for the library. The librarian can serve the people effectively, efficiently as well as rapidly with the help of automation using good library software package, which is integrated by all required services. In fact, the entire range of services available in selected packages can be divided into three groups, which are as follows:

**(i) Core Services**

Core services are the basic services necessary for library routines and are recommended to be available with library automation packages. The existence of any automation software depends on the available services, facilities, and coverage of library and information activities in various modules. The different facilities in the library automation package are acquisition, cataloging, classification, OPAC, circulation, serial control, information services, management, technical services and maintenance, and so on.

Academic libraries acquire not only the English language documents but also acquire documents available in various foreign languages for the research purpose. Therefore, the software should have the facility of multiple script acceptances.

**(ii) Enhanced Services**

It includes the additional services of the modern library which make work of the librarians easy, comfortable and smooth. Customized report generation, GUI-based user interface and color, interlibrary loan, multilingual support, union catalog,
and so on, are the examples of these type of services. Therefore, any software package having more facilities are certainly treated more suitable and advanced in comparison to those having limited facilities.

(iii) Value-Added Services

Value-added services are those types of services that are not generally included within a general scope of software packages. With the emergence of advanced technology, these types of services also became essential for the libraries of developed countries for the users’ easiness. Moreover, with the development of the software package, these type of services are provided. Therefore, the best software is that which have these types of services and facilities. Self-circulation, self-reservation, online user training, stock verification facility, barcode generation, gate pass generations and RFID are some examples of value-added services.

11.5.4 System Support and Maintenance

Customer support services mainly include the training, maintenance and documentation. It also includes publications (e.g., manual and newsletter) which contain information about the latest development of the software. It helps to keep the users up-to-date in the latest development of the library software.

(i) Training

The training of the library staff in computer operation is of vital importance. Every library staff member should be given a training and orientation about the computer system. The responsibility of the software designer or supplier does not end by selling the software without training until and unless people learn the operations of the software completely. This is because the most important people in making library computerization successful are the librarians. It must be realized that librarians will not be able to make any use of computer equipment until they are provided with the know-how required to use it. So, it is necessary to make training arrangements for the professional development of the librarians.

Maintenance

One should very carefully examine the support and maintenance arrangements being offered by the vendor/supplier. Maintenance may include removing the bugs or errors that might become evident in the software as it is used for a greater variety of applications and improving the software. Regarding maintenance, the following points should be kept in mind in the software selection process:

- Does the software has debugging facility and scope of proper error message while executing the software?
- How quickly are non-critical software bugs fixed for upgrading the software to adopt a new technology?^
- Is there any supplier for annual maintenance contract in discounted rate?
NOTES

Library Automation

Documentation

The reference manual with detailed written instruction (step-by-step) is necessary for using software package after a training program. The language of the manual should be easy to understand and should have a table of contents, glossary and index. It is also important to know whether they have any regular newsletter, user information or updated publication regarding the library software.

Performance

The provision for searching the OPAC and Web simultaneously (metasearch) using a single word search, search response time, search options, backup facilities, database security, and so on, shows the performance of any library automation software. The functions of packages are interrelated to each other. The response time of the search module depends on different factors, such as file organization, operating system, hardware platform, numbers of records in database, and so on.

Search Options

The search option includes simple search, Boolean search, (AND, OR, NOT) advanced search, string search, keyword search, field limitation search, truncation, use of related terms in searching, and so on. The provision for multiple manipulations and adequate searching capabilities must be in good characteristic software.

Security

Security mechanism prevents the software from misusing the database by the users and other people. For the safety purpose, the software should have the following:

- Provision of user ID/barcode, and so on
- Provision of access restriction to certain records/fields
- Provision for students and staff to log in and log off on their own
- Modification/new version of the software obtained by the librarian

User-Friendliness

The system should be easy to use. It should be checked whether the system empowers the experienced user with short cuts and flexible tools. The system should be easy to learn, menu driven and command mnemonic based. Besides the above criteria, copyright and licensing consideration is also important for the evaluation of the software.

Copyright and Licensing Considerations

All commercial software is copyright protected. The purchased package will contain a licensing statement to which the purchaser agrees by the action of opening the package. An advantage of the licensing agreement is that a registered owner (registration cards are also included in the software package) can usually obtain upgrades at far less than the full market price. Free software is not copyright
protected. Usually referred to as ‘Public Domain Software’, such packages are freely copy-able and/or transferable. Another software called ‘shareware’ is offered freely to everyone through user groups or over the Internet with the suggested provision that someone copying or downloading such a program voluntarily sends a small amount of money to the creator/developer of the software.

11.6 RETROSPECTIVE CONVERSION: IMPLEMENTATION AND EVALUATION

Nowadays, libraries and information centers are automating their activities and functions to meet the users’ increasing needs efficiently and effectively. The first major bottleneck is the Retrospective Conversion of existing catalogs into machine-readable forms. It may take years depending upon the size of the existing collection of the libraries or information centers. Smaller and new libraries have an advantage over the larger and established libraries because of the lesser quantity of data for retrospective conversion.

• Need for Retroconversion

One may ask, what does retroconversion, the replacement of manually cataloged records in machine-readable form, mean to a medium-sized university library in Nigeria? Retroconversion is necessary for old libraries like the university library, which has just become computerized. However, a new university library, which from the beginning has been able to catalog its books with the help of the computer, is in the happy position of being able to meet the demand of users who want to search for recent acquisitions by the library. Retroconversion has the reputation of being one of the most time and money consuming activities in library automation. Library management, therefore, secured the support of the university authority before the project planning started. The basic purposes of the retroconversion project are as follows:

  o To maximize access to the material in the library collections. This gives the ability to profit from existing and future developments in retrieval techniques. It makes the library catalog machine-readable. This is a prerequisite for taking full advantage of these opportunities.

  o To facilitate library management, library automation has been embraced because of its application to library procedures, which are under heavy strain.

• Retrospective Conversion: Definition

The word ‘Retrospective’ indicates that the process is only for already existing records, and the meaning of the word ‘Conversion’ refers to the form and format of the records changing something from one form to another. Thus, retrospective conversion in library and information center means changing already existing catalog from existing traditional form to a machine-readable form.
Retrospective conversion, according to ALA Glossary of Library & Information Science, has been defined as the process of converting the database of library holdings from non-machine-readable form to machine-readable form and that are not converted during day-to-day process.

Harrod’s Librarian’s Glossary defines retrospective conversion (information retrieval) as a partial or complete conversion of an existing catalog into machine-readable form as opposed to converting records created currently.

From the above definitions, it can be concluded that retrospective conversion is:

- Conversion of bibliographical information of library holdings
- From non-machine-readable form to machine-readable form
- That are not created during day-to-day process

Retrospective conversion can be accomplished in a number of ways. The choice of the best method(s) for any library or information center depends on the type and size of the collection, budget available, quality standards desired, time constraints, and staff, and so on. Though essential and one time activity, it is a time consuming and costly undertaking for a library.

**Need for Retrospective Conversion**

The conversion of database of library holdings from non-machine-readable form to machine-readable form is a prerequisite to implementing an automated system. This database would become the foundation for other library activities, such as OPAC, circulation, catalog maintenance, resource sharing, and so on. These records provide the means of generating statistics and other information that is needed to improve the existing services and introduction of new one.

**Objectives for Retrospective Conversion**

The objectives of retrospective conversion are as follows:

- To create a database for the automation system
- To maximize access to the collection
- To improve the services
- Reduction in time for searching of a document
- To improve library internal procedures: the integration of acquisition and cataloging through automation and streamlining of other technical services
- To maximize returns on automation expenditure

**Planning**

For successful retrospective conversion project, there is a need for sound and detailed plan strengthened with realistic expectations. The plan should:

- Clearly identify the objectives
- Carefully document procedures (paying close attention to efficient workflow)
• Specify standards to be used
• Identify reporting requirements
• Identify the necessary staff training
• Plan for regular monitoring of quality and schedule

If in-house conversion is to be done, each staff member on the project must clearly understand his/her tasks and responsibilities, the proper sequence of activities, and the standards to be enforced. If the conversion is undertaken through a vendor, care must be taken to ensure that the contract has no loopholes, and that sufficient legal safeguards are included to protect the library in the event of serious difficulties with the vendor. In this regard, libraries can prevent many problems by requiring progress checkpoints and periodic tests of the quality results.

Retrospective conversion is never easy. It can be done successfully, with minimal problems, if expectations are clearly understood at the outset, and if planning and documentation precedes the actual conversion. Once the project begins, success can be best assured through regular and frequent monitoring of progress and quality as per planned documents. The plan and schedule for the conversion project must take care of all the parameters of the conversion project. These parameters have multiple dependencies, such as follows:

• **Budget:** It is a function of number of records, fields, quality and rate.
• **Quality:** It is a function of manpower quality, supervision and planning.
• **Manpower:** It is a function of number of records and speed.
• **Manpower Quality:** It is a function of wages and training.
• **Supervision:** It is a function of quality and speed.
• **Speed:** It is a function of manpower, quality and number of fields.
• **Period:** It is a function of number of records, fields and speed.

If any one of these variables is changed, it may affect several others. It implies that a single variable cannot be changed by affecting the related parameters. The above variables mean:

• **Budget:** Total budget of the conversion project
• **Quality:** Standards and freedom from errors of records on OPAC
• **Manpower:** Number of persons working on the conversion project

**Planning Framework**

A planning framework provides a logical progression and suggests a series of checkpoints to guide library administrators in developing a basic framework for retrospective conversion. First, librarians should examine the following four basic assumptions of library automation:

(i) Provide patrons with a broad range of services in a timely, reliable and cost-effective manner
(ii) Allow the staff to complete necessary tasks with fewer efforts, rather than more

(iii) Requires a database of bibliographical records in order to function

(iv) The rate of expansion of library automation services is dependent on the allocation of resources and the growth of the bibliographic database

Given these assumptions, librarians should address the following important questions:

- What minimum set of records must be converted to establish a database that will support enhanced labor saving services?
- What functions can be supported by library automation to achieve the desired level of services?
- How should resources be allocated most economically to achieve a balance between retrospective conversion and the range of automated functions to be acquired?

By working through these assumptions and questions, librarians can develop an approach to automation that links retrospective conversion and library automation, so that these can be managed as a single integrated effort.

11.7 PRE-CONVERSION ISSUES

The following are the various pre-conversion issues:

- **Record Format**
  
  To ensure that the first conversion is the last conversion of the library or information center, it is important that the bibliographical information of the documents should be converted into a standard format.

- **Fields in the Database**
  
  It is time to decide that what fields are to be included in the database and what not. Current practices for recording the bibliographical information may need modification when added to the machine-readable form. Decision should be taken after considering the users’ present requirements and future needs.

- **Source for Bibliographical Information**
  
  Will the accession register, shelf list or public catalog be the source to record the bibliographical information for conversion? The choice should be based on that source which has accurate and complete information to meet the requirements and quality standards.

- **Priorities of Conversion**
  
  Determine priorities of the areas of conversion so that more important areas of the holdings may be converted first into machine-readable format.
11.7.1 The Problems behind Retrospective Conversion

Retrospective conversion is troublesome primarily because of the following facts:

- With traditional techniques, retrospective conversion is very expensive.
- Typically, it is a multi-year project.
- Since, it is often considered such a lackluster or boring subject, the topic generates little managerial interest and involvement.

Despite the unfortunate reputation, retrospective conversion has acquired importance, which cannot be overemphasized. The database resulting from a retrospective conversion project may long outlive the first, second or third generation of automated systems installed in a library. Over the years, it can be very difficult to try to live with a poor database that is the result of budgetary or staff shortages. As library scientist Barbara Markuson has commented, ‘Librarians never have enough money to do the job right the first time, but libraries have enough money to do the job over again a second time.’

11.7.2 Basic Retrospective Conversion Guidelines

The success of a conversion project is closely tied to a number of decisions. First, the library staff must decide whether to undertake a partial or full conversion, and whether the conversion will be done in-house or through an external agency. A library must take decisions of equally critical importance regarding the completeness and consistency of records. It is inevitable that converted records will differ qualitatively, to some extent, from new catalog, because converted records are derived from local data that are limited by previous cataloging practices. Nevertheless, a library’s catalog database is a long-term investment, and machine-readable records should reflect information that is as complete and accurate as possible.

Methods of Retrospective Conversion

There are a number of ways to convert the catalog into a machine-readable form. The best method for a library or information center depends upon the available resources at hand.

- In-House Conversion

In in-house conversion, the conversion is completed by the existing library staff that leads to high quality and control, as the staff understands the users’ needs, quality requirements and the objectives of the conversion well. However, it has the following disadvantages:
  
  (i) It disturbs the routine work.
  
  (ii) Increases work-load.
  
  (iii) More time is required for the completion of the project.
• **Outsourced In-House Conversion**

In outsourced in-house conversion, the conversion is completed by externally contracted persons within the library premises. The points that should be taken care is that the persons performing the conversion should be competent. The advantages are as follows:

(i) Easy to meet quality standards as conversion is done under the supervision of the library staff.

(ii) Less disturbance in the routine work of the library.

However, this type of conversion also has the following disadvantages:

(i) Temporary additional space is required.

(ii) Higher cost of conversion.

• **Outsourced Off-Site Conversion**

In outsourced off-site conversion, the process is completed by an agency away from the library or information center. The only advantage of this type of conversion is that the process is completed within the time frame with less impact on the library’s routine work. However, it has the following disadvantages:

(i) Conversion cost per item will be more.

(ii) The library has least control during the process.

(iii) Shelf list/catalog may probably have to leave the library. One possible solution to this problem is to provide photocopy of the title page of each of the document but it incurs additional cost and is labor intensive.

11.7.3 **Steps in Retrospective Conversion**

The following steps need to be taken into consideration for the Retrospective Conversion:

• **Filling of Data Input Sheets/Worksheets**

Current practices for recording the bibliographical information may need modification when converted to the machine-readable format. Thus, as per requirements, data input sheets/worksheets may be printed so that all the required information may be noted, forgetting no field and repeating none. Those who have good knowledge of cataloging, scope, goals, and objectives of the project, must design the data input sheets. The person employed to fill up the Data Input Sheets must be aware of what information has to be recorded and what not. These data input sheets/worksheets must be checked by the library staff to ensure that correct and required information has been recorded to meet the quality standards.

• **Entering Data into Software**

After filling the data input sheets/worksheets, the information is keyed in the library automation package. This can be done by one who has a basic knowledge of
computer and is good at typing. Here, the knowledge of cataloging is not required but it will be good if he is made aware of the cataloging rules to avoid/reduce mistakes.

- **Editing of the Database**
  After keying the bibliographical information into the software, the database must be checked for errors and edited by a responsible person to achieve the quality standards. This process must be repeated into a loop till the required precision is not achieved. Type graphic spelling mistakes make the catalog problematic for search.

- **Key to Success**
The key to successful retrospective conversions is careful and meticulous planning. Several positive actions of the library contribute significantly to the success of the conversion project. These measures include:
  (i) Careful planning
  (ii) Close examination of each method of the conversion, taking into account the library’s budget, time and manpower constraints
  (iii) Weeding of titles and copies that have marginal value. Since it is expensive, it makes no economic sense to convert materials that are of little or no worth

### 11.7.4 Problems and Peculiarities
Retroconversion is an issue which every librarian must face sooner or later. To keep pace with the rapid developments made possible in library services and tackle adequately the effects of the increase in, and diversification of, demands for information, the automation of all library processes has become inevitable and retroconversion has been described as an indispensable tool to achieve such an objective. The question has never been whether a library should undertake retroconversion, but rather how it should be done. Each library catalog has its peculiarities and imperfections, which may cause problems during the crucial conversion process. As a result, those involved in the conversion process at the university library spend some time during the planning stage to discover those odd practices of the past and devise solutions to the problems. Some solutions call for policy decisions, which are made before the project begins.

Here are some of the problems discovered while setting up the parameters for the conversion project.

- **Training Needs**
  Problems can arise in retroconversion if the staff is not properly trained in the various areas in which they have to be initiated. It was agreed that there will be a basic training for almost all staff members including catalogers, key users of the workstations and data input clerks. The training will need to be at various stages, introducing the individuals involved at the appropriate stage.
● Editing
Here, a firm decision was taken that the responsibility for editing should be done by the heads of units, and, therefore, not be everybody’s job. This will facilitate proper monitoring by the university librarian.

**Check Your Progress**

5. Why is retrospective conversion considered troublesome?
6. List the advantages of outsourced in-house conversion.

**Automation Identification Methods: Bar Coding and RFID**

No other gadget or technology has affected retailing more than RFID. It stands for Radio Frequency Identification which is a small chip with an antenna. This chip can carry data of around 2000 bytes. The RFID tag, as it is called, is similar to a barcode or the magnetic strip that you find at the back of a credit card or an ATM card. It provides identification for the particular object. The data is stored in the tag and requires a scanner to read it. A barcode may be difficult to scan (you may have found the store clerk struggling with the scanner to read the barcode). The RFID device can be read much easily. They allow almost simultaneous reading of multiple tags in the vicinity of the reader. Moreover, each tag may have a unique code which can be used for tracking it.

Although the technology has been available for more than fifty years now, only recently has it become affordable and feasible to use it on a mass scale. The price of a tag is about Rs 10 and may fall even further with mass usage. In USA, a volume purchase may get tags for as low as 10 cents.

The retail application of RFID include, among others, reading of the following:

- Date of manufacture
- Time spent in transportation
- Location of the distribution centre
- The selling price
- Mode of payment
- Date of expiry
- Warranty period and many more (Source: www.imagesretail.com)

Most retailers use RFID tags with the box/pellet of the products to track their movement within the company. International retailers are carrying out pilot projects to track products between companies (supplier and retailer) and between retailer and customer. Wal-Mart has reported significant savings after introducing RFID tags.
There are enormous benefits of RFID in retailing. Look at the following examples:

- RFID helps the retailers to understand product usage pattern. A tag attached to a pack of coffee will give information like date of purchase and date of disposal (a scanner moved near the garbage dump can quickly trace the packet). The retailer can estimate how long the average customer will take to consume a pack of coffee and then plan his inventory.

- A customer picks up a product (fitted with a RFID tag) and puts it in his shopping trolley (fitted with a RFID scanner): At the back-end, an electronic message goes to the store asking for replenishment of the product. (The RFID tag can even alert the supplier about the next replenishment cycle). A store clerk comes and immediately replaces the product on the shelf. At the front-end, the item picked up is marked against the trolley number. When the customer finally checks out, the bill is ready for her. She does not have to go through the lengthy process of waiting in the queue.

- In case the customer is a shoplifter (one who steals items form stores), the RFID tag can raise an alert when she tries to leave without paying for the item. Items lost due to theft, wastage and damage is known as shrinkage in retailing. It is one of the major sources of loss for retailers. RFID tags can dramatically bring down shrinkage. In India, companies like Pantaloons (helped by Wipro) and Big Bazaar have used RFID on a pilot basis and have reported good results in the area.

- In India, Infosys has developed a RFID based system to help retailers in their merchandising activities. It is known as smart visual merchandising. (SVM). A RFID tag is placed on the shirt or a trouser. When an interested customer holds the product against an LCD panel, all relevant information (material, price, designs, availability) is displayed, making it easier for the saleperson to close the sale. Each tag costs around Rs 10. This technology can also be used in the trial room, saving time for the customer and the salesman.

1.8 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Most software can be divided into two major categories. These are as follows:
   (a) System Software
   (b) Application Software
2. Utility programs refer to those programs that perform a very specific task, usually related to managing system resources. Operating systems contain a number of utilities for managing disk drives, printers and other devices.

3. Schedule feasibility is defined as the probability of a project to be completed within its scheduled time limits, by a planned due date. If a project has a high probability to be completed on time, then its schedule feasibility is appraised as high.

4. The first generation software was developed to run on specific hardware platform and proprietary operating systems. Low-level programming language was used and the non-standard database management systems were the common features of these software.

5. Retrospective conversion is troublesome primarily because of the following facts:
   (a) With traditional techniques, retrospective conversion is very expensive.
   (b) Typically, it is multi-year project.
   (c) Since, it is often considered such a lackluster or boring subject, the topic generates little managerial interest and involvement.

6. The advantages of outsourced in-house conversion are as follows:
   (a) Easy to meet quality standards as conversion is done under the supervision of the library staff.
   (b) Less disturbance in the routine work of the library.

11.9 SUMMARY

- Automation of a library is an important and essential step; it should be properly planned and implemented.
- Planning for library automation has been defined as planning for ‘integrated library management systems’ that computerize an array of traditional library functions using a common database.
- A feasibility study is carried out to know objectively and rationally uncover the strengths and weaknesses of an existing or proposed venture, opportunities and threats present in the environment, the resources required to carry through, and ultimately the prospects for success.
- Hardware is the primary requirement for library automation; different types of hardware are available in the market.
- The term ‘software’ refers to a set of computer programs, procedures and associated documents (flow charts, manuals, and so on) that describe the program and how they are to be used.
- System software is a set of one or more programs, designed to control the operation and extend the processing capability of a computer system.
• System software is a type of computer program that is designed to run a computer’s hardware and application programs. If we think of the computer system as a layered model, the system software is the interface between the hardware and user applications.

• An Operating System (OS) is a system software that manages computer hardware and software resources, and provides common services for computer programs.

• Application software is a set of one or more programs, designed to solve a specific problem or perform a specific task.

• Commercial software is easy to use as they come with all the necessary program features. Using commercial software is easy because of lack of limits and restrictions imposed on users.

• Open Source Software (OSS) is an antonym for closed source and refers to any computer software that is released free of cost and its licenses usually prohibit modifications and commercial redistribution.

• The purpose of the economic feasibility assessment is to determine the positive economic benefits to the organization that the proposed system will provide. It includes quantification and identification of all the benefits expected.

• Operational feasibility is a measure of how well a proposed system solves the problems and takes advantage of the opportunities identified during scope definition, and how it satisfies the requirements identified in the requirements analysis phase of system development.

• Circulation module and cataloging module were the priority issues for these systems. Although these software packages were module-based systems, there was no or very little integration between these modules.

• The second generation library software packages, with the introduction of UNIX and DOS based systems, become moveable between various platforms.

• The third generation library management software packages provide fully integrated systems. They are based upon relational database structure.

• The hardware requirement to run the software has to be determined precisely whether the existing hardware of the library would suffice or any modification is required has to be decided.

• Application software package for library work should incorporate various modules for different types of activities, such as acquisition, cataloging, circulation, serials control, and so on.

• A library automation software package should be user-friendly. In other words, it should be developed in such a manner that it can be used after a short training and practice.
NOTES

The software should have provision for local variation. Different libraries may like to provide different records differently.

The cost of commercial software package varies considerably across the range of packages available except open source and free software. Most of the library automation software is costlier.

The training of the library staff in computer operation is of vital importance. Every library staff member should be given training and orientation about the computer system.

The responsibility of the software designer or supplier does not end by selling the software without training until and unless the people learn the operations of the software completely.

Library automation refers to the use of computers in the routine functions and services of a library. Automation of a library has mainly two components, namely computerization and networking.

The word “Retrospective” indicates that the process is only for already existing records, and the meaning of the word ‘Conversion’ refers to the form and format of the records changing something from one form to another.

Retroconversion is an issue which every librarian must face sooner or later. To keep pace with the rapid developments made possible in library services and tackle adequately the effects of the increase in, and diversification of, demands for information, the automation of all library processes has become inevitable and retroconversion has been described as an indispensable tool to achieve such an objective.

11.10 KEY WORDS

Feasibility Study: It is carried out to know objectively and rationally uncover the strengths and weaknesses of an existing or proposed venture, opportunities and threats present in the environment, the resources required to carry through, and ultimately the prospects for success.

Hardware: It is the primary requirement for library automation; different types of hardware are available in the market.

System Software: It is a set of one or more programs, designed to control the operation and extend the processing capability of a computer system.

Operating System (OS): It is system software that manages computer hardware and software resources, and provides common services for computer programs.

Open Source Software (OSS): It is an antonym for closed source and refers to any computer software that is released free of cost and its licenses usually prohibit modifications and commercial redistribution.
11.11 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions
1. What is a feasibility study?
2. Differentiate between economic feasibility and operational feasibility.
3. What is software? Name the different types of software.
4. What are the methods to select the software?
5. What is retrospective conversion?
6. What is the need for retroconversion?
7. List the objectives of retrospective conversion.
8. List the various pre-conversion issues.
9. What are the methods of retrospective conversion?
10. List the steps in retrospective conversion.

Long-Answer Questions
1. Explain the concept and importance of library management.
2. Write a critical note on the history of library automation software.
3. What is the criteria for selecting library software packages?
4. Discuss the guidelines for the selection of library automation systems.
5. Evaluate the concept of retrospective conversion in library automation.

11.12 FURTHER READINGS

UNIT 12 COMMUNICATION: LANDLINE AND MOBILE NETWORKS

Structure
12.0 Introduction
12.1 Objectives
12.2 Data Transmission in cellular/Telephone networks
12.3 Motivation for ISDN
12.4 ISDN Channels
12.5 ISDN User Interfaces
12.6 Broadband ISDN
12.7 Fax, Modem and Teletext
12.8 Internet
12.9 E-mail
12.10 Answers to Check Your Progress Questions
12.11 Summary
12.12 Key Words
12.13 Self Assessment Questions and Exercises
12.14 Further Readings

12.0 INTRODUCTION

In this unit, you will learn about the cellular networks, ISDN and Broadband ISDN. A cellular network is a wireless network distributed over a land areas called cells. Integrated Services Digital Network (ISDN) is a set of communication standards for simultaneous digital transmission of voice, video, data, and other network services over the traditional circuits of the public switched telephone network.

12.1 OBJECTIVES

After going through this unit, you will be able to:
- Explain the data transmission in cellular network
- Discuss the main features of ISDN
- Explain the different types of ISDN channels and interfaces
- Understand the architecture of broadband ISDN
- Define internet
12.2 DATA TRANSMISSION IN CELLULAR/TELEPHONE NETWORKS

In the late 60’s it was proposed to alleviate the problem of spectrum congestion by restructuring the coverage area of mobile radio systems. IMTS required a single powerful base station and Line Of Sight (LOS) for the mobile units to cover areas of 50km radius. The cellular concept does not use broadcasting over large areas. Instead smaller areas called cells are handled by less powerful base stations that use less power for transmission. Now the available spectrum can be re-used from one cell to another thereby increasing the capacity of the system. However this did give rise to a new problem, as a mobile unit moved it could potentially leave the coverage area (cell) of a base station in which it established the call. This required complex controls that enabled the handing over of a connection (called handoff) to the new cell that the mobile unit moved into.

The Cellular Network

A cellular network or mobile network is a wireless network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station. In a cellular network, each cell uses a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed bandwidth within each cell.

When joined together these cells provide radio coverage over a wide geographic area. This enables a large number of portable transceivers (e.g., mobile phones, pagers, etc.) to communicate with each other and with fixed transceivers and telephones anywhere in the network, via base stations, even if some of the transceivers are moving through more than one cell during transmission.

Cellular networks offer a number of desirable features:

- More capacity than a single large transmitter, since the same frequency can be used for multiple links as long as they are in different cells.
- Mobile devices use less power than with a single transmitter or satellite since the cell towers are closer.
- Larger coverage area than a single terrestrial transmitter, since additional cell towers can be added indefinitely and are not limited by the horizon.

Major telecommunications providers have deployed voice and data cellular networks over most of the inhabited land area of the Earth. This allows mobile phones and mobile computing devices to be connected to the public switched telephone network and public Internet. Private cellular networks can be used for research or for large organizations and fleets, such as dispatch for local public safety agencies or a taxicab company. In a cellular radio system, a land area to be supplied with radio service is divided into regular shaped cells, which can be hexagonal, square, circular or some other regular shapes, although hexagonal cells...
are conventional. Each of these cells is assigned with multiple frequencies \( f_1 \ldots f_6 \) which have corresponding radio base stations. The group of frequencies can be reused in other cells, provided that the same frequencies are not reused in adjacent neighboring cells as that would cause co-channel interference.

The increased capacity in a cellular network, compared with a network with a single transmitter, comes from the mobile communication switching system developed by Amos Joel of Bell Labs that permitted multiple callers in the same area to use the same frequency by switching calls made using the same frequency to the nearest available cellular tower having that frequency available and from the fact that the same radio frequency can be reused in a different area for a completely different transmission. If there is a single plain transmitter, only one transmission can be used on any given frequency. Unfortunately, there is inevitably some level of interference from the signal from the other cells which use the same frequency. This means that, in a standard FDMA system, there must be at least a one cell gap between cells which reuse the same frequency.

In the simple case of the taxi company, each radio had a manually operated channel selector knob to tune to different frequencies. As the drivers moved around, they would change from channel to channel. The drivers knew which frequency covered approximately what area. When they did not receive a signal from the transmitter, they would try other channels until they found one that worked. The taxi drivers would only speak one at a time, when invited by the base station operator (this is, in a sense, Time Division Multiple Access (TDMA)).

Cell Signal Encoding

To distinguish signals from several different transmitters, Frequency Division Multiple Access (FDMA) and Code Division Multiple Access (CDMA) were developed.

With FDMA, the transmitting and receiving frequencies used in each cell are different from the frequencies used in each neighboring cell. In a simple taxi system, the taxi driver manually tuned to a frequency of a chosen cell to obtain a strong signal and to avoid interference from signals from other cells. The principle of CDMA is more complex, but achieves the same result; the distributed transceivers can select one cell and listen to it.

Other available methods of multiplexing, such as Polarization Division Multiple Access (PDMA) and Time Division Multiple Access (TDMA) cannot be used to separate signals from one cell to the next since the effects of both vary with position and this would make signal separation practically impossible. Time division multiple access, however, is used in combination with either FDMA or CDMA in a number of systems to give multiple channels within the coverage area of a single cell.

The key characteristic of a cellular network is the ability to re-use frequencies to increase both coverage and capacity. As described above, adjacent cells must use different frequencies; however there is no problem with two cells sufficiently
far apart operating on the same frequency. The elements that determine frequency reuse are the reuse distance and the reuse factor.

The reuse distance, $D$, is calculated as

$$D = R\sqrt{3N},$$

Where $R$ is the cell radius and $N$ is the number of cells per cluster. Cells may vary in radius from 1 to 30 kilometres (0.62 to 18.64 mi). The boundaries of the cells can also overlap between adjacent cells and large cells can be divided into smaller cells.

The frequency reuse factor is the rate at which the same frequency can be used in the network. It is $1/K$ (or $K$ according to some books) where $K$ is the number of cells which cannot use the same frequencies for transmission. Common values for the frequency reuse factor are 1/3, 1/4, 1/7, 1/9 and 1/12 (or 3, 4, 7, 9 and 12 depending on notation).

In case of $N$ sector antennas on the same base station site, each with different direction, the base station site can serve $N$ different sectors. $N$ is typically 3. A reuse pattern of $N/K$ denotes a further division in frequency among $N$ sector antennas per site. Some current and historical reuse patterns are 3/7 (North American AMPS), 6/4 (Motorola NAMPS), and 3/4 (GSM).

If the total available bandwidth is $B$, each cell can only use a number of frequency channels corresponding to a bandwidth of $B/K$, and each sector can use a bandwidth of $B/NK$.

Code division multiple access-based systems use a wider frequency band to achieve the same rate of transmission as FDMA, but this is compensated for by the ability to use a frequency reuse factor of 1, for example using a reuse pattern of 1/1. In other words, adjacent base station sites use the same frequencies, and the different base stations and users are separated by codes rather than frequencies. While $N$ is shown as 1 in this example that does not mean the CDMA cell has only one sector, but rather that the entire cell bandwidth is also available to each sector individually.

Depending on the size of the city, a taxi system may not have any frequency-reuse in its own city, but certainly in other nearby cities, the same frequency can be used. In a large city, on the other hand, frequency-reuse could certainly be in use.

Recently also orthogonal frequency-division multiple access based systems, such as LTE are being deployed with a frequency reuse of 1. Since such systems do not spread the signal across the frequency band, inter-cell radio resource management is important to coordinate resource allocation between different cell sites and to limit the inter-cell interference. There are various means of Inter-Cell Interference Coordination (ICIC) already defined in the standard. Coordinated scheduling, multi-site MIMO or multi-site beams forming are other examples for inter-cell radio resource management that might be standardized in the future.
The Need for a Spectrum Efficient System

To illustrate the need for efficient spectrum usage for a radio communications system, take the example where each user is allocated a channel. While more effective systems are now in use, the example will take the case of an analogue system. Each channel needs to have a bandwidth of around 25 kHz to enable sufficient audio quality to be carried as well as enabling there to be a guard band between adjacent signals to ensure there are no undue levels of interference. Using this concept it is only possible to accommodate 40 users in a frequency band 1 MHz wide. Even of 100 MHz were allocated to the system this would only enable 4000 users to have access to the system. Today cellular systems have millions of subscribers and therefore a far more efficient method of using the available spectrum is needed.

Cell Systems for Frequency Re-Use

The method that is employed is to enable the frequencies to be re-used. Any radio transmitter will only have a certain coverage area. Beyond this the signal level will fall to a limited below which it cannot be used and will not cause significant interference to users associated with a different radio transmitter. This means that it is possible to re-use a channel once outside the range of the radio transmitter. The same is also true in the reverse direction for the receiver, where it will only be able to receive signals over a given range. In this way it is possible to arrange split up an area into several smaller regions, each covered by a different transmitter / receiver station.

These regions are conveniently known as cells, and give rise to the name of a "cellular" technology used today. Diagrammatically these cells are often shown as hexagonal shapes that conveniently fit together. In reality this is not the case. They have irregular boundaries because of the terrain over which they travel. Hills, buildings and other objects all cause the signal to be attenuated and diminish differently in each direction.

It is also very difficult to define the exact edge of a cell. The signal strength gradually reduces and towards the edge of the cell performance will fall. As the mobiles themselves will have different levels of sensitivity, this adds a further greying of the edge of the cell. Therefore it is never possible to have a sharp cut-off between cells. In some areas they may overlap, whereas in others there will be a "hole" in coverage.

Cell Clusters

When devising the infrastructure technology of a cellular system, the interference between adjacent channels is reduced by allocating different frequency bands or channels to adjacent cells so that their coverage can overlap slightly without causing interference. In this way cells can be grouped together in what is termed a cluster.
Often these clusters contain seven cells, but other configurations are also possible. Seven is a convenient number, but there are a number of conflicting requirements that need to be balanced when choosing the number of cells in a cluster for a cellular system:

- Limiting interference levels
- Number of channels that can be allocated to each cell site

It is necessary to limit the interference between cells having the same frequency. The topology of the cell configuration has a large impact on this. The larger the number of cells in the cluster, the greater the distance between cells sharing the same frequencies.

In the ideal world it might be good to choose a large number of cells to be in each cluster. Unfortunately there are only a limited number of channels available. This means that the larger the number of cells in a cluster, the smaller the number available to each cell, and this reduces the capacity. This means that there is a balance that needs to be made between the number of cells in a cluster, and the interference levels, and the capacity that is required.

**Cell Size**

Even though the number of cells in a cluster in a cellular system can help govern the number of users that can be accommodated, by making all the cells smaller it is possible to increase the overall capacity of the cellular system. However a greater number of transmitter receiver or base stations are required if cells are made smaller and this increases the cost to the operator. Accordingly in areas where there are more users, small low power base stations are installed.

The different types of cells are given different names according to their size and function:

- **Macro Cells**: Macro cells are large cells that are usually used for remote or sparsely populated areas. These may be 10 km or possibly more in diameter.
- **Micro Cells**: Micro cells are those that are normally found in densely populated areas which may have a diameter of around 1 km.
- **Pico Cells**: Picocells are generally used for covering very small areas such as particular areas of buildings, or possibly tunnels where coverage from a larger cell in the cellular system is not possible. Obviously for the small cells, the power levels used by the base stations are much lower and the antennas are not position to cover wide areas. In this way the coverage is minimised and the interference to adjacent cells is reduced.
- **Selective Cells**: Sometimes cells termed selective cells may be used where full 360 degree coverage is not required. They may be used to fill in a hole in the coverage in the cellular system, or to address a problem such as the entrance to a tunnel etc.
**Umbrella Cells:** Another type of cells known as an umbrella cell is sometimes used in instances such as those where a heavily used road crosses an area where there are microcells. Under normal circumstances this would result in a large number of handovers as people driving along the road would quickly cross the microcells. An umbrella cell would take in the coverage of the microcells (but use different channels to those allocated to the microcells). However it would enable those people moving along the road to be handled by the umbrella cell and experience fewer handovers than if they had to pass from one microcell to the next.

### 12.3 MOTIVATION FOR ISDN

The main features of ISDN are:

- Digital network services that can be implemented in the existing telephone network.
- It provides a data rate of 2 Mbps on a local link and 64 Kbps/128 Kbps over a wide area link.
- Connecting remote users to a LAN.
- LAN to LAN linking.
- High bandwidth interoffice FAX.
- High speed internet access.

Another important feature of ISDN is its flexibility. It automatically switches among different devices attached to it. A typical ISDN interface consists of a phone, FAX machine, and a PC. ISDN also can be used as a local access link in frame relay and X.25 networks.

### ISDN Evolution

**Analog Voice Communication**

![Fig. 12.1 Voice Communication over Analog Network](image)

Initially, Telecommunications networks were entirely analog and were reserved for the transmission of analog information in the form of voice. The local loops, connecting the subscriber’s handset to the telephone company’s central...
office were also analog. With the advent of digital processing, subscribers needed to exchange data and voice. Modems were developed to allow digital exchanges over existing analog lines. To reduce cost and improve performance, the telephone companies gradually began to offer digital technologies while continuing their analog services to their customers.

Three types of customers were identified at this time:
- Customers using only analog services. (Figure 12.1)
- Customers using analog facilities to transmit digital information via modem.
- Customers using digital services to transmit digital information.

Of these, the first group was still the most prominent, and therefore most of the services offered remained analog.

Figure 12.2 shows Voice and Data Communications over Telephone Network and Figure 12.3 shows Analog Digital Services over Telephone Network.

Integrated Digital Network (IDN)

To cater to the need to access a variety of networks such as packet-switched networks and circuit-switched networks, the telephone companies created integrated digital networks (IDNs). An IDN is a combination of networks available for different purposes. Figure 12.4 shows Integrated Digital Network. These networks are accessed through digital pipes, which are time-multiplexed channels,
sharing very high-speed paths. Customers can use their local loops to transmit both voice and data to the appropriate digital networks via the digital pipes through the telephone central office.

**Integrated Services Digital Network (ISDN)**

The ISDN integrates customer services with the IDN. Fully digital services are much more efficient and flexible than analog services. To receive the maximum benefit from the integrated digital networks, the next step is to replace the analog local loops with digital subscriber loops. Figure 12.5 shows the conceptual ISDN Network. Voice transmissions can be digitized at the source, thereby removing the final need for analog carriers. It then becomes possible to send data, voice, image, facsimile, and so on, over any digital network. With ISDN, all customer services will become digital rather than analog, and the flexibility offered by the new technology will allow customer services to be made available on demand.

**Fig. 12.5 Conceptual ISDN Network**

ISDN incorporates all communication connections in a home or building into a single interface. Each user in an ISDN network is linked to the central office through a digital pipe. These pipes can be of different capacities to allow different rates of transmission and support different subscriber needs.
12.4 ISDN CHANNELS

The ISDN standard defines three channel types, each with a different transmission rate:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Data Rate (Kbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearer (B)</td>
<td>64</td>
</tr>
<tr>
<td>Data (D)</td>
<td>16, 64</td>
</tr>
<tr>
<td>Hybrid (H)</td>
<td>384, 1536, 1920</td>
</tr>
</tbody>
</table>

**Bearer Channels (B)**

Bearer channel (B Channel) operates at a rate of 64 KBps. It is the basic user channel and can carry any type of digital information in full-duplex mode as long as the required transmission rate does not exceed 64 KBps. For example, a B channel can be used to carry digital data, digitized voice, or other low-data-rate information. Several transmissions intended for a single receiver can be multiplexed into a single B-channel. A B channel permits only end-to-end transmission. Signal cannot be de-multiplexed in the middle.

**Data Channels (D)**

A data channel (D Channel) can operate either at 16 or 64 KBps, depending on the needs of the user. The primary function of a D channel is to carry control signals for the B channels. ISDN uses a separate channel for control signals such as call establishment, ringing, call interrupt, or synchronization. This channel is known as a data channel. A D channel carries the control signalling for all the channels for the given path, using a method called Common-Channel Signalling (CCS).

In this mechanism, a subscriber uses the D channel to connect to the network and secure a B channel connection. The subscriber then uses the B channel to send actual data to another user. All the devices attached to a given subscriber loop use the same D channel for signalling, but each device sends data over a B channel, dedicated to a single exchange for the duration of the exchange. Using the D channel is similar to having a telephone operator place a call for you. You pick up the phone and tell the operator what type of call you wish to place and the number you wish to contact. The operator finds an open line appropriate for your needs, rings your party, and connects you. The D channel performs the functions of physical, data link, and the network layer of the OSI model. Figure 12.6 shows Comparison of D Channel Operations and OSI Model.)
### H Channels (H)

Hybrid channels (H channels) are operated with data rates of 384 Kbps known as H0 channels, 1536 Kbps (H11) or 1920 Kbps (H12). These rates make H channels suitable for high data-rate applications such as video, teleconferencing, and so on.

### 12.5 ISDN USER INTERFACES

ISDN provides two basic types of interfaces to users.

- Basic Rate Interface (BRI)
- Primary Rate Interface (PRI)

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**Fig. 12.6 D Channel Operations and OSI Model**

**Fig. 12.7 ISDN Basic Rate Interface**

**Fig. 12.8 ISDN Primary Rate Interface**
**Basic Rate Interface (BRI)**

Basic Rate Interface specifies a digital pipe, consisting of two 64 Kbps B channels and one 16 Kbps D channel for a total of 144 Kbps (2B+D). Figure 12.7 shows the structure of Basic Rate Interface. In addition, the BRI service itself requires 48 Kbps operating overhead. BRI therefore requires a digital pipe of 192 Kbps. Conceptually, the BRI service is like a large pipe that contains three smaller pipes, two for the B channels and one for the D channel. The remainder of the space inside the large pipe carries the overhead bits required for its operation. All 192 Kbps can be used to carry a single signal.

The BRI is designed to cater to the needs of home users and small-business establishments. In most cases, there is no need to replace the existing local-loop cable. The existing twisted pair local loop can be used to carry digital transmission.

**Primary Rate Interface (PRI)**

Primary Rate Interface is intended for users with higher data rate requirements, such as large business establishments, offices with a digital PBX, or a LAN. Because of differences in the digital-transmission hierarchies used in different countries, it was not possible to reach an agreement on a single data rate. The United States, Canada and Japan make use of a transmission structure based on 1.544 Mbps; this corresponds to the T-1 transmission facility of AT & T. In Europe, 2.048 Mbps is the standard rate. Both of these data rates are provided as a Primary Rate Interface.

Typically, the channel structure for the 1.544 Mbps rate will be 23 B channels and one 64 Kbps D channel and, for the 2.048 Mbps rate, 30 B channels and one 64 Kbps D channel. (Figure 12.8 shows the structure of Primary Rate Interface).

It is also possible for a customer with few requirements to employ fewer B channels, in which case, the channel structure is \( nB + D \), where \( n \) ranges from 1 to 23 or from 1 to 30 for the two primary services. Also, a customer with high data-rate demands may be provided with more than one primary physical interface. In this case, a single D channel on one of the interfaces may suffice for all signalling needs, and the other interfaces may consist solely of B channels (24B or 31B).

**PRI with H-channels**

The Primary Rate Interface may also be used to support H channels. Some of these structures include a 64 Kbps D channel for control signalling. When no D channel is present, it is assumed that a D channel on another primary interface at the same subscriber location will provide any required signalling. The following structures are recognised:

**Primary Rate Interface (PRI) H0 channel structures**

This interface supports multiple 384 Kbps H0 channels. The structures are 3H0+D and 4 H0 for the 1.544 Mbps interface and 5H0 +D for the 2.048 Mbps interface.
Primary Rate Interface (PRI) H11 and H12 channel structures

The H11 channel structure consists of one 1,536 Kbps H11 channel. The H12 channel structure consists of one 1,920 Kbps H12 channel and one D channel.

Primary Rate Interface (PRI) structures for mixtures of B and H0 channels

This interface consists of zero or one D channel and any possible combination of B and H0 channels up to the capacity of the physical interface (e.g., 3H0 + 5B + D and 3H0 + 6B for the 1.544 MBps interface).

12.6 BROADBAND ISDN

Evolution

In 1988, as part of its 1st-series of recommendations on ISDN, CCIIT issued the first two recommendations, relating to broad-band (B-ISDN). The first one, known as I.113, contains the Vocabulary of Terms used to specify the Broad-band Aspects of ISDN and the second one called I.121 presents the Broadband Aspects of ISDN. These documents provided a preliminary description and a basis for future standardization and development work, and from those documents, a rich set of recommendations has been developed. Some of the important notions developed in these documents are:

**Broad-band** A service or a system, requiring transmission channels capable of supporting rates greater than the primary rate.

**Leased lines** An exclusive network connection of fixed bandwidth, provided to the users for leased basis. The main drawback is that switching is not possible.

**Asynchronous transfer mode (ATM)** is the transfer mode for implementing B-ISDN and is independent of the means of transport at the Physical Layer.

**B-ISDN Architecture**

B-ISDN is a broad-based attempt to set up a single unified, worldwide high-speed network, to replace the multiplicity of the existing networks. This new universal network is intended to take over the functions of current speech, data, television, and all other communication facilities. B-ISDN is mainly based on the concepts already developed for ISDN. The evolution of B-ISDN enables the development of new and advanced services in the near future. Since the B-ISDN is based on overall ISDN concepts, the ISDN access reference configuration is also the basis for the B-ISDN reference configuration.
CCITT modestly defines B-ISDN as a service, requiring transmission channels supporting data rate higher than the primary rate. With B-ISDN, services, especially video services, requiring data rates in excess of those that can be delivered by ISDN will become available. To contrast this new network and these new services to the original concept of ISDN, that original concept is now being referred to as narrow-band ISDN.

B-ISDN differs from a narrow-band ISDN in a number of ways. To meet the requirement for high-resolution video, an upper channel rate of approximately 150 Mbps is needed. To simultaneously support one or more interactive and distributive services, a total subscriber line rate of about 600 Mbps is needed. Such a higher data rate can be supported only by optical fibers. Hence, the introduction of B-ISDN depends on the pace of introduction of fiber subscriber loops.

Selection of proper switching technique is the key issue in networks. The switching facility has to be capable of handling a wide range of different bit rates and traffic parameters (e.g., burstness). Despite the increasing power of digital circuit-switching hardware and the increasing use of optical fiber, it is difficult to implement B-ISDN with circuit-switching technology. For this reason, there is increasing interest in some type of fast packet switching as the basic switching technique for B-ISDN. This form of switching readily supports ATM at the user-network interface.

**Functional Architecture**

Figure 12.9 shows the functional architecture of B-ISDN. As with narrow-band ISDN, control of B-ISDN is based on common-channel signalling.

![Fig. 12.9 B-ISDN Functional Architecture](image)

Figure 12.10 shows the Architecture of B-ISDN

B-ISDN must, of course, support all of the 64-Kbps transmission services, both circuit switching and packet switching, that are supported by narrow-band ISDN. This protects the user’s investment and facilitates migration from narrowband to broad-band ISDN. In addition, broadband capabilities are provided for higher...
data rate transmission services. At the user-network interface, these capabilities will be provided with the connection-oriented asynchronous transfer mode (ATM) facility.

**Fig. 12.10** B-ISDN Architecture

**B-ISDN User-network Interface and Reference Points**

The reference configuration defined for narrow-band ISDN is considered general enough to be used for B-ISDN. To clearly illustrate the broad-band aspects, the notations for reference points and functional groupings are appended with the letter B (e.g., B-NT1, TB). The broad-band functional groups are equivalent to the functional groups defined for narrow-band ISDN, and (shown in Figure 12.11) are discussed below. Interfaces at the reference point R may or may not have broad-band capabilities.

**Fig. 12.11** B-ISDN Functional Groups

**B-ISDN Reference Configurations**

Reference point R is defined such that it may or may not have optional B-ISDN functions. Along with reference points, components with the following names represent the functional groupings.

- **B-TA** Broad-band terminal adaptor
- **B-TE** Broad-band terminal equipment
- **B-NT** Broad-band network terminal.

B-NT1 functions are similar to Layer1 of the OSI reference model and some of the functions are:

- Transmission Line Termination
- Transmission Interface handling
- OAM functions
B-NT2 functions are similar to layer 1 and higher layers of the OSI model. Some functions of B-NT2 are:

- Adaptation between different transmission media and topologies
- Synchronization to the individual cells
- Multiplexing and de-multiplexing and concentration of traffic
- Buffering of ATM cells
- Assignment of transmission path
- Resource allocation and usage parameter control
- Signalling the AAL layer
- Signalling protocol handling
- Interface handling
- Switching of internal connections
- SB and TB indicate reference points between the terminal and the B-NT2 and between B-NT2 and B-NT1 respectively

**Broad-band Terminal Equipment**

The functions to be carried out by the B-ISDN equipment are:

- The interface and protocol for user-to-user system interfaces.
- Transmission interface and related layer 1 functions.
- Protocol for signalling.
- Set up and release connections to other TEs.
- OAM functions.

Broadband Terminal Equipment of type 1 is a system conforming to the specifications for interfaces at reference points SB and TB. Broadband Terminal Equipment of type 2 is a system, which does not conform to the specifications for interfaces at reference points SB and TB.

**Broadband Terminal Adaptor (B-TA)**

Terminal adaptors enable B-TE1 or B-TE2 terminal equipments to be adapted to the B-ISDN network. Terminal equipments B-TE1 does not have broadband capability and terminal equipments B-TE2 have this capability. A terminal adaptor is capable of adapting both these equipments.

**Transmission Structure**

In terms of data rates available to B-ISDN subscribers, three new transmission services are defined. The first of these consists of a full-duplex 155.52-Mbps service. The second service defined is asymmetrical, providing transmission from the subscriber to the network at 155.52 Mbps, and in the other direction at 622.08
Mbps; and the highest-capacity service yet defined is a full duplex, 622.08 Mbps service.

A data rate of 155.52 Mbps can certainly support all of the narrowband ISDN services. That is, such a rate readily supports one or more basic or primary-rate interfaces; in addition, it can support most of the B-ISDN services. At that rate, one or several video channels can be supported, depending on the video resolution and the coding technique used. Thus, the full-duplex 155.52 Mbps services is probably the most common B-ISDN service. The higher data rate of 622.08 Mbps is needed to handle multiple video distribution, such as might be required when a business conducts multiple simultaneous video conferences. This data rate makes sense in the network-to-subscriber direction. The typical subscriber will not initiate distribution services and thus would still be able to use the lower, 155.52 Mbps services. The full-duplex 622.08 Mbps service would be appropriate for a video-distribution provider.

**Broad-band ISDN Protocol Reference Model**

The logical-architecture for B-ISDN introduces some new elements, which are not found in the ISDN architecture, as depicted in Figure 12.12.

**Fig. 12.12** B-ISDN Layer Protocol Reference Model

B-ISDN is based on the OSI Reference model (ITU X.200). The four layers of the B-ISDN protocol model are linked together via 3 planes, namely the user plane, the control plane, and management plane.

**User plane** The information flow to all layers takes place within the user plane. Apart from this, the user plane also takes care of control functions such as transfer error correction and data flow monitoring.

**Control plane** The control plane performs call-control and connection-control functions such as connection setup, connection release, and connection monitoring. As ATM is a connection-oriented transfer mechanism, every connection within the ATM layer is assigned a unique identifier via the control planes signalling procedure. This number is either the Virtual Path Identifier (VPI) or Virtual Channel Identifier (VCI), depending on the hierarchy of the connection.
Management plane  The management plane has two functions: plane management and layer management. Plane management coordinates the functions and procedures of the management plane with those of the other two planes. Layer management function performs management functions relating to resources and parameters residing in its protocol entities. It is responsible for functions such as Meta signalling and the OAM information flow.

Meta signalling is a separate information channel to control the various signalling procedures (that is, signalling for the signaling hence, meta-signaling). This is required because the task given to signalling in broadband ISDN networks is far more complicated and extensive than, for example, that of D-channel signalling in narrow-band ISDN.

OAM (Operation And Maintenance) information is used to monitor network performance and for error management at ATM level. Special cells known as OAM cells are used for this.

Functions of the Layers in the B-ISDN Reference Model
The four layers of the B-ISDN reference model are:
- The Physical layer
- The ATM layer
- The ATM adaptation layer (AAL)
- The User layer

The physical layer consists of two sub-layers: the transmission convergence sub-layer and the physical medium (PM).

Transmission Convergence Sub-layer (TC)  The TC sub-layer mainly does five functions as shown in the Table 12.1. The lowest function is generation and recovery of the transmission frame. Transmission Convergence (TC) is used for embedding the cells of the ATM layer in the transmission frames of the transport medium in use. The next function, i.e. transmission frame adaptation takes care of all actions to adapt the cell flow according to the used payload structure of the transmission system in the sending direction. It extracts the cell flow, from the transmission frame in the receiving direction. The frame can be a synchronous digital hierarchy (SDH) envelope or an envelope, according to ITU-T Recommendation G.703.

Cell delineation  To ensure that the ATM Cell information is always distinguished from the header, the information is transmitted in scrambled form. Cell delineation function enables the receiver to recover the cell boundaries. Scrambling and de-scrambling are to be done in the information field of a cell before the transmission and reception, respectively, to protect the cell delineation mechanism. Thus the ATM header can be clearly identified, whatever the bit combination in the ATM cell’s information field may be.
HEC generation The TC layer is also responsible for calculating the checksum on the cell’s header information. This checksum is known as the HEC (Header Error Control) and is carried in the fifth byte of the cell. The HEC sequence generation is done in the transmit direction and its value is recalculated and compared with the received value and thus used in correcting the header errors. If the header errors cannot be corrected, the cell will be discarded.

Cell rate decoupling inserts the idle cells in the transmitting direction, to adapt the rate of the ATM cells to the payload capacity of the transmission system. It suppresses all idle cells in the receiving direction. Only assigned and unassigned cells are passed to the ATM layer.

Table 12.1 Summary of Functions of Various Layers of B-ISDN

<table>
<thead>
<tr>
<th>Higher Layers</th>
<th>Higher Layer Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM Adaptation Layer (AAL)</td>
<td>Convergence</td>
</tr>
<tr>
<td>1. Convergence sub-layer (CS)</td>
<td>Segmenting and Reassembly</td>
</tr>
<tr>
<td>2. Segmentation and Reassembly sub-layer (SM)</td>
<td></td>
</tr>
<tr>
<td>ATM Adaptation Layer (ATM)</td>
<td>Generic Flow Control</td>
</tr>
<tr>
<td>Asynchronous Transfer Mode (ATM)</td>
<td>Cell Header Generation/Extraction</td>
</tr>
<tr>
<td>Cell VP/VC Translation</td>
<td>Cell Multiplex and Demultiplex</td>
</tr>
<tr>
<td>Transmission Control sub-layer (TC)</td>
<td>Cell Rate Decoupling</td>
</tr>
<tr>
<td></td>
<td>HFC: Header Fragmentation/Data Generation/Recovery</td>
</tr>
<tr>
<td></td>
<td>Cell Detection</td>
</tr>
<tr>
<td></td>
<td>Transmission Frame Generation/Recovery</td>
</tr>
<tr>
<td>Physical Medium sub-layer (PM)</td>
<td>Bit Timing</td>
</tr>
<tr>
<td></td>
<td>Physical Medium</td>
</tr>
</tbody>
</table>

Physical Medium sub-layer (PM) The PM sub-layer contains only the Physical Medium dependent functions. It provides bit transmission capability including bit alignment. It performs Line coding and also electrical/optical conversion if necessary. It includes bit-timing functions such as the generation and reception of waveforms suitable for the medium and also insertion and extraction of bit timing information. Optical fibre will be the physical medium and in some cases, coaxial and twisted pair cables are also used. In addition, during the last few years several other less costly transmission media types for local area networks have been defined (e.g. shielded and unshielded twisted pair cabling STP and UTP and multimode fiber). However, the standards for B-ISDN are set up in such a way that practically any physical medium can be used as soon as an appropriate transmission adaptor has been specified.

The maximum transmission bandwidths for copper cables over short distances ranges between 300 and 400MHz; optical fibers can provide bandwidth in the order of terahertz (10^12Hz). This means that, for LANs, electrical transmission methods can still be justified for B-ISDN. For wide area applications, on the
other hand, B-ISDN as a system will certainly be based on optical media. High bandwidths are simply far less expensive to carry over long distances, using optical media than by electrical means.

The ATM layer The decision to use ATM for B-ISDN is a remarkable one; it implies that B-ISDN will be a packet-switched network, certainly at the interface, and almost certainly in terms of its internal switching. Although the recommendation also states that B-ISDN will support circuit-mode applications, this will be done over a packet-based transport mechanism. Thus, ISDN, which began as an evolution from the circuit-switching telephone network, will transfer D1 itself into a packet-switching network as it takes on broadband services.

The functions of the ATM layer are completely independent of those of the physical plane below it. The main task of the ATM layer is to transport the data passed down to it by the adaptation layer (AAL) to its intended destination. This makes the ATM layer, the transport mechanism in B-ISDN networks. The information units of the ATM layer are 53-byte cells, each of which includes in its cell header, a numerical identifier allocating it to a specific connection. In the direction of transmission, the cells for various connections are multiplexed in a non-continuous flow. These cell streams are divided between two logical hierarchies: virtual channels and virtual paths. A physical transfer medium (for example, an optical fiber) can carry a number of virtual connection paths, and these in turn are made up of a number of connection channels. Each cell can be assigned to a specific path or channel by reference to the numerical path or channel identifier (VPI, VCI) contained in its header.

VPI/VCI conversion If cells are routed via ATM switches or cross-connects, the VCI and VPI values, applying up to that point need to be converted into new VPIs, or VCIs specifying the cell’s new destination.

Generating the cell header If the ATM layer receives an information unit from the AAL layer above, it must generate an appropriate ATM header (except for the Header Error Control field (HEC), which is supplied by transmission convergence (TC). The header of an ATM cell consists of 4 bits for Generic Flow Control (GFC), 20 bits for the channel and path identifiers (VPI and VCI), 3 bits defining the Payload Type and one bit for the Cell Loss Priority. Cells for network-to-network communication (NNI) differ from user-to-network (UNI) cells in having no flow control field, resulting in a larger field for the path identifier (VPI) values. It is a central task of the ATM layer to convert network addresses in the higher levels into the corresponding VPI and VCI values.

Generic Flow Control (GFC) In the case of a number of subscribers, accessing the same physical medium, the GFC field in an ATM cell can be used to control cell transfer.

The ATM Adaptation Layer (AAL) The job of the AAL layer is to ‘segment’ the data streams from the higher applications layers into 48-byte units of information.
The functions of the ATM layer depend on the characteristics of the governing applications, that is, the AAL layer is service-dependent. It consists of two sub-layers:

The Convergence Sub-layer (CS)

The Segmentation and Reassembly Sub-layer (SAR).

**Different AAL types** To limit the number of different AAL implementations, four service classes have been defined for the AAL layer: AAL1, AAL2, AAL3/4 and AAL5. The definition of the various AAL types is based on the following three parameters:

- Real-time requirements,
- Bit rate (constant or variable),
- Connection type (connection-oriented or non-connection-oriented).

The Signalling Adaptation Layer (SAAL) Within B-ISDN, similar to the D-channel in narrowband ISDN, special channels are used to carry the signalling information. The AAL layer of these signalling channels is known as the SAAL. The SAAL has the task of converting the signalling protocols of the applications layer (for example, Q.2931, B-ISUP) to those used at the ATM level. An adaptation layer of type 3/4 or 5 (AAL3/4 or AAL5) is used with the service-specific SSCOP sub-layer to do this. The procedure used at AAL level must guarantee a high degree of transfer security, since the Q.2931 protocol and the other signalling protocols at higher levels operate on the basis that their data packets are always transmitted and have no facilities for repeat sending of any lost units of information.

Table 8.1 summarises the various services of the B-ISDN layers.

**Higher layers** The initial applications for B-ISDN include Cell Relay, Frame Relay, SMDs/CBDs, B-ISDN signalling, and LAN emulation, along with network management for B-ISDN and various video services.

### 12.7 FAX, MODEM AND TELETEXT

**Fax**

The telephonic transmission of scanned printed material (both text and images), normally to a telephone number connected to a printer or other output device.
Modem

A modem is a hardware device that converts data so that it can be transmitted from computer to computer over telephone wires.

Teletext

Teletext is a means of sending pages of text and simple geometric shapes from mosaic blocks to a VBI decoder equipped television screen by use of a number of reserved vertical blanking interval lines that together form the dark band dividing pictures horizontally on the television screen.

12.8 INTERNET

The word Internet is the short form of internetwork or interconnected network. Therefore, it can be said that the Internet is not a single network, but a collection of networks. These networks have one thing in common—to communicate with each other. The Internet consists of the following groups of networks:

- **Backbones**: These are large networks that exist primarily to interconnect other networks. Some examples of backbones are NSFNET in the USA, EBONE in Europe and large commercial backbones.
- **Regional networks**: These connect, for example, universities and colleges. ERNET (Education and Research Network) is an example in the Indian context.
- **Commercial networks**: They provide access to the backbones to subscribers, and networks owned by commercial organizations for internal use and also have connections to the Internet. Mainly, the Internet Service Providers come in this category.
- **Local networks**: These are campus-wide university networks.

The networks connect users to the Internet using special devices called gateways or routers. These devices provide connection and protocol conversion of dissimilar networks to the Internet.

Gateways or routers are responsible for routing data around the global network until they reach their ultimate destination as shown in Figure 12.13. The delivery of data to its final destination takes place based on some routing table maintained by router or gateways.

Over time, TCP/IP defined several protocol sets for the exchange of routing information. Each set pertains to a different historic phase in the evolution of the architecture of the Internet backbone.
History of the Internet

The Internet, www and Information Super Highway are terms which have deep impact on the lives of millions of people all over the world. This global nature of the internet could not be possible without the development of Transmission Control Protocol/Internet Protocol (TCP/IP). This is the protocol suite developed specifically for the Internet. The information technology revolution of today cannot be achieved without this vast network of networks.

During late 1960s and 1970s, organizations were inundated with many different LAN and WAN technologies such as packet switching technology, collision-detection local area networks, hierarchical enterprise networks, and many other excellent technologies. The major drawbacks of all these technologies were that they could not communicate to each other without expensive deployment of communication devices. These were not only expensive, but also put users at the mercy of the monopoly of the vendor they would be dealing with. Consequently, multiple networking models were available as a result of the research and development efforts made by many interest groups. This paved the way for development of another aspect of networking known as protocol layering. This allows applications to communicate with each other. A complete range of architectural models was proposed and implemented by various research teams and computer manufacturers. The result of all this great know-how is that today, any group of users can find a physical network and an architectural model suitable for their specific needs. This includes cheap asynchronous lines with no other error recovery than a bit-per-bit parity function, through full-function wide area networks (public or private) with reliable protocols such as public packet switching networks or private SNA networks, to high-speed but limited-distance local area networks.
This is now evident that organizations or users are using different network technology to connect computers over the network. The desire to share more and more information among homogeneous or heterogeneous interest group motivated the researcher to devise the technology so that one group of users may extend its information system to another group of users who happen to have a different network technology and different network protocols. This necessity was recognized in the beginning of the 1970s by a group of researchers in the United States of America who hit upon a new principle popularly known as internetworking. Other organizations also became involved in this area of interconnecting networks, such as ITU-T (formerly CCITT) and ISO. All were trying to define a set of protocols, layered in a well-defined suite, so that applications would be able to communicate to other applications, regardless of the underlying network technology and the operating systems where those applications run.

**ARPAnet**

ARPAnet was built by DARPA. This initiated the packet switching technology in the world of networking and therefore, it is sometimes referred as the ‘grand-daddy of packet networks’. The ARPAnet was established in the late 1960s for the Department of Defense to accommodate research equipment on packet switching technology, besides allowing resource sharing for the Department of Defense’s contractors. This network includes research centres, some military bases and government locations. It soon became popular with researchers for collaboration through electronic mail and other services. ARPAnet formed the beginning of the Internet.

ARPAnet provided interconnection of various packet-switching nodes (PSN) located across the continental USA and western Europe using 56 Kbps leased lines. ARPAnet provided connection to minicomputers running a protocol known as 1822 (after the number of a report describing it) and dedicated to the packet-switching task. Each PSN had at least two connections to other PSNs (to allow alternate routing in case of circuit failure) and up to twenty-two ports for user computer connections. Later on, DARPA replaced the 1822 packet switching technology with the CCITT X.25 standard. Subsequently, the excessive increase in the data traffic made the capacity of the existing lines (56kbps) insufficient. ARPAnet has now been replaced with new technologies.

**Intranet**

An intranet is a private network that is contained within an enterprise. It may consist of many interlinked local area networks and also use leased lines in the wide area network. Typically, an intranet includes connections through one or more gateway computers to the outside Internet.
12.9 E-MAIL

Electronic mail, or e-mail, allows computer users locally and worldwide to exchange messages. E-mail users have an electronic mailbox into which incoming mail is dropped. Messages sent through e-mail arrive within a matter of seconds. User accesses these mails with a mail reader program, called mail user interface that is usually associated with computer account. One user may have different electronic mailboxes. Electronic mailbox is identified by an e-mail address and is given a user’s account ID. This is not always true because on non-networked multi-user computer, e-mail address is just account ID.

Mail delivery among networked computers is more complicated. In this case, a mail must identify the computer as well as the mailbox. Syntactically, e-mail address is composed of computer name and mailbox name; for example, user_id@domain.

E-mail message format contains header and body. Header includes delivery information and body carries message part. The header and body are separated by blank line. An e-mail message can only be transmitted in the form of 7-bit ASCII (American Standard Code for Information Interchange) data. ASCII is a 7-bit code, resulting in a maximum of 128 characters. The data in e-mail could not contain arbitrary binary values, e.g., executable program. There are techniques for encoding binary data so that binary data may be transported.

A powerful aspect of e-mail is the option to send electronic files to a person’s e-mail address. Non-ASCII files, known as binary files, may be attached to e-mail messages. These files are referred to as MIME (Multi-purpose Internet Mail Extensions) attachments. MIME extends and automates encoding mechanisms and was developed to help e-mail software handle a variety of file types. It allows inclusion of separate components, i.e., programs, pictures, audio clips in a single mail message. The sending program identifies the components so that the receiving program can automatically extract and inform mail recipient. Many e-mail programs, including Eudora and Netscape Messenger, offer the ability to read files written in html, which is itself of MIME type.

E-mail communication is actually a two-part process. The user composes mail with an e-mail interface program. This mail transfer program delivers the mail to the destination and waits for the mail to be placed in outgoing message queues. SMTP (Simple Mail Transfer Protocol) is the standard application protocol for delivery of mail from source to destination. It provides reliable delivery of messages using TCP and message exchange between client and server including e-mail address lookup and e-mail address verification.

The e-mail can be considered as an electronic version of paper-based office memo, which is quick and much cheaper than a written communication. Because e-mail is encoded in an electronic medium, therefore fast, automatic processing in the form of sorting and reply is possible. It allows quick, asynchronous
communication across the entire Internet. Asynchronous communication consists of asynchronous characters which gives output at a rate that is independently generated by the transmitter. The asynchronous characters are actually self-synchronized because they are framed by Start and Stop bits that delineate the character. E-mail is the most widely used the Internet service. The best feature of the mail is its quick and reliable delivery of messages.

Check Your Progress

1. What is cellular network?
2. Write any two features of ISDN.
3. What are the three types of ISDN channels?
4. What are the different types of ISDN interfaces to users?

12.10 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. A cellular network or mobile network is a wireless network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station.
2. Digital network services that can be implemented in the existing telephone network.
   - High bandwidth interoffice FAX.
3. Customers using only analog services.
   - Customers using analog facilities to transmit digital information via modem.
   - Customers using digital services to transmit digital information.
4. Basic Rate Interface (BRI).
   - Primary Rate Interface (PRI).

12.11 SUMMARY

- A cellular network or mobile network is a wireless network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station.
- Micro cells are those that are normally found in densely populated areas which may have a diameter of around 1 km.
- The need to access a variety of networks such as packet-switched networks and circuit-switched networks, the telephone companies created integrated digital networks.
• B-ISDN is a broad-based attempt to set up a single unified, worldwide highspeed network, to replace the multiplicity of the existing networks.

• The control plane performs call-control and connection control functions such as connection setup, connection release, and connection monitoring.

• ARPAnet was built by DARPA. This initiated the packet switching technology in the world of networking and therefore, it is sometimes referred as the ‘granddaddy of packet networks.

• Electronic mail, or e-mail, allows computer users locally and worldwide to exchange messages. E-mail users have an electronic mailbox into which incoming mail is dropped.

• The Internet, www and Information Super Highway are terms which have deep impact on the lives of millions of people all over the world.

### 12.12 KEY WORDS

• **Regional Networks:** These connect, for example, universities and colleges. ERNET (Education and Research Network) is an example in the Indian context.

• **Commercial Networks:** They provide access to the backbones to subscribers, and networks owned by commercial organizations for internal use and also have connections to the Internet. Mainly, the Internet Service Providers come in this category.

### 12.13 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short-Answer Questions**

1. What are the desirable features of cellular networks?
2. Define cell clusters and cell size.
3. What are the different types of cells?
4. Write a short note on internet and E-mail.

**Long-Answer questions**

1. Explain the term ISDN.
2. Explain the different types of ISDN channels.
3. What are the two basic types of interfaces? Explain.
4. Explain the broadband ISDN with its architecture.
12.14 FURTHER READINGS


UNIT 13 NATIONAL INFORMATION SYSTEMS

Structure
13.0 Introduction
13.1 Objectives
13.2 NISCAIR
13.3 DESIDOC
13.4 SENDOC
13.5 INFLIBNET
13.6 DELNET
13.7 Answers to Check Your Progress Questions
13.8 Summary
13.9 Key Words
13.10 Self Assessment Questions and Exercises
13.11 Further Readings

13.0 INTRODUCTION

In this unit, you will learn about the national information system like NISCAIR and DESIDOC. NISCAIR is an information institute located in New Delhi that promotes communication in science using the most appropriate technologies. DESIDOC maintains the defense system library. You will also learn about the SENDOC, INFLIBNET and DELNET.

13.1 OBJECTIVES

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

- Discuss the aims of NISCAIR
- Understand the functions of DESIDOC and SENDOC
- Discuss the objectives of INFLIBNET and DELNET

13.2 NISCAIR

National Institute of Science Communication and Information Resources or NISCAIR is located in New Delhi. NISCAIR is an information institute related to science.

NISCAIR came into existence with the merger of National Institute of Science and Communication (NISCOM) and Indian National Scientific
Self-Instructional Material

NOTES

National Information Systems

Documentation Service (INSDOC), both of which disseminate and document information related to science and technology. NISCAIR is the prime custodian of all information sources in science and technology. NISCAIR promotes communication in science using the most appropriate technologies.

The aim of NISCAIR is to:

- Provide formal linkage of communication among scientific community.
- Disseminate science and technology information to general public, especially students.
- Use information technology applications with reference to science communication and modernizing libraries.
- Facilitate access to relevant and accurate information.
- Further facilitate economic, social, industrial, scientific and communication development with scientific information.
- Develop human resources in science and technology communication.
- Collaborate with international institutions and organizations having similar goals.
- Manage science and technology information systems and services.

NISCAIR offers services like:

- E-publishing
- Editing
- Indexing
- Print and Production
- Translation Services
- Training Programs
- Short term courses in science and communication
- Content abstracts and photocopy services
- Literature search services

NISCAIR offers online access to information including 18 journals and three science magazines.

The main aim of NISCAIR is to make science and technology information available at a centralized location. The information is indexed and organized in an efficient manner in NISCAIR so that it can be easily retrieved. The information related to science and technology needs to be updated frequently and NISCAIR is flexible to allow that. Thus, it not only provides historical information but also the latest and current information related to science and technology. NISCAIR also makes possible to search for information in the database using keywords thus making it an easy to use and flexible information system.
13.3 DESIDOC

DESIDOC (Defense Scientific Information & Documentation Centre) is a division of the DRDO (Defense). It is located in Delhi and its main function is the collection, processing, and dissemination of relevant technical information for DRDO scientists. Ms. Alka Suri is the present director of DESIDOC.

History

DESIDOC started its functioning as Scientific Information Bureau (SIB) in 1958. It was a division of the Defence Science Laboratory (DSL) which is now called Laser Science & Technology Centre. The DRDO library which had its beginning in 1948 became a division of SIB in 1959. In 1967 SIB was reorganised with augmented activities and named Defence Scientific Information and Documentation Centre (DESIDOC). It still continued to function under the administrative control of DSL. DESIDOC became a self-accounting unit and one of the laboratories of DRDO on 29 July 1970.

The Centre was functioning in the main building of Metcalfe House, a landmark in Delhi and a national monument. In August 1988 it moved to its newly built five-storeyed building in the same Metcalfe House complex. Since it became a self-accounting unit, DESIDOC has been functioning as a central information resource for DRDO. It provides S&T information, based on its library and other information resources, to the DRDO headquarters, and its various laboratories at various places in India.

Functions

- **Library**
  DESIDOC maintains the Defence Science Library (DSL) headed by Sh. V Senthil, Scientist E, a well-equipped library housing 262,000 documents. It also provides access to various databases, as well as newspaper archives and other reference material. Additionally, DESIDOC has taken up the initiative of digitizing complete research papers of DRDO scientists, as well as preparing presentation material and promotional material for DRDO scientists.

- **Publications**
  DESIDOC functions as the publication wing of DRDO, providing scientific and technical information via specialised publications, monographs, technical bulletins, online journals and popular science publications. These cover current developments in Indian Defence R&D. The publications are unclassified and available free of charge online. Monographs and other publications are available on payment. The periodicals published are:
  - Defence Science Journal - A bi-monthly research periodical.
Technology Focus - A bi-monthly periodical focusing on the technologies, products, processes, & systems developed by DRDO.

DRDO Newsletter - Monthly Newsletter with house bulletins of DRDO activities.

DESIDOC Journal of Library & Information Technology (earlier DESIDOC Bulletin of Information Technology (DBIT)) - A bi-monthly publication bringing out the current developments in library and information technology.

Training programs

Short term training programmes and workshops are conducted every year for DRDO personnel, mainly in the areas of library automation, Internet use, DTP, multimedia development, communication skills, stress management, etc.

13.4 SENDOC

Small Enterprises National Documentation Centre (SENDOC) was set up in 1970 when ni-msme, was SIET, to energies MSMEs in India and the developing countries around the world with information and knowledge. Since then, it has been functioning as a clearing house of information both for entrepreneurs and extension agents. The Centre has emerged as a one - stop global and IT powered information centre for a wide spectrum of MSMEs, academia, students, research institutions, industry associations and entrepreneurs.

The main objectives are to collect, store and disseminate techno-managerial information pertaining to MSMEs and to conduct need and demand based training programmes. It’s library contains 18000 volumes of journals, 30000 reports, 70000 books, 7500 product profiles, 65000 journal abstracts and subscribes to 140 national and international periodicals.

It has also a collection that provides information on statistics, economics, production, finance, marketing, technology, machinery and equipment, raw materials, consultants, Government policies and programmes, exports and imports, investment, trade and area literature, licensing, etc. Experts working in the Centre scan and arrange information systematically for quick retrieval using LIMS (Library Information Management System) package. The information is accessible through our website www.nimsme.org.

Following are the services provided by the Centre.

- Inter-library lending of documents
- Lending of books
- Reference Services (preparation of bibliographies) and literature search
- Newspaper clippings (on select items)
- Technical enquiry
- Reprographic Services
13.5 INFLIBNET

Emerged as a front runner with the growth of LIS, INFLIBNET facilitates the automation and networking of academic libraries with the help of network and access to information. Established in 1991 INFLIBNET is the national network of libraries among Indian Universities and is located in in Gujarat, India. It is a major national program initiated by University Grant Commission under the Inter-University Centre for Astronomy and Astrophysics (IUCAA) and became an independent autonomous Inter-University Centre (IUC) in 1996 under UGC (University Grant Commission) with the aim to modernize all academic libraries of higher education and connecting them through a nationwide high speed data network in order to promote communication between academicians and researchers. It uses computer and communication technologies for the optimum utilization of information. The participants included in INFLIBNET are colleges, universities, institutes of higher learning, information centers, R&D institutes, institutes of national importance and document resource centers. There are 142 universities that have been covered under this program so far. The program also covers all the disciplines including science, technology, medicine, fine arts, humanities, agriculture, and so on.

Objectives

The major objectives to establish INFLIBNET are as follows:

- To implement computerization of services and operations for the modernization in the libraries and information center by building and strengthen of ICT infrastructure with value added services.
- To create virtual network of the people and resources with the help of latest technologies in order to provide efficient and effective access to information through innovation, collaborations and perseverance.
- To link libraries and information centers through computer network to avoid duplication of efforts.
- To provide ubiquitous, reliable and seamless access of the electronic resources to the academic community for effective use and increase value of information through variety of tools and services.
- To provide reliable, secure and convenient access to information in electronic format by creating online union catalogs of library collections from anywhere and anytime.
- To encourage cooperation among libraries and information centers for their mutual benefits by pooling and sharing of resources.
- To facilitate the communication between experts including scientists, researchers, faculties and students.
The ultimate aim of the program is to promote communication facilities by resource sharing offered by modern information technology.

**Activities of INFLIBNET**

A number of activities have to be taken up to convert records into machine readable formats for information resource sharing, which is the aim of networking. The various activities that are involved are as follows:

- Standards are required to ensure compatibility for interconnecting the libraries and information centers at national and international levels for effective, efficient and easy transfer of information. Standardization reduces the barrier in information flow. Standards and formats have been created and declared by INFLIBNET for serials, books, thesis and dissertation and also for creating database. Anglo American Cataloguing Rule Revised (AACR2) has been adopted by INFLIBNET for entering data. Guidelines have been provided with detailed manuals on standards and formats.

- Training has been imparted to the manpower of universities for data capturing and automated services and to get them acquainted with the latest technologies. Onsite trainings are also provided by INFLIBNET to provide assistance in software installation, creating database, email, barcodes, and so on.

- A state-of-the-art library software management, SOUL (Software for Universities Libraries) has been developed by INFLIBNET Centre, based on AACR2 format. The software consists of the following modules:
  - Acquisition
  - Catalogue
  - Circulation
  - OPAC
  - Serial Control

  The software is based on client-server architecture and working with Windows operating system and adheres to the internationally acceptable standards, that is, AACR2, CCF (Common Communication Format), MARC 21 and ISO 2709.

- Utmost care has been taken for one of the most important activity of developing and creating Union Catalogue of resources (Union database) called IndCat that is an important source of bibliographic information and is used for collection of different types of library materials such as serials, dissertations, thesis, and so forth for different libraries. This database is made available on online as well as offline mode. The database is accessible through ERNET, I-NET and NICNET connectivity. Apart from this, INFLIBNET has developed expert records with profiles of the subject experts serving the universities and records of experts in the field of science and technology.
• For library automation awareness national convention is organized annually by INFLIBNET through which they provide platform to the librarians for interaction, assessment of programs made in computerization activity and building future plans.

13.6 DELNET

Delhi is being increasingly seen as an important centre of information resources in India; it caters to the specialized as well as the general users. The information resources may be located in any of the following: information and documentation centres, college and university libraries, research libraries, institutional libraries, government libraries, department libraries, public libraries. During recent years, increase in information has led to increase in the demands of the users. It has been noticed that in this era of information explosion, libraries in India are generally ill-equipped to handle and retrieve information effectively. Further, the financial resources and the space requirement for housing library collection are limited in almost all the libraries. Not a single library can afford to house every necessary document even in its chosen area of interest. Resource sharing, thus assumes great importance in such a scenario and therefore, the forward looking librarians keep exploring the options to promote the sharing of resources by automation and networking. With this objective, the India International Centre initiated efforts for the establishment of Delhi Library Network in January 1988. This network is now known as Developing Library Network

DELNET is the first fully operational digital library network in India. It was started in January 1988 as a project of the India International Centre. The project initially received financial and technical support from NISSAT, Department of Scientific and Industrial Research. The project got registered as a society in June 1992 under the Societies Registration Act, 1860. It is currently being run and promoted by the National Informatics Centre NIC under Planning Commission as a Government of India and India International Centre initiative by New Delhi.

The main goal of DELNET is to promote resource sharing among the libraries; this is to be achieved through the development of a network of libraries. Apart from offering computerized services to users, DELNET aims to store and disseminate information. It aims to develop collection and to cut down the unnecessary duplication of resource storage wherever possible.

DELNET is currently in the process of compiling various union catalogues of the resources available in several member libraries. It has already been successful in creating several collections such as the Union Catalogue of Books, Union Catalogue of Periodicals, Union List of Current Periodicals, CD-ROM Database, Database of Periodical Articles, Database of Indian Specialists, Union List of Video Recordings, Database of Theses and Dissertations, Urdu Manuscripts’
Database and several sample databases of language publications. For language publication the GIST technology is being used. The data is not only fed but also being regularly updated in these databases and is growing rapidly. All the DELNET databases reside on DELSIS. DELSIS is an in-house software developed on BASISPlus, which is an RDBMS and the product of Information Dimensions Inc., USA.

DELNET provides several facilities. DELNET’s efforts in resource sharing have been of great help in modernization and digitization of libraries in India.

The key objectives of DELNET are to:
- Develop a network of libraries to promote resources sharing among the libraries and to collect, store and disseminate information by offering computerized services to the users.
- Act as a referral centre, to monitor and facilitate catalogue search and maintain a central online union catalogue of books and non-book materials of all the member libraries.
- Provide guidance to the member libraries on cataloguing database services, acquisition, circulation, serials control, selection of hardware and software.
- Coordinate efforts for collection development and reduction of duplication wherever possible.
- Develop a database of projects, institutions and specialists.
- Promote delivery of documents mechanically.
- Maintain electronic and mechanical equipment for quick communication of information and delivery of email.
- Provide for the publication of journals and newsletters with the aim of networking and sharing of resources.
- Coordinate efforts with local, regional, national and international networks for exchange of documents and information.

DELNET Activities/Services

Promotion of Database Creation

It has been suggested by several specialists that standard bibliographic data should be available in machine readable form with the libraries for networking of libraries. DELNET has therefore concentrates its efforts to promote the standardization of databases in the member libraries. Focus groups were conducted and regular meetings were arranged for the librarians and computer specialists to provide a common platform for discussion of problems and the areas of cooperation. Following the discussions, some libraries have demonstrated an interest in database creation while the efforts of computer and networking specialists are ongoing to discuss further possibilities of database creation and resource sharing.
DELNET has come forward to provide technical assistance to member libraries in the following areas:

- Creation and maintenance of bibliographic databases
- Hardware and software requirements
- User services
- Serials controls
- Current awareness and SDI services
- Union catalogue preparation
- Subject profiles construction
- Authority data compilation
- Inter-library loan and user services
- Abstracting services
- Access to local, national and international databases
- Document transfer/copying facilities

With the assistance of the Department of Culture, Government of India in 1998, DELNET undertook a pilot project for the compilation of the National Bibliographic Database. As part of this project, fifty thousand records of books were created out of which 15,000 books were in Tamil and Punjabi each and 20,000 books were in English. This project was operational at the International Institute of Tamil Studies, Chennai and Punjabi University, Patiala. Later at Andhra University, 10,000 records were created in Telugu and 15,000 records were created in English. Similarly 25,000 records each were created at the Asiatic Society, Kolkata and Mumbai.

**Resource Sharing**

By rationalizing subscriptions to foreign periodicals in the years 1991-1993 through resource sharing, DELNET has helped us save foreign exchange worth ₹ 10 million. This has been a major achievement and has helped us develop ourselves in physical science, medical science and agricultural sciences domains. It is speculated that continuing with the sharing of periodical resources with DELNET, we will be able to save more foreign exchange in the coming years. Earlier in 1991, a courier service was launched by a private agency to support the efforts of inter-library lending; however, the service was not very effective. Later, DELNET introduced its own courier service for inter-library loaning. The service was started with the financial help of NIC.

DELNET plans to get several knowledge centres established in India with the support of the state and the central government. It is understood that communication technologies can help bridging the knowledge gap through networking libraries and other resource centres and connecting people. This can be achieved if we have the required content and the requirements of users are
available to us in a machine readable form. We also plan to use the knowledge technology to maximize the use of the knowledge resources in the country. The use of knowledge technology is not limited to match the needs of the user base with the existing knowledge resources but can also facilitate decision making in a global perspective.

Having a good understanding of the importance of knowledge centres, DELNET has proposed that knowledge centres need to be established in public libraries and centres of learning need to be setup in each state. DELNET is also planning to establish the National Knowledge Centre at DELNET.

The National Knowledge Centre will also promote the creation of suitable content at the Knowledge Centres and make it available to the public in the country. It will add links to every useful information that is already existing and make all knowledge available to the public, including researchers, students and teachers.

The main objectives of DELNET that promote working of knowledge centres include:

(i) Coordinate the efforts of knowledge centres in different states in the country
(ii) Develop resource collections on important subjects
(iii) Serve the National Knowledge Centre
(iv) Maintain information on knowledge repositories by creating databases and developing an Intranet
(v) Use international standards of physical and electronic resources to create indexes and catalogues in a machine readable form
(vi) Provide access to information through DELNET on various subjects and collect relevant information on the subjects from other sources

Note: DELNET has a collection comprising of 70 lakh records of books. It coordinates the efforts of 1100 libraries in India and 6 other countries with the purpose of sharing of information.

(vii) Develop an active database of experts and connect each component of knowledge with a set of experts
(viii) Develop links between physical resources such as institutions and individuals and electronic resources such as the ones available through the Internet
(ix) Capture and make the knowledge available in a database form. The knowledge can be collected from a variety of sources such as projects, grey literature, assignments, case studies, and experts on given subjects
(x) Act as an information centre to the users and provide as much information to the users as may be needed by them to complete their assignments
(xi) Turn each knowledge centre such as a public library into a one-stop centre for accessing knowledge on different subjects or topics.

(xii) Train every user to access information and guide them to appropriate resources.

Knowledge centres will have an arduous task of collating knowledge from a variety of sources which includes printed sources such as newspapers, journals, books and digital resources which includes CDs, metadata, Internet, and databases. New research methodologies need to be adopted to collect information on the issues of interest to each knowledge centre. Eventually, a digitized library needs to be developed on several topics. The library will have links and in-house resources that can be utilized by the users 24 hours a day, throughout the year.

**Online databases**

DELNET provides access to twenty databases that are available online for its users. These databases include:

- Union Catalogue of Books: MARC Format
- Union Catalogue of Books: UCF
- Union Catalogue of Periodicals
- Union List of Current Periodicals
- Indian Specialists Database
- Database of Periodic Articles
- Union list of Video recordings
- CD-ROM database
- Union List of Newspapers
- Union List of Sound Recordings
- Union Catalogue of Hindi Books
- Union List of Serials of Management Libraries
- Urdu Manuscripts Database
- Multilingual Books: Sample database
- DEVINSA Database
- Database of Theses and Dissertations
- Books in-Print Database
- Serials: Petroleum and Natural Gas
- Directory of Libraries
- Jain Database
Koha

Koha is a web-based multilingual integrated library system (ILS) that caters to the automation needs of medium and large libraries. It is an open-source ILS. DELNET uses a customized version of Koha. All the functional requirements of a library management system can be fully met by Koha as it provides all necessary features of MARC-based ILS to cater to the needs of libraries.

Features of Koha

- MARC Import/Exports
- MARC 21 compatible
- Z39.50 search
- Comprehensive advance search
- Multilingual Web OPAC
- Printing functions for barcode labels, and reports
- Flexibility to customize according to your library needs
- Barcode and spine label printing
- Virtual book shelf
- Branch Libraries Management and Items transfers
- Copy Cataloguing
- Customizable Data Entry Sheet
- Budget Management
- No platform dependence
- Uses MySQL as backend RDBMS and Apache Web server. Both these software are also open source. It can be run on Linux or Windows

Modules

- Cataloguing
- Multilingual Web OPAC
- Acquisition
- Patron Management
- Authorities Control
- Circulation
- Reports
- FAQ
Why Koha?

**It is a full-featured ILS.** Koha is a true enterprise-class ILS that provides comprehensive functionality of basic as well as advanced options. It has been successfully used worldwide in libraries of all sizes. Koha includes modules for cataloguing, circulation, serials, acquisitions, reservation, branch relationships and user management.

**It uses a dual database design.** Koha utilizes the strengths of the two major industry-standard database types, text-based and RDBMS. Because of this design feature, Koha is scalable enough to meet the transaction load of small as well as big libraries.

**It is library standards compliant.** Koha is built using library standards and protocols that ensure inter-operability between Koha and other technologies, while supporting the existing workflows and tools.

**It uses web-based Interfaces.** Koha’s OPAC uses state-of-the-art self-checkout interfaces and circulation management which are based on standards compliant with WWW technologies — such as XHTML, CSS and Javascript. This makes Koha a truly platform-independent solution.

**It is free/open source.** Koha is available for use and can be distributed under the open-source general public license.

### Check Your Progress

1. Write any two aims of NISCAIR.
2. Who is the present director of DESIDOC?
3. What is DELNET?
4. What is Koha?

### 13.7 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Two aims of NISCAIR are given below.
   - Provide formal linkage of communication among scientific community.
   - Develop human resources in science and technology communication.
2. Ms. Alka Suri is the present director of DESIDOC.
3. DELNET is the first fully operational digital library network in India.
4. Koha is a web-based multilingual integrated library system (ILS) that caters to the automation needs of medium and large libraries. It is an open-source ILS.
13.8 SUMMARY

- NISCAIR is the prime custodian of all information sources in science and technology.
- DELNET is the first fully operational digital library network in India.
- The main objectives are to collect, store and disseminate techno-managerial information pertaining to MSMEs and to conduct need and demand based training programmes.
- DESIDOC functions as the publication wing of DRDO, providing scientific and technical information via specialised publications, monographs, technical bulletins, online journals and popular science publications.
- SENDOC objectives are to collect, store and disseminate techno-managerial information pertaining to MSMEs and to conduct need and demand based training programmes.

13.9 KEY WORDS

- **ICT**: It refers to the convergence of audio-visual and telephone networks with computer networks through a single cabling or link system.
- **Koha**: It is an open source Integrated Library System, used world-wide by public, school and special libraries.

13.10 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short-Answer Questions**

1. Write a short note on NISCAIR.
2. What are the functions of DESIDOC?
3. Discuss the activities of INFLIBNET.

**Long-Answer questions**

1. What are the major objectives to establish INFLIBNET?
2. What is DELNET? Explain its key objectives.
3. What is koha? Also, write its features.
13.11 FURTHER READINGS


UNIT 14 INTERNATIONAL INFORMATION SYSTEM

14.0 INTRODUCTION
In this unit, you will learn about the international information systems (i.e. INIS, AGRIS, and BIOSYS). These are the systems that deliver the totality of measurable data worldwide within a defined context. The International Nuclear Information System (INIS) is the world’s leading information system on the peaceful uses of nuclear science and technology. It is operated by the International Atomic Energy Agency (IAEA) in Vienna, Austria, INIS that covers all aspects of the peaceful uses of nuclear science and technology, from nuclear reactors, reactor safety and nuclear fusion to applications of radiation and radioisotopes in medicine, agriculture or industry. AGRIS is the International System for Agricultural Science and Technology providing access to bibliographic information on agricultural science and technology.

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

- Discuss the historical aspects of information systems
- Understand the significance of information systems
INIS is the International Nuclear Information System that is a collaborative information system operated by the Atomic Energy Agency. INIS is maintained by its member states and the various international organizations that need to access information from this system. The INIS is the world’s leading information system that provides information on the peaceful uses of nuclear science and technology. The information in INIS is maintained in a database. The information that the database contains includes:

- At least 3.3 million bibliographic references on nuclear science and its peaceful uses.
- Scientific literature on peaceful uses of nuclear power.
- Collection of full text documents on peaceful uses of nuclear power.

The INIS has historical as well as latest information on nuclear power. The oldest documents of the INIS date back to 1946. The information in INIS is indexed and organized in a manner that makes access and retrieval easy and quick.

The information in INIS covers all aspects of peaceful uses of nuclear science and technology. Information in INIS relates to nuclear reactors, nuclear fusion, reactor safety, application of radiation and radio-isotopes in medicine, nuclear chemistry, nuclear physics and materials science. INIS also contains information that emphasizes on the environmental, health and economic impacts and effects of nuclear science and technology. The database also contains information pertaining to the legal and social aspects of nuclear energy. The INIS also provides information about non-nuclear energy sources and their environmental and economic scope.

The information contained in INIS can be divided into two categories: conventional and non-conventional. The conventional information is the information which is available via normal distribution channels like books and magazines. The non-conventional information refers to the INIS full text documents. Non-conventional information sources include scientific and technical reports, patent documents, conference papers, and non-commercially published thesis. The information is not available via commercial distribution channels.
AGRIS or International System for Agricultural Science and Technology is a global public database or an information system that provides information about agricultural science and technology. The information database of AGRIS is maintained by CIARD and the information is provided by the contributing and participating institutions from across the globe. These institutions form a network of AGRIS centres. The main objective of AGRIS is to provide information and meet the information exchange needs of developed and developing countries. AGRIS contains more than 7 billion bibliographic references on agricultural research and technology. It also contains links to data sources on the Web.

AGRIS is a collaborative network of more than 150 institutions from 65 countries. The AGRIS is maintained by FAO of the United Nations and provides access to agriculture related information. AGRIS offers a multi-lingual database for agricultural science. The database provided information on food, nutrition, agriculture, forestry, fisheries, environment, and so on. The information is available in the form of unpublished scientific and technical reports, thesis, conference papers, government publications and unique grey literature.

AGRIS aims to improve access of the information available on the web by maintaining and enhancing the database that contains information related to agriculture science and technology. It facilitates exchange of common standards and methodologies across various users.

AGRIS can be accessed online by anyone who wishes to make use of the information contained in the database. An information seeker just needs to enter the keyword on the basis of which AGRIS will return results. The search results will contain bibliographic references for the entered keyword as well as the web links to the related data sources. These sources usually point to full text documents that contain information about the keyword entered by the user. An information seeker can even use advanced search operations to make information searching and retrieval easier and quicker.
BIOSIS previews is a bibliographic database service having abstracts and citation indexing. It is a part of Clarivate Analytics Web of Science suite and having data from 1926 to the present. It is also a part of life sciences that encompasses biomedical science literature and life sciences and their wide range of related subject areas. This is accomplished with access to indexed journal content from Biological Abstracts, and supplemental indexed non-journal content from Biological Abstracts/Reports, Reviews, Meetings (BA/RRM or Biological Abstracts/RRM) and the major publications of BIOSIS. This coverage encompasses literature in pre-clinical and experimental research, methods and instrumentation, animal studies, environmental and consumer issues, and so on.

Biological Abstracts comprises 350,000 references for almost 5,000 primary journal and monograph titles. Biological Abstracts/RRM additionally encompasses more than 200,000 non-journal citations. BIOSIS Previews covers 5,000 peer reviewed journals. Non-journal coverage includes coverage of meetings, meeting abstracts, conferences, literature reviews, U.S. patents, books, software, book chapters, notes, letters, and selected reports in relevant disciplines including botany, microbiology, and pharmacology. BIOSIS Previews contains more than 18 million records; more than 500,000 records are added each year, and back files are available from 1926 to present. Specialized indexing has also been developed, which has increased the accuracy of retrieval. Taxonomic data and terms, enhanced disease terms, sequenced databank numbers, and a conceptually controlled vocabulary go back to 1969.

Some U.S. patents are also part of the BIOSIS Previews archives from 1926 to 1968, from 1986 to 1989, and from 1994 to present. Archived data is the electronic formatted content of the print Biological Abstracts volumes 1-49.

**Check Your Progress**

1. What is the full form of INIS?
2. What does INIS provides?
14.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. INIS stands for international nuclear information system.
2. INIS is the world’s leading information system that provides information on the peaceful uses of nuclear science and technology.

14.6 SUMMARY

- INIS is the International Nuclear Information System that is a collaborative information system operated by the Atomic Energy Agency.
- AGRIS or International System for Agricultural Science and Technology is a global public database or an information system that provides information about agricultural science and technology.
- The INIS is the world’s leading information system that provides information on the peaceful uses of nuclear science and technology.
- AGRIS aims to improve access of the information available on the web by maintaining and enhancing the database that contains information related to agriculture science and technology.

14.7 KEY WORDS

- CIARD: It is a global movement dedicated to open agricultural knowledge.
- Food and Agriculture Organization of the United Nations (FAO): It is an agency of the United Nations that leads international efforts to defeat hunger.

14.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What are the two categories of information contained in INIS?
2. What is conventional and non-conventional information?
Long-Answer Questions

1. Write a detailed note on INIS.
2. Write a detailed note on AGRIS.

14.9 FURTHER READINGS


