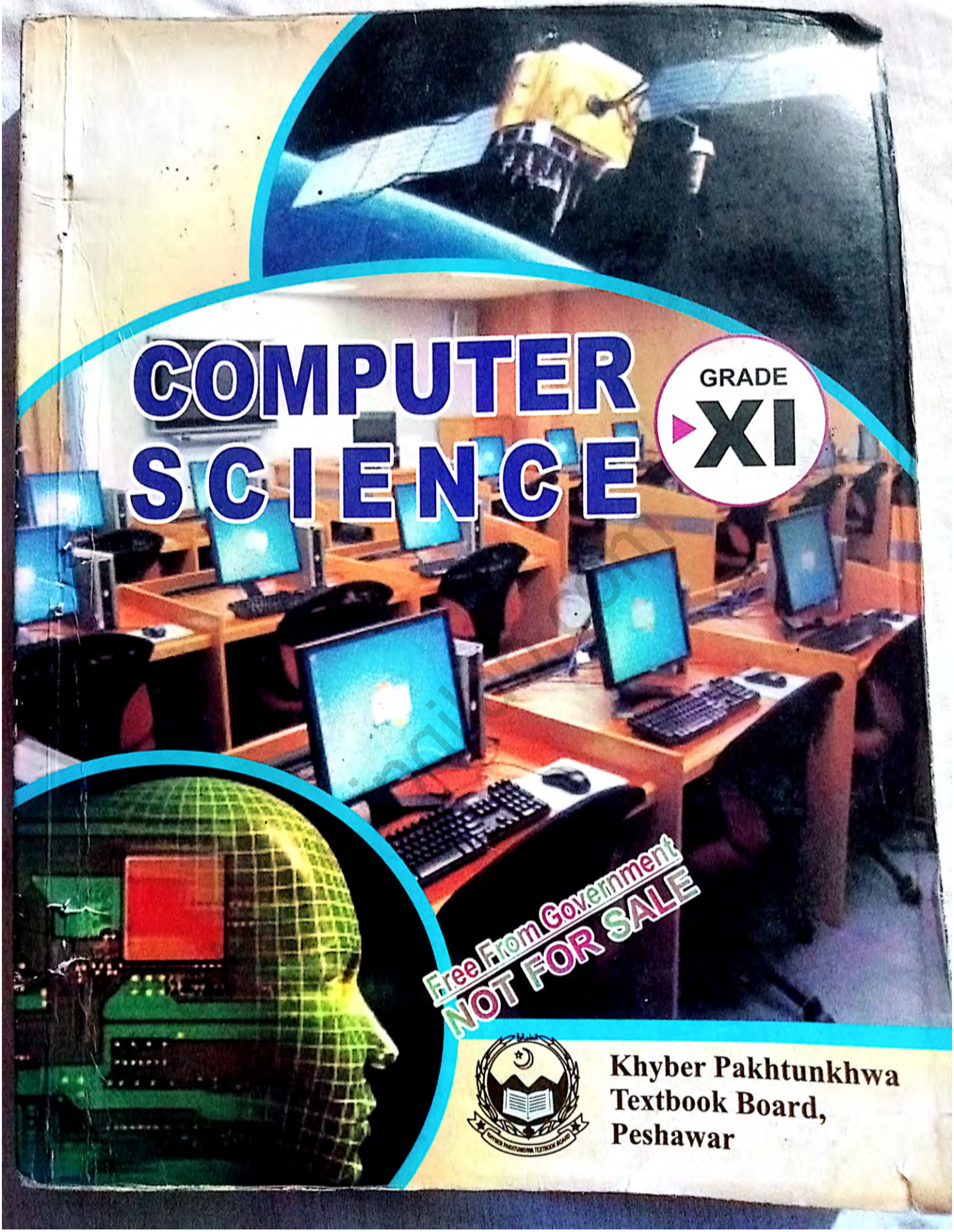

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Table of Contents

بسم اللہ الرحمٰن الرحیم

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TABLE OF CONTENTS

UNIT 1 OVERVIEW OF COMPUTER SYSTEM	1
1.1 INTRODUCTION TO COMPUTER SYSTEM	2
1.1.1 Computing Devices	2
1.1.2 Computer and its Basic Operations	6
1.1.3 Classification of Computers	7
1.1.4 Hardware and Software	11
1.2 COMPUTER SOFTWARE	13
1.2.1 Types of Software	13
1.2.2 Types of System Software	14
1.2.3 Types of Application Software	15
1.2.4 Software Terminologies	18
1.2.5 Firmware	19
1.3 COMPUTER HARDWARE	19
1.3.1 Input Devices	21
1.3.2 Output Devices	27
1.3.3 Difference between Soft Copy and Hard Copy	32
SUMMARY	34
EXERCISE	37
UNIT 2 COMPUTER MEMORY	41
2.1 INTRODUCTION	42
2.1.1 Units of Memory	42

	44
2.2 PRIMARY MEMORY	44
2.2.1 Chip memory and Magnetic memory	46
2.2.2 Volatile and Non-Volatile memory	47
2.2.3 Fundamental types of Main Memory	53
2.3 SECONDARY STORAGE	54
2.3.1 Secondary Storage Devices	54
2.3.2 Sequential Access and Direct Access Secondary Storage	55
2.3.3 Types of Secondary Storage Devices	63
2.3.4 Types of Chip Memory as Secondary storage	67
SUMMARY	69
EXERCISE	
UNIT 3 CENTRAL PROCESSING UNIT	72
3.1 INSIDE CPU (CENTRAL PROCESSING UNIT)	73
3.1.1 Basic Components of CPU	73
3.1.2 Types of Registers	76
3.1.3 System Bus	80
3.2 CPU OPERATION	81
3.2.1 Instructions and their types	82
3.2.2 Instruction Format	84
3.2.3 Instruction Cycle	86
3.2.4 CISC and RISK architecture	87
3.2.5 Intel and AMD Processors	88
SUMMARY	90
EXERCISE	93
UNIT 4 INSIDE SYSTEM UNIT	96
4.1 COMPUTER CASING/SYSTEM UNIT	97

Table of Contents

4.1.1 CPU and System unit	97
4.1.2 Computer Casings	98
4.1.3 Exploring the System Unit	99
4.2 PORTS AND SLOTS ON MOTHERBOARD	109
4.2.1 Types of Ports	109
4.2.2 Types of Expansion Cards	112
4.2.3 Memory Chips	114
SUMMARY	117
EXERCISE	120
UNIT 5 NETWORK COMMUNICATION AND PROTOCOLS	123
5.1 COMPUTER NETWORK	124
5.1.1 Basic Data Communication Components	124
5.1.2 Modes of Communication	126
5.1.3 Communication Media	130
5.1.4 Communication Devices	136
5.1.5 Network Architecture	138
5.1.6 Network Types	142
5.1.7 Network Topologies	146
5.2 DATA COMMUNICATION STANDARDS	152
5.2.1 Purpose of Communication Standards	152
5.2.2 Open System Interconnection (OSI) Model	152
5.2.3 Examples of Devices and Protocols on Layer of OSI Model	157
5.3 TCP/IP	158
5.3.1 TCP/IP Protocol Suite Architecture	159
5.3.2 Comparison of TCP/IP and OSI Models	163

5.3.3 Packet Switching and Circuit Switching 165
5.3.4 IP Addressing 166
SUMMARY 171
EXERCISE 175

UNIT 6 WIRELESS COMMUNICATIONS 178

6.1 INTRODUCTION 179
6.1.1 Wireless network 179
6.1.2 Advantages and disadvantages of Wireless Networks 181
6.1.3 Important Wireless Communication Terminologies 182
6.1.4 Short distance and Long distance wireless communication 185

6.2 SHORT DISTANCE WIRELESS COMMUNICATION TECHNOLOGIES 185
6.2.1 Wi-Fi 185
6.2.2 WiMAX 187
6.2.3 BLUETOOTH 188
6.2.4 INFRARED 188

6.3 LONG DISTANCE WIRELESS COMMUNICATION TECHNOLOGIES 188
6.3.1 Cellular Communication 189
6.3.2 Global Positioning System (GPS) 190
6.3.3 Classification of Satellite Systems 191

6.4 MOBILE DEVICE COMMUNICATION 193
6.4.1 Requirements of Mobile Communication System 194
6.4.2 Features and Limitations of Mobile Communication System 196
6.4.3 Architecture for Communication over Mobile Devices 199
SUMMARY 202
EXERCISE 204

Table of Contents

UNIT 7 DATABASE FUNDAMENTALS 207

7.1 INTRODUCTION 208
7.1.1 Data and Information 208
7.1.2 File Management System 209
7.1.3 Database 211
7.1.4 Database Management System (DBMS) 212
7.1.5 Advantages of DBMS over the File Management System 213
7.1.6 Role of the Database Administrator (DBA) 214
7.1.7 Database Models 215
7.1.8 Database Languages for Relational 218

7.2 BASIC DATABASE TERMINOLOGIES 219

7.3 PLANNING A DATABASE 221
7.3.1 Steps for Designing a Database 221

7.4 DATA MODELING AND ENTITY RELATIONSHIP DIAGRAM 223
7.4.1 Elements of Entity Relationship Diagram 224
7.4.2 Cardinality and Modality 231
7.4.3 Sample E-R Diagrams 232

7.5 RELATIONAL SCHEMA 237
7.5.1 Transformation of E-R Model into Relational Schema 237
7.5.2 Normalization 238

SUMMARY 243
EXERCISE 245

UNIT 8 DATABASE DEVELOPMENT 248

8.1 INTRODUCTION 249
8.1.1 Different Types of Database Management Systems 249

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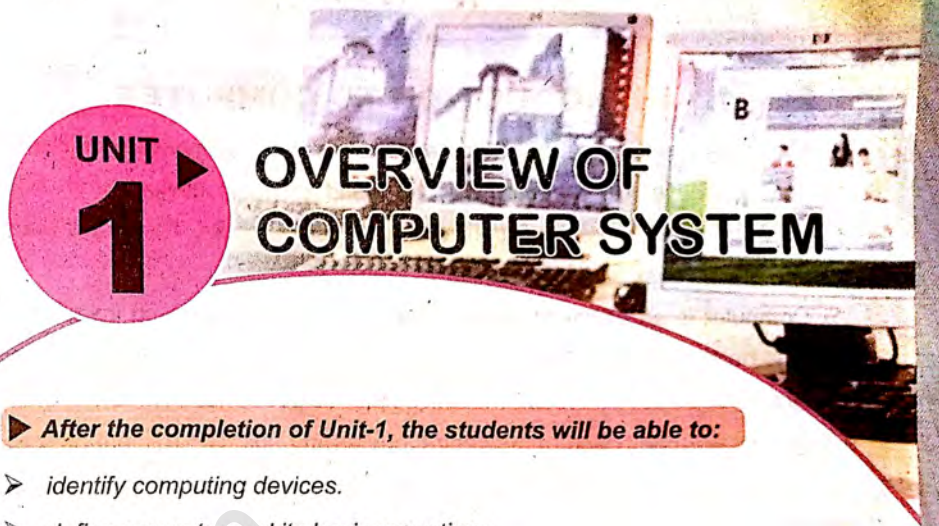
Table of Contents

8.1.2 MS Access 2007	250
8.1.3 Creating and Saving an Access Database	253
8.1.4 Database Objects	253
8.2 WORKING WITH TABLES	254
8.2.1 Creating a Table in Access	254
8.2.2 Data Types in Access	260
8.2.3 Creating Primary Key and Foreign Key	263
8.2.4 Creating and Editing Relationships between Tables	264
8.2.5 Using Navigation buttons to Navigate through Records in a Table	267
8.2.6 Adding, Modifying and Deleting Records	268
8.3 WORKING WITH FORMS	270
8.3.1 Creating Access Form	271
8.3.2 Using Form Controls	273
8.4 WORKING WITH QUERIES	280
8.4.1 Creating the Query	281
8.4.2 Types of Queries in Access	283
8.5 GENERATING REPORTS	288
8.5.1 Using the Report Wizard to generate a report	289
8.5.2 Saving and Printing a Report	293
SUMMARY	294
EXERCISE	296
ANSWERS TO MCQs	298
GLOSSARY	300
INDEX	316
ABOUT AUTHORS	320



UNIT 1

OVERVIEW OF COMPUTER SYSTEM

After the completion of Unit-1, the students will be able to:

- *identify computing devices.*
- *define computer and its basic operations.*
- *classify computers (micro, mini, mainframe, super and mobile computers).*
- *differentiate between hardware and software.*
- *describe system software and application software.*
- *describe the types of system software (operating system, device driver, utility software, language processor).*
- *describe types of application software (productivity, business, entertainment, education software).*
- *elaborate licensed software, open source software, shareware and freeware.*
- *define firmware.*
- *define computer hardware (input/output, memory, cpu).*
- *describe different types of input devices.*
- *describe different types of output devices.*
- *differentiate between softcopy and hardcopy.*

1.1 INTRODUCTION TO COMPUTER

In today's information age, computers are used in every walk of life for different purposes. The computers are found in many devices from MP3 players to fighter aircraft and from toys to industrial robots. They have made the life of ma easy and comfortable.

"A Computer is an electronic device that accepts input data and instructions with the help of input devices, stores them until needed, processes it and then produces the output as a result with the help of output devices".

Computers are composed of the central processing unit (CPU), input devices, output devices, primary storage, secondary storage, and communication devices. The CPU is the main component of a computer that interprets and executes instructions.

1.1.1 Computing Devices

The term "Computing Device" is used for all such machines that can perform calculations. These calculations could be very simple, like adding two numbers to very complex, like managing the stock control system for a big shopping mall. Computer is considered to be the fastest computing device ever. A computing device can perform or help to perform computations. The computing devices can be classified into early and modern computing devices.

a. Early Computing devices

The **abacus**, which emerged about 5,000 years ago in Asia and is still in use today, may be considered the first computer. This device allows users to make computations using a system of sliding beads arranged on a rack.

Figure 1.1 Abacus

In 1694, a German mathematician and philosopher, Gottfried Wilhem Von Leibniz created a **Computing machine** that could add, subtract and multiply. Leibniz's mechanical multiplier worked by a system of gears and dials. The real beginnings of computers was laid by an English Professor of Mathematics, Charles Babbage. In 1822 Babbage proposed a machine to perform differential equations, called a **Difference Engine**. After working on the Difference Engine for 10 years, Babbage was suddenly inspired to begin work on the first general-purpose computer, which he called the **Analytical Engine**.

Figure 1.2 Leibniz Calculator

Figure 1.3 Analytical Engine

In 1889, an American inventor, Herman Hollerith applied the Jacquard loom concept to computing and developed a **tabulating machine**. His first task was to find a faster way to compute the U.S. census.

Vannevar Bush developed a **Calculator** for solving differential equations in 1931. The machine could solve complex differentials.

In 1940, John V. Atanasoff , a professor at Lowa State College and his graduate student, Clifford Berry, envisioned an **All-electronic computer** that applied Boolean algebra to computer circuitry.

Figure 1.4 Tabulating Machine

By 1941 German engineer Konrad Zuse had developed a computer, the **Z3**, to design airplanes and missiles.

Figure 1.5 Z3 Computer

Howard H. Aiken, a Harvard engineer working with IBM, succeeded in producing an all-electronic calculator by 1944. The Harvard-IBM Automatic Sequence Controlled Calculator, or **Mark I** for short, was an electronic relay computer. It used electromagnetic signals to move mechanical parts perform basic arithmetic as well as more complex equations.

Figure 1.6 Mark 1 Computer

Another computer development was the Electronic Numerical Integrator and Computer (**ENIAC**). It was developed by John Presper Eckert and John W. Mauchly. ENIAC was a general-purpose computer that computed at speed 1,000 times faster than Mark I.

Von Neumann designed the Electronic Discrete Variable Automatic Computer (**EDVAC**) in 1945 with a memory to hold both a stored program as well as data.

Figure 1.7 UNIVAC-1 Computer

In 1951, the **UNIVAC-I** (Universal Automatic Computer), built by Remington Rand, became one of the first commercially available computer.

b. Modern Computing devices

By 1948, the invention of the **transistor** greatly changed the computer's development. The first large-scale machines to take advantage of this transistor technology were early supercomputers, Stretch by IBM and LARC by Sperry-Rand. These computers, both developed for atomic energy laboratories, could handle an enormous amount of data, a capability much in demand by atomic scientists.

Throughout the early 1960's, there were a number of commercially successful computing devices used in business, universities, and government. One important example was the **IBM 1401** computer, which was universally accepted throughout the industry.

Figure 1.8 IBM 1401 Computer

The development of Integrated Circuits (**ICs**) in 1958 by Jack Kilby had completely revolutionized the computing devices in terms of processing speed, memory and peripheral supporting capabilities.

The **Intel 4004** chip, developed in 1971, took the integrated circuit one step further by locating all the components of a computer (central processing unit, memory, input and output controls) on a single chip.

In 1981, IBM introduced its personal computer **(PC)** for use in the home, office and schools. Computing devices continued their trend toward a smaller size, working their way down from desktop to laptop computers to palmtop or tablet PCs which can fit inside a pocket. Figure 1.9 shows some modern computing devices.

Figure 1.9 Modern Computing devices

1.1.2 Computer and its Basic Operations

A computer is an electronic machine that accepts data, stores it, processes the data according to the instructions provided by the user, and finally returns the results to the user in the form of output. The computer can do all these operations with very high speed as compared to humans.

All computers perform four basic operations: input, processing, output, and storage to carry out any task. The four basic operations of computer are shown in Figure 1.10.

Input Operation: It is the process of capturing or accepting data or information, by using input devices. Input can take a variety of forms, from commands we enter by the keyboard to data from another computer or device.

Processing Operation: It is the transformation process to convert the input into output. The central processing unit (CPU) performs processing tasks under the direction of a program. To process the data, the CPU stores the program instructions and the data in the computer's memory, where it is directly accessible for processing.

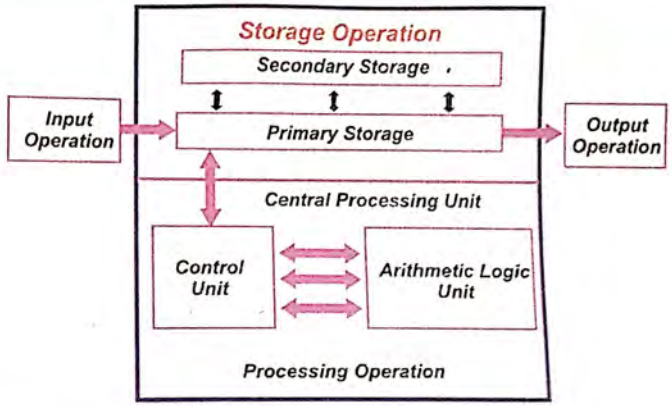


Figure1.10 Basic Operations of Computer

Output Operation: It is the result, which comes from the transformation process or it is the outcome of the processing. The monitor shows the results of processing operations on the screen. Speakers enable users to hear the results of sound processing. The printer generates output on paper.

Storage Operation: It is the process of storing the data or information or instructions, so that the user can retain and retrieve it whenever required. Computer data storage is referred to as storage or memory, which can save digital data. Examples are RAM, Hard Disks or removable memory sticks, etc.

1.1.3 Classification of Computers

Based on physical size, performance and application areas, the computers are generally classified into Microcomputers, Mainframe, Super and Mobile Computers.

a. Microcomputers

Microcomputers are more commonly known as personal computers (PCs). The microcomputer is generally the smallest and least expensive of the

computer family. Originally, these computers were designed only for individual users, but nowadays they have become powerful tools for many businesses that, when networked together, can serve more than one user.

Microcomputers include the following types:

- Desktop Computers
- Notebook Computers
- Laptop Computers
- Handheld Computers

i. Desktop Computers

A desktop computer is the most common type of micro computer. Many people use desktop computers at work, home, school, or the library. They can be small, medium, or large in style.

Figure1.11 Desktop Computer

ii. Notebook Computers

A notebook computer is designed to provide mobile computing that offer all the power that the mobile users require for work. This is easy to carry around and preferred by students and business people to meet their assignments and other necessary tasks.

Figure1.12 Notebook Computer

iii. Laptop Computers

A laptop is a portable computer that a user can carry around. The biggest advantage of laptops is that they are lightweight and can be used anywhere and at any time, especially while travelling. Moreover, they do not need any external power supply because a rechargeable battery is completely self-contained.

Figure1.13 Laptop Computer

iv. Handheld Computers

Figure1.14 Handheld Computer

Handheld computers are a unique type of portable computers that allow users to work "on the go." Since these computers can easily be placed on the top of the palm, they are also known as palmtop computers and are lightweight. The most popular types of handheld computers include personal digital assistants (PDAs) and smartphones, iPhones and Treos).

b. Mainframe Computers

Mainframe computers are the second powerful and expensive computers than supercomputers. Mainframes are used mainly by large organizations for critical applications, typically bulk data processing such as census, industry and consumer statistics, enterprise resource planning, and financial transaction processing. These computers have powerful processors and large memories to process large amounts of data at very high speed, such as billions of instructions per second (BIPS). These computers support many terminals at the same time.

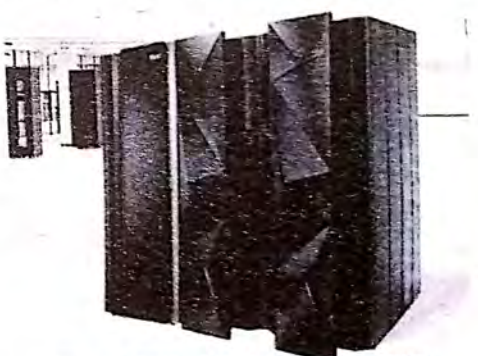


Fig 1.15 IBM's Z12 Mainframe Computer

These are widely used as super-servers for large client/server networks and for high volume websites. Mainly these are used by Airline companies, government departments, banks and insurance companies. Automated Teller Machine (ATM) is an example of a mainframe computer. Airline companies use mainframe systems for flight scheduling, reservations, ticketing, and meeting a range of customer service needs.

c. Super Computers

Supercomputers are the most powerful and the most expensive computers designed for scientific, engineering, and business applications. These computers can process billions to trillions of instructions per second. The usage includes world-wide weather forecasting, weapon research, stock analysis, automobile designing, special effects for movies and used for applications requiring complex mathematical calculations. Supercomputers possess extremely high computing speed, higher capacity for storage, faster primary memory and faster secondary storage as compared to other types of computers. IBM's supercomputer, **Sequoia**, can perform around 16 thousand trillion instructions per second.

These computers are used for research and exploration purposes, like **NASA** uses supercomputers for launching space shuttles, controlling them and for space exploration purpose.

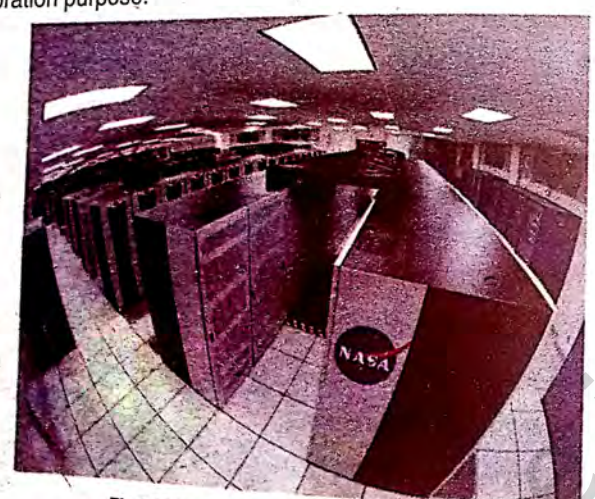


Fig 1.16 IBM's Supercomputer at NASA

d. Mobile Computers

Mobile Computing is a technology that allows processing and transmission of data, voice and video via a computer or any other wireless enabled device

without having to be connected to a fixed physical link. **Mobile Computers** are devices which are used for mobile.computing. These devices include portable Laptops, Smartphones, Tablet Pc's and Personal Digital Assistants.

Figure 1.17 Different types of Mobile computing devices

These devices will have receptor medium that are capable of sensing and receiving signals. These devices are configured to operate in full-duplex, whereby they are capable of sending and receiving signals at the same time. They do not have to wait until one device has finished communicating for the other device to initiate communications. In most cases, it would be a wireless network.

Mobile software is the actual program that run on the mobile hardware. It deals with the characteristics and requirements of mobile applications.

Since portability is the main factor, this type of computing ensures that users are not tied or pinned to a single physical location, but are able to operate from anywhere. It will incorporate all aspects of wireless communications.

1.1.4 Hardware and Software

Computer **hardware** refers to the physical parts or components of a computer such as monitor, keyboard, Computer data storage, hard disk, mouse, CPU, memory, motherboard and chips, all of which are physical objects that we can actually touch. Software refers to the set of programs or instructions that

enable the computer to do something and operate the hardware. A combination of hardware and software forms a usable computing system. Hardware and software work together in digital devices and computers to provide computerized functionality.

Difference between hardware and Software

	Hardware	Software
1	Hardware refers to the physical components of the computer required to store and execute the software.	Set of instructions that enable a user to interact with the computer.
2	It is physical in nature.	It is logical in nature.
3	Hardware understands only Binary Data or digits i.e. 0s and 1s in the form of voltage pulses	Software tells the Hardware everything in the form of Binary Data or digits i.e. 0s and 1s only.
4	Types: Input, storage, processing, output and communication devices.	Types: System software and Application software.
5	Hardware starts functioning once software is loaded.	Software includes the programs that run on the hardware, such as Microsoft XP is the software that makes the computer functional.
6	Hardware faults are physical.	Software faults are logical.
7	Examples: Monitor, printer, hard disk, video card, scanners, routers, and modems, etc.	Examples: Windows, Word, Excel, games, graphic programs and many more.

1-2 COMPUTER SOFTWARE

Computer software is set of instructions that direct the computer what to do and how to do. It turns the data into information that makes computer a useful machine. A computer needs instruction for doing a job because it is a machine and cannot do anything on its own. The instructions given to the computer are done with the help of a program which is written in a specific computer language and the set of such computer instructions (programs) are called software.

1.2.1 Types of Software

The computer software are broadly divided into two categories.

a. System Software
b. Application Software

a. System Software

System software are set of programs that operate and control the computer system. System software can do one or more of the following jobs:

- Supports the development of other application software.
- Supports the execution of other application software.
- Monitors the efficient use of various hardware resources.
- Communicate with and controls the operation of peripheral devices.

Operating system, device drivers and language processors are some examples of System software.

b. Application Software

Application software is a type of software that can be used for a variety of tasks. It is not limited to one particular function. It helps to solve problems in the real world. Examples include enterprise software, accounting software, office suites, graphics software, and media players.

1.2.2 Types of System Software

System software falls into following categories.

a. Operating System
b. Device Driver
c. Utility Software
d. Language Processor

a. Operating System

Operating system is a set of programs that manages and coordinates the hardware of a computer and provides services to application software, programmers and users of computer. Without operating system a computer cannot do anything useful.

Some common examples of operating systems include Windows, Macintosh Operating System, UNIX, Linux, OS/2, and DOS.

b. Device Driver

A device driver is a program that controls a particular type of device that is attached to the computer. Without driver, a hardware device would not be able to work with the computer. There are device drivers for printers, monitors, CD-ROM drives, diskette drives, etc. When we buy an operating system, many device drivers are built into the product. However, if we later buy a new type of device that the operating system did not anticipate, we will have to install the new device driver.

c. Utility Software

Utility software is a kind of system software designed to analyze, configure, optimize and maintain the computer. A single piece of utility software is usually called a utility or tool. Utility software usually focuses on how the computer infrastructure operates. Most of the operating systems come with several pre-installed utilities. Examples of utility software are Disk Defragmentation, Disk Cleaner, Backup, Antivirus etc.

d. Language Processor

Language processor or translator is a type of system software that translates a source program (other than machine language) into object program (Machine language).

There are three types of language processors.

i. Interpreter

A language processor that translates a high level language program line-by-line (statement-by-statement) and carries out the specified actions in sequence is called Interpreter. It translates and runs the program at the same time. It converts one program statement into machine language, executes it, and then proceeds to the next statement. Examples of languages that use interpreters include BASIC, LISP, Smalltalk, PHP and PERL.

ii. Compiler

Compiler is a program that translates source code (written by programmer in a high-level language e.g., C++) into a set of machine-language instructions that can be understood by a digital computer's CPU. Compilers are very large programs, with error-checking and other abilities. Examples of languages that use compilers include COBOL, FORTRAN, C/C++, JAVA, etc.

iii. Assembler

An assembler is a translator which is used to convert an assembly language program into a machine-language program for later execution. Assembly language is also called a Symbolic language.

1.2.3 Types of Application Software

Application software includes a variety of programs that can be subdivided into general-purpose and customized categories.

a. General Purpose Application Software

General-purpose applications software are programs that perform common information processing jobs for end users. These are called packages or

commercial software. A single software can be applied to a wide variety of tasks. By using such software a user can fulfill his or her general needs. These are divided into the following main categories.

i. Productivity Software
ii. Business Software
iii. Entertainment Software
iv. Education Software

b. Special Purpose or customized Application Software

The software that is designed to perform a specific task is known as special purpose application software. This is also called Custom software. The Software can perform only one task for which it has been designed. Custom software for the tasks of a large organization may be extremely complex and takes a lot of time to develop.

For example, Software to process inventory control, software to maintain Bank Accounts, etc.

Types of General Purpose Application Software

i. Productivity software

The productivity software is a type of Application software that is used to produce documents, presentations, databases, charts and graphs.

Some common types of productivity software are:

Database Software: This software allows creating a database and to retrieve, manipulate, and update the data that we store in the database. e.g. MySQL, Microsoft SQL Server and Oracle.

Multimedia Software: They allow the users to create and play audio and video media. They are capable of playing media files. Examples of this type of software include Real Player and Media Player.

Word processors: Word processing software is used to create, edit, and format text documents . The most popular examples of this type of software are MS-Word, WordPad and Notepad.

Spreadsheet Software: Spreadsheet software are used to work with numbers and formulae. User enters numbers in the grid of rows and columns on the worksheet and computer performs the calculations. MS Excel and Lotus 1-2-3 are examples of Spreadsheet software.

Presentation software: Presentation software is designed for creating on-screen presentations, reports, and slideshows. It allows to combine both text and graphics in a single document. Microsoft PowerPoint is the best example of presentation software.

ii. Business Software

Any software that helps business to increase or measure its productivity is called business software. The term covers a large variation of uses within the business environment, and can be categorized by using a small, medium and large matrix. Some common types of business software include, Marketing software, Payroll system, Inventory control system, Communication software and Accounting software, etc.

iii. Entertainment software

Entertainment software allows a computer system to be used as an entertainment tool. Some examples of entertainment software are Media Player, Video Game, etc.

iv. Educational software

Education software allows a computer system to be used as a teaching and learning tool. Some examples of education software are:

Computer Based Training (CBT): These Application software are used for the purpose of training.

Example: A training software for pilots how to fly an airplane and also for doctors to train them surgeries.

Encyclopedia: Encyclopedia software contains entries like dictionary and provides complete linguistic information about them. Encyclopedia articles focus on information or knowledge collected from the whole. The main aim of the encyclopedia software is to preserve the knowledge of present time to the

new generation for their use. Encarta and Britannica are popular encyclopedia software.

Computer Aided Learning (CAL): The term Computer Aided Learning (CAL) covers a range of computer-based packages, which aim to provide interactive instruction usually in a specific subject area. These can range from sophisticated and expensive commercial packages to applications developed by individuals.

Teachers can use audio video software aids through computer to prepare lesson plans. They can use Power Point to prepare electronic presentations about their lectures. These electronic presentations can be displayed on multimedia projectors in class rooms.

1.2.4 Software Terminologies

a. Licensed or Proprietary Software

A computer software that is licensed, giving the right to use the software under certain conditions, but restricted from other uses, such as modification, further distribution and re-building etc under exclusive legal right of the copyright holder. Examples of proprietary or licensed software include Microsoft Windows, Adobe Flash Player, Adobe Photoshop, Google Earth, Skype and WinZip etc.

b. Open Source Software

Computer software of which source code is also available to the user. Its license allows the user to study, change, improve and at a time also to distribute the software. Such software are often developed in a public, collaborative manner. Example Includes LINUX operating system.

c. Shareware

Shareware is also called trial-ware and refers to licensed software that is delivered to the user without payment for trial uses with limited functionality

and for a specific period after which it expires. Such software are developed for the purpose that the user becomes used to it and to knows that whether it meets his requirements or not. They are often downloadable from the Internet.

d. Freeware

The term freeware refers to the meaning "free software". It is a computer software available to the user with no cost or for an optional fee, but usually with one or more restrictions to the user like copy, distribute and make derivative works of the software.

1.2.5 Firmware

It is a term often used for the fixed, small programs embeded in hardware that control various electronic devices. These programs are written in machine languages and are permanently embedded in the hardware for which it is developed. Examples of devices containing firmware are ROM, Mobile phones, Digital cameras, Toys, etc. In all such devices firmware is used to enable the device's basic operation as well as implementing higher-level functions. Users can not change such software by their own.

1.3 COMPUTER HARDWARE

Hardware are the physical components that make up a computer system. They include all electrical and mechanical devices attached to the computer for the purpose of input, process, storage and output operations.

Generally all hardware components are classified as follows.

a. Input devices
b. Output devices
c. CPU
d. Memory

a. Input devices

Input devices are the external hardware components that are used to enter or accept data and instructions into computer memory for processing. Examples include: Keyboard, Mouse, Track ball, Joy stick, Touch Screen, Light pen, Scanner.

b. Output devices

Output devices are used to give results of processing to the user. Examples include: Monitors, Printers, Plotters, Speakers.

Some types of hardware can act as both, input and output. These devices are called **I/O devices**. One example is the Touch screen, a type of monitor. Users can also touch and give input to the computer using a touch screen.

c. CPU (Central Processing Unit)

It is the main hardware of every computer system. It consists of two parts i.e the Control unit (CU) and Arithmetic Logic Unit (ALU).The CU is responsible for controlling the overall activities of the computer system while the ALU performs two types of operations i.e. the Arithmetic operations such as addition, subtraction multiplication, division, etc. and Logical operations such as comparison like greater than, smaller than, equal to.

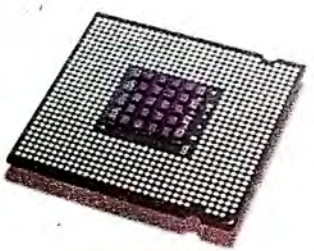


Figure 1.18 CPU

d. Memory

Computer memory is a semiconductor hardware device used to store data or programs for use in computers either on permanent or temporary basis. Data or program in computer is represented as binary code, written as a stream of 0s and 1s. Each binary digit (or "bit") has bi-stable capability to represent 0 for OFF and 1 for ON. RAM and ROM are common examples of computer memory.

1.3.1 INPUT DEVICES

The following are some important types of input devices.

a. Keyboard

Keyboard is the most commonly used input device to enter data and instructions into the computer directly. Keyboards are almost compulsory part of every computer system. Keyboard has a set of keys like a typewriter. A keyboard has over 100 keys on it. When we press a key a predefined value (code) in the form of electrical signal is sent to the computer to tell it which key is pressed. The keys are arranged in different groups.

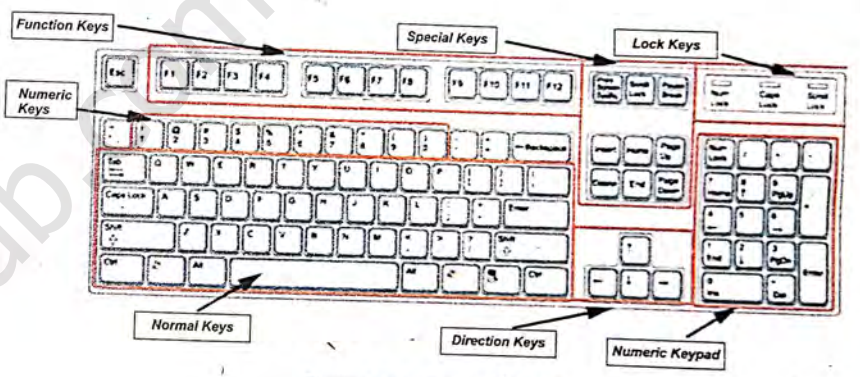


Figure 1.19 Standard Keyboard

b. Pointing Devices

Pointing devices are used to enter data into the computer by pointing the data or commands through Graphical User Interface (GUI). The pointing device movements are echoed on the screen by movements of the pointer. Examples of pointing devices include the mouse, trackball, light pen, joystick and touch screen.

i. Mouse

Figure 1.20 Mouse

Mouse is an input device with two or more buttons used to open and close files, navigate the screen or web sites. It is very user-friendly device. As we move the mouse, the mouse pointer (the little arrow on the screen) moves in the same direction. It controls the motion of pointer on screen. A mouse has two or three buttons called Left, Right and Middle button. Buttons are used to perform different functions. Old mouse has a rubber or metal ball inside its body. Mouse is rolled over a flat surface called mouse pad. The movement of ball is detected by internal circuits of mouse. These circuits convert this movement into digital signals, which are sent to computer. The optical mouse uses an LED to detect changes in movement by scanning a surface. A laser mouse is a type of mouse that uses a laser beam rather than a ball to track the movement of the user's hand. Mouse is used in many graphical applications.

ii. Trackball

Figure 1.21 Trackball

Track Ball is a pointing input device. This is like an upside-down mouse where the users roll the wheel in the direction they want the pointer to go. They are often used with video games and information kiosks. A tracker ball (or trackball) is an alternative to a mouse. It works in the same way as a mouse except that the ball is on top. This ball is moved by fingers or thumb and the pointer moves accordingly on screen. Tracker balls are used mainly when there is not enough space for a mouse as in portable computers or laptops.

iii. Joystick

Figure 1.22 Joystick

A joystick is an input device consisting of a stick situated on a base and reports its angle or direction to the device. It has one or more push-buttons whose state can also be read by the computer. Joysticks are often used to control video games.

iv. Touch Screen

Figure 1.23 Touch Screens

A Touch screen is an electronic visual display that can detect the presence and location of a touch within the display area with the help of pressure sensitive sensors. It can be touched with a finger or stylus (also called a pointing stick). It is used as mobile screens, in airports and large shopping malls to guide people.

v. Light Pen

Figure 1.24 Light Pen

A light pen is a pointing input device. It provides input in the form of a light-sensitive pen used in combination with a computer's monitor. It allows the user to point to display objects, or draw on the screen, in a similar way to a touch screen but with greater positional accuracy. A light pen can only work with any CRT-based display.

vi. Touchpad

Figure 1.25 Touchpad

It is also called track-pad. It is a pointing device consisting of specialized surface that can translate the motion and position of a

user's fingers to a relative position on screen. They are commonly used in laptop computers. They can also be found on PDAs.

Figure 1.26 Microphone

c. Microphone

A microphone, also called a mic, is a voice input device. It uses special sensor that converts sound into an electrical signal. Microphones are used in many applications such as telephones, tape recorders and hearing aids.

d. Digital Cameras

A digital camera is an input device that takes videos or still photographs, or both, digitally by recording images via an electronic image sensor. Digital cameras are incorporated into many devices ranging from PDAs and mobile phones to vehicles.

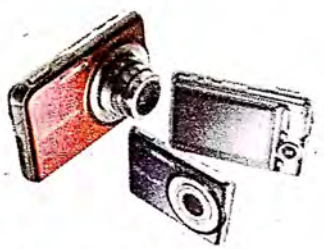


Figure 1.27 Digital Cameras

e. Scanner

Scanner is an input device. It is an electronic device that scans printed or handwritten text documents, images, or a particular object to convert them into a digital file format. The following are some common types of scanners.

i. Handheld Scanners

There are two forms of Handheld scanners; **Document Scanner** and **3D Scanner**. The document scanners are dragged across the surface of the image to be scanned and requires a steady hand.

The 3D scanners are used for producing three-dimensional models of objects and are expensive than document scanners. These scanners are used in industrial design, digital manufacturing and medical applications.

Figure 1.28 (a) Document Scanner

Figure 1.28 (b) 3D Scanner

ii. Flat-bed Scanner

A flatbed scanner has a glass pane, under which there is a bright light which illuminates the pane, and a moving optical array in CCD (Charged Couple Display) scanning. Images to be scanned are placed face down on the glass. The sensor array and light source move across the pane, reading the entire area. An image is therefore visible to the detector only because of the light it reflects.

Figure 1.29 Flatbed Scanner

iii. Optical Scanner

Optical Scanner uses optical light to read text or illustrations printed on paper and translate the information by digitizing an image, dividing it into a grid of boxes. The resulting matrix of bits, called a bit map, can then be stored in a file, displayed on a screen, and manipulated by programs.

Figure 1.30 Optical Scanner

f. Magnetic cards/devices based systems

Magnetic cards/devices based systems are widely used by many different organizations to provide both convenience and security. Hotels use them for room access, credit card companies use them for handling purchases, and

college campuses use magnetic cards for both building access and electronic payments. The following are some common types of magnetic cards.

i. Magnetic Ink Character Recognition (MICR)

MICR system reads characters printed in a special magnetic ink into the computer. The main users of MICR are banks. They use it to read information from cheques into their computers so that the cheques can be cashed. Figure 1.31 shows some information stored on a cheque using MICR.

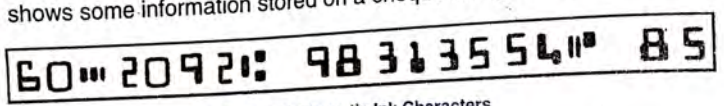


Figure 1.31 Magnetic Ink Characters

ii. Magnetic Stripe Card

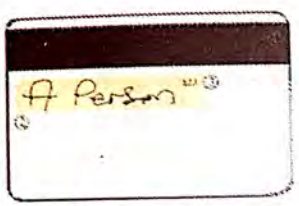


Figure 1.32 Magnetic Stripe Card

Magnetic stripes are built into many plastic cards such as credit cards. The strip can contain up to 60 characters (numbers or digits) of information which is stored magnetically. Usually the information is put onto the strip when the card is made and is never changed. To read the card it is swiped through a Magnetic stripe reader, which quickly and accurately reads the pattern of magnetism. The information stored on the card can be destroyed by exposure to magnetic fields, by scratching or by coming into contact with some liquids.

iii. Smart card

A smart card contains a small RAM chip. When the card is put into a Smart card reader data can be read from the card or written onto it. A smart card can store much more data than a magnetic stripe. It is more secure than Magnetic stripes though more expensive to produce.

Figure 1.33 Smart Card

A new generation of smart cards is now appearing which contain a small microprocessor as well as memory.

1.3.2 OUTPUT DEVICES

Output devices are computer hardware which are used to communicate the results of data processing carried out by the computer to the users. The following are different types of output devices.

a. MONITORS

A monitor or display, sometimes called a visual display unit, is an electronic output device for computers. It displays the results of the user activities. The output produced by monitors is called **softcopy** output. There are different types and sizes of monitors, each can be distinguished on the basis of the following features:

Size: The size of the monitor is measured diagonally. Standard size is 15 to 19 inches.

Color: The monitor can be either monochrom (one color) or color monitor.

Resolution: The number of pixels (or dots) per square inch is called resolution.

Refresh Rate: It is the speed with which the monitor redraws the screen in per unit time.

Dot Pitch: The distance between the pixels on the monitor is called dot pitch. The lesser dot pitch monitors have sharp images.

CRT (cathode ray tube) and LCD (Liquid Crystal Display) are the two common types of monitors.

i. Cathode Ray Tubes (CRT) Monitors

Figure 1.34 CRT Monitor

CRT monitors are similar to the standard television sets because they contain Cathode Ray Tube. The Cathode Ray Tube (CRT) is a vacuum tube containing an electron gun and a phosphors coated screen. The electron gun, fires a beam of electrons which falls repeatedly on the phosphors coated screen and it glows for a fraction of a second. In color CRT monitors there are three electron guns while the phosphors atoms are in three different colors i.e. Red, Green, Blue (RGB). Other colors are produced by the combinations of these three colors.

ii. Liquid crystal display (LCD) Monitors

Figure 1.35 CRT Monitor

Liquid Crystal Display (LCD) is a thin and light weight monitor. It contains a substance called liquid crystal between two sheets. The molecules of this substance are lined up in such a way that the light behined the screen is blocked or allowed to create an image on the screen. LCDs provide a sharper image than CRT monitors and emit less radiation. They are used in a wide range of applications, including computer monitors, televisions, and clocks. They are usually more compact, lightweight, portable, less expensive, more reliable, and easier on the eyes than CRT monitors.

b. PRINTERS

Printers are output devices which are used to produce output on physical media such as paper. The output produced by printers is called **hardcopy** output. Printers are divided into the following two categories.

i. Impact Printers
ii. Non-Impact Printers

i. Impact Printers

An Impact printer creates an image by pressing an inked ribbon against the paper, using pins or hammers to shape the image. It works like a typewriter, which uses small hammers to strike the ribbon. Each hammer is embossed with the shape of an alphanumeric character; that shape is transferred through the inked ribbon onto the paper, resulting in a printed character. Common types of impact printers are Dot Matrix printer, Drum printer and Chain printer.

Dot-Matrix Printer

Figure 1.36 Dot Matrix Printer

A type of impact printer that produces text and graphics by striking pins against an ink ribbon to print closely spaced dots in the appropriate shape. Different characters are printed by using different pin combinations. The printer receives the data from the computer and translates it to identify which character is to be printed and the printing head prints dots on the paper.

Dot-matrix printers vary in terms of speed and the number of pins they have. The number of pins, which can vary between 9 to 24, determines the quality of the print job. Dot matrix printers are commonly used for printing invoices, purchase orders, shipping forms and labels.

Figure 1.37 Drum Printer

Drum Printer

In these printers a fixed font character set is engraved onto a number of print wheels. The wheels, joined to form a large drum, spin at

high speed. As the desired character for each column passes the print position, a hammer strikes the paper from the rear, which presses the paper against the ribbon and the drum, causing the desired character to be printed on the continuous paper. A full set of hammers delivers (600 lines-per-minute of output) and a half set of hammers delivers (300 LPM).

Chain Printer

A chain printer uses a printing mechanism that uses character typefaces linked together in a chain. The chain spins horizontally around a set of hammers aligned with each position. When the required character is in front of the selected print position, hammer in that position hits the paper into the ribbon against the character in the chain.

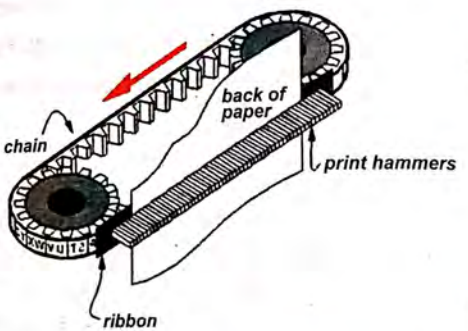


Figure 1.38 Chain Printer mechanism

This printer is not commonly found around microcomputers, because it is a very expensive, high-speed machine designed originally for mainframes and minicomputers.

ii. Non-impact printers

Non-impact printers print characters and graphics on the paper with Lase or with sprayed ink or with heat and pressure without striking the paper. These printers are faster, not noisy and have high quality of print but costly as compared to impact printers. Laser-jet or inkjet and Laser printers are common types of non-impact printers.

Inkjet or Laser jet Printer

Inkjet or Laser jet Printer is the most popular printer. It sprays tiny drops of ink onto a page to create an image. This is achieved by using magnetized plates

which direct the ink's path onto the paper in the desired pattern. Ink-jet printers are capable of producing high quality print which almost matches the quality of a laser printer. A typical ink-jet printer has a resolution of 300 to 600 dots per inch (dpi).

Figure 1.39 Inkjet Printer

Laser Printer

Laser printer utilizes a laser beam to produce an image on a drum. The drum is then rolled through a toner (containing dry ink), and the electrically charged portions of the drum pick up ink. Finally, using a combination of heat and pressure, the ink on the drum is transferred onto the page. Laser printers print very fast and produce very high-quality print. Laser printers are sometimes called page printers.

Figure 1.40 Laser Printer

One of the important characteristics of laser printers is their resolution. The available resolutions range from 300 dpi to 1200 dpi.

c. PLOTTERS

Plotters are hardcopy output devices. They are mainly used by architects, engineers, and others who need to generate high-precision graphical output of large sizes on papers. Plotters are more expensive than printers.

Figure 1.41 Drum Plotter

i. Drum Plotter

In the drum plotter the paper, on which the design has to be made is placed over the

drum, which can rotate in both clockwise and anti-clockwise direction. The drawing pens are mounted on the drum. During rotation of the drum the pens move left and right and create the desired image on the paper. The advantage of drum plotter is that the length of the plot is almost unlimited and the width of the image depends on the width of the drum.

ii. Flatbed Plotter

A flatbed plotter plots a design on a sheet in such a way that the sheet is spread and fixed over a rectangular flatbed table. In such plotters the pen holding mechanism is designed to provide all types of motions under the computer control, necessary to draw a design or graph. Most flatbed plotters have one or more pens of different colors and width.

Figure 1.42 Flatbed Plotter

d. Speakers

Speakers and headphones are the audio output devices. These devices have an internal amplifier and are connected to a sound card in the system unit. The sound card is used to capture as well as playback recorded sound. Laptops come with integrated speakers.

Figure 1.43 Speakers

1.3.3 Difference between Soft Copy and Hard Copy

	Soft Copy	Hard Copy
1	The output which is stored in a memory and displayed on the screen is called Soft Copy	The output which is printed on a paper is called Hard Copy.
2	It is easy to modify and correct.	It is hard to modify and correct.
3	An electronics medium is required to read out softcopy output.	No electronics medium is required to read out hard copy output.
4	Soft copy is intangible	Hard copy is tangible.
5	Soft Copy is electronic/digital version of a document.	Hard copy is a physical version of a document printed on paper.
6	Soft copy can be transmitted electrically to any place.	Hard copy can only be transmitted physically from one place to the other.

SUMMARY

- A Computer is an electronic device that accepts input data with the help of input devices, stores it until needed, processes it and then displays the output as a result with the help of output devices.
- The term "Computing Device" is used for all such machines that can perform calculations.
- The abacus, which emerged about 5,000 years ago in Asia and is still in use today, may be considered the first computer.
- By 1948, the invention of the transistor greatly changed the computer's development.
- Processing operation is the transformation process to convert the input into output.
- Storage operation is the process of storing the data or information or instructions, so that the user can retain and retrieve it whenever required.
- Microcomputers are more commonly known as personal computers (PCs). The microcomputer is generally the smallest and least expensive of the computer family.
- Mainframe computers are the second powerful and expensive computers than supercomputers. Mainframes are used mainly by large organizations for critical applications, typically bulk data processing such as census, industry and consumer statistics, enterprise resource planning, and financial transaction processing.
- Supercomputers are the most powerful and the most expensive computers designed for scientific, engineering, and business applications. These computers can process billions to trillions of instructions per second.
- Mobile Computing is a technology that allows transmission of data, voice and video via a computer or any other wireless enabled device without having to be connected to a fixed physical link.
- Computer hardware refers to the physical parts or components of a computer such as monitor, keyboard, Computer data storage, hard disk, mouse, CPU, memory, motherboard and chips.

- Computer software is a step by step set of instructions that directs the computer what to do and how to do. It turns the data into information - that makes a computer useful.
- System software are set of programs that operate and control the computer system.
- Application software is a type of software that can be used for a variety of tasks according to the user requirements.
- Operating system is a set of programs that manages and coordinates the hardware of a computer and provides services to application software, programmers and users of computer.
- A device driver is a program that controls a particular type of device that is attached to the computer.
- Utility software is a kind of system software designed to analyze, configure, optimize and maintain the computer.
- Language processor or translator is a type of system software that translates a source program (other than machine language) into object program (Machine language).
- General-purpose applications software are programs that perform common information processing jobs for end users.
- The software that is designed to perform a specific task is known as special purpose application software.
- The productivity software is a type of application software that are used to produce documents, presentations, databases, charts and graphs.
- Licensed or Proprietary Software is a computer software that is licensed, giving the right to use the software under certain conditions, but restricted from other uses, such as modification, further distribution and re-building under exclusive legal right of the copyright holder.
- Open Source Software is computer software of which source code is also available to the user.
- Shareware is also called trial-ware and refers to licensed software that is delivered to the user without payment for trial uses with limited functionality and for a specific period after which it expires.

- Firmware is a term often used for the fixed, small programs embedded in hardware that control various electronic devices.
- Input devices are the external hardware components that are used to enter or accept data and instructions into computer memory for processing.
- Output devices are used to display results of processing to the user.
- CPU (Central Processing Unit) is the main hardware of every computer system. It consists of two parts i.e. the Control unit (CU) and Arithmetic Logic Unit (ALU).
- Computer memory is a hardware device used to store data or programs for use in computers either on permanent or temporary basis.
- Scanner is an input device. It is an electronic device that scans printed or handwritten text documents, images, or a particular object to convert them into a digital file format.
- Printers are output devices which are used to produce output on physical media such as paper.
- Plotters are hardcopy output devices. They are mainly used by architects, engineers, and others who need to generate high-precision graphical output of large sizes on papers.

EXERCISE

Q1. Select the best choice for the following MCQs.

i. Which of the following device is considered to be the first computer?
A. Difference Engine B. ABACUS
C. Tabulating Machine C. Mark 1

ii. Which of the following is the process of storing the data, information and instructions?
A. Input operation B. Processing operation
C. Output operation C. Storage operation

iii. _____ computers are the second powerful and expensive computers than supercomputers.
A. Microcomputers B. Mini computers
C. Mainframe computers C. Laptops

iv. Which of the following software are set of programs that operate and control the computer system?
A. Freeware B. Shareware
C. System Software D. Application Software

v. _____ is not a portable computer.
A. Laptop B. PDA
C. Notebook D. Mainframe

vi. _____ is a program that controls a particular type of device that is attached to the computer.
A. Operating System B. Device Driver
C. Utility Software D. Language Processor

vii. Which software is used to analyze, configure, optimize and maintain the computer?

A. Operating System B. Device Driver
C. Utility Software D. Language Processor

viii. _____ translates a high level language program line-by-line.

A. Interpreter B. Compiler
C. Assembler D. Processor

ix. Which of the following is not an input device?

A. Mouse B. Scanner
C. Digital Camera D. Speaker

x. Which software is delivered to the user without payment for trial uses with limited functionality and for a specific period of time?

A. Open source B. Firmware
C. Shareware D. Freeware

xi. _____ is a term often used for the fixed, small programs that control various electronic devices.

A. Open source B. Firmware
C. Shareware D. Freeware

xii. The number of pixels (or dots) per square inch area of a monitor is called _____.

A. Size B. Resolution
C. Dot Pitch D. Refresh Rate

xiii. The distance between the pixels on the monitor is called _____.

A. Size B. Resolution
C. Dot Pitch D. Refresh Rate

xiv. The output produced by printers is called _____.

A. Hardcopy output B. Softcopy output
C. Plain output D. Rough output

xv. _____ Printer creates an image by pressing an inked ribbon against the paper.

A. Laser jet Printer B. Plotter
C. Laser Printer D. Dot-Matrix Printer

Q2. Give short answers to the following questions.

i. What is a Computer?
ii. What is processing operation?
iii. Show basic operations of a computer with the help of a block diagram.
iv. What is a notebook computer?
v. State five differences between hardware and software.
vi. Differentiate between an Interpreter and a compiler.
vii. How Application software help Users?
viii. Differentiate between shareware and freeware.
ix. What is Licensed Software?
x. What is firmware?

Q3. Give detailed answers to the following questions.

i. What are computing devices? Explain early and modern computing devices.

ii. Explain different classifications of computers.

iii. What is software? Explain its two main types with examples.

iv. Explain different types of General Purpose Application Software.

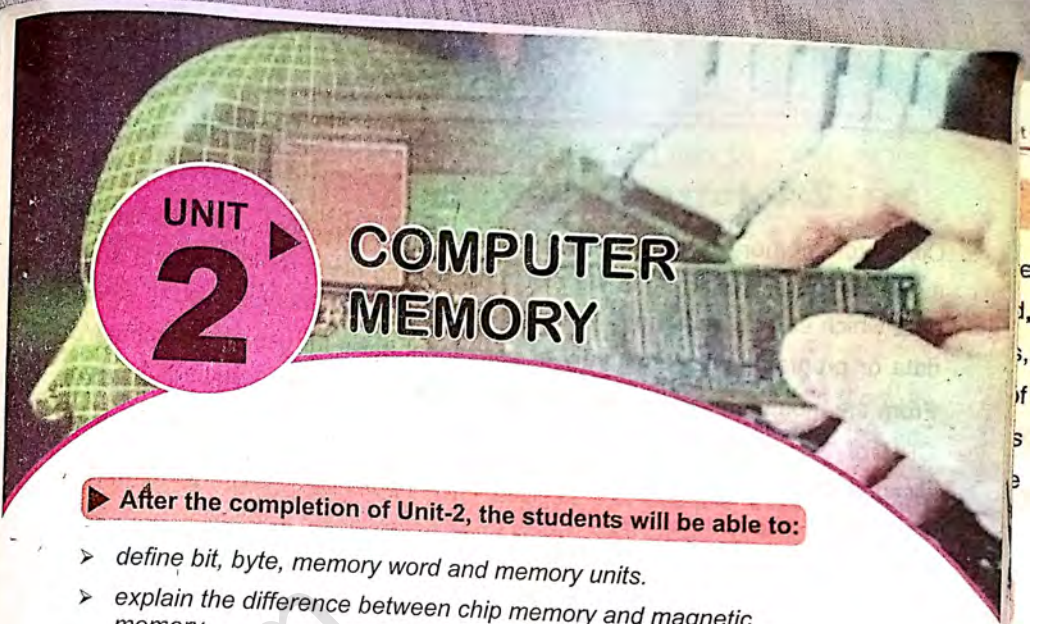
v. Write short note on any five input devices.

vi. What is output? Briefly explain softcopy output devices.

vii. What is the importance of magnetic cards/devices based systems? Explain different types of magnetic cards.

viii. What are impact and non-impact printers? Explain any two types of printers in each category.

ix. How a plotter is different from a printer? Explain different types of plotters.



UNIT 2 COMPUTER MEMORY

After the completion of Unit-2, the students will be able to:

- *define bit, byte, memory word and memory units.*
- *explain the difference between chip memory and magnetic memory.*
- *differentiate between volatile and non-volatile memory.*
- *explain internal processor memory, ram and rom, and their types.*
- *explain secondary storage devices.*
- *explain the difference between sequential access and direct access.*
- *describe magnetic tapes, magnetic disks and optical disks (CD, DVD, Blue Ray).*
- *describe flash memory and memory cards with advantages and disadvantages.*

2.1 Introduction

Computer memory is one of the important and compulsory components of every computer system. It is the electronic holding place for instructions and data which can be accessed by computer. Computer memory is used to store data or programs on a temporary or permanent basis for use in a computer. From the moment user turn the computer on until the time it is shut down, the CPU of the computer is constantly using memory. Memory is sometimes distinguished from storage, or the physical medium that holds the much larger amounts of data for later use.

Computer memory is divided into two main types.

- Primary or Main or Internal Memory
- Secondary or Auxiliary or Backing Storage Memory.

Primary or Main memory holds instructions and data when a program is executed, while secondary memory (also called auxiliary memory) holds data and programs not currently in use and provides long-term storage.

2.1.1 Units of Memory

The following are basic memory measurement units.

a. Bit
b. Byte
c. Memory Word

a. Bit

A **bit** or **binary digit** is the basic unit of information in computing. A **bit** is the smallest amount of memory a computer can recognize. A bit can hold only one of two values, either '0' or '1'. It is also applied to a unit of computer memory corresponding to the ability to store the result of a choice between two alternatives. Computers represent information in binary code, written as

sequences of 0s and 1s. Each binary digit (or "bit") may be stored by any physical system that can be in either of two stable states, to represent 0 and 1. Such a system is called bi-stable. In computers many bits are combined together to hold more information. For example, eight bits make up a byte, which can hold up to 256 characters.

b. Byte

In most computer systems, a **byte** is a unit of data that is eight bits long. A byte is the unit most computers use to represent a character such as an alphabet, a number, or a special symbol. For example A, h, 6, 4, #, @, *, etc. Computer storage is measured in byte multiples. For example, a 500 Gigabyte (GB) hard drive holds 500 billion bytes of data.

Higher units of memory

The following are higher units of memory. These are the multiple of the unit byte for digital information storage.

Kilobyte: Kilo means one thousand (1000) but in digital computer as information is stored in binary digits (0, 1) and its units are power of 2 and the most nearest number near thousand is $2^{10} = 1024$. It is commonly abbreviated as KB (for Kilo Bytes).

Megabyte: Mega means one Million ($2^{20} = 1048576$). It is commonly abbreviated as MB. 1MB = 1024 KB

Gigabyte: The prefix Giga means 2^{30}. The unit symbol for the Gigabyte is GB. 1GB = 1024 MB

Terabyte: The prefix Tera means 2^{40}. The unit symbol for the Terabyte is TB. 1TB = 1024 GB

c. Memory Word

A **word** is a term for the natural unit of data used by a particular computer design. A word is simply a fixed sized group of bits that are handled together by the system. The number of bits in a word (the word size or word length) is

an important characteristic of computer architecture. Modern computers usually have a word size of 16, 32 or 64 bits. A computer that has a bigger word size can transfer more bits into the microprocessor at a time for processing and this improves the processing speed of the computer.

2.2 PRIMARY MEMORY

Main memory or Primary memory is the part of the computer that holds data and instructions for processing. Computer internal memory is used to store data that is used by the system at startup and to run various types of programs such as the operating system. Typically, internal memory is contained on small microchips that are either attached or connected to the computer's motherboard. Computer memory can range from a couple of megabytes to several gigabytes. Although it is closely associated with the CPU, in fact it is separate from it. When users load software from a storage medium, it is stored in the main memory first and then it is executed. CPU gets programs from the main memory for processing.

2.2.1 Chip memory and Magnetic memory

Computer memory, as for as its manufacturing is concerned, is divided into two types, i.e. Chip memory and Magnetic memory.

a. Chip memory

Chip or **microchip** is a small piece of semi-conducting material (usually silicon). A small circuit called IC (Integrated Circuit) is embedded in it. A typical chip contains millions of electronic components (transistors). It is extremely complex and small module used as computer memory or provides logic circuitry for microprocessors.

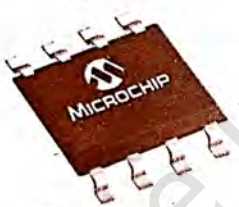


Figure 2.1 A Chip

A chip is manufactured from a silicon (or, in some special cases, a sapphire) wafer, which is first cut to size and then etched with circuits and electronic devices. It uses metal-oxide semiconductor technology. The current stage of microchip is known as Very Large-Scale Integration (VLSI).

Chip memories are very fast as compared to other memories as there are no mechanical moving parts in them but on the other hand chips rely on electric currents.

Examples of chip memory are main memory (RAM, ROM and Cache), Flash memory drives, memory cards and registers. Many special-purpose chips, known as application-specific integrated circuits, are also being made today for automobiles, home appliances, telephones, and other devices. Figure 2.1 shows a chip memory.

b. Magnetic memory

Magnetic core memory was the most widely used form of digital computer memory from its birth in the early 1950s until the era of Chip memory began in the early 1970s. Aside from being extremely reliable, magnetic core memory is an appealing technology because it is based on a very simple idea. A core is a ring of magnetic material, stores one bit by the direction of its magnetization. A magnetic core is a ring of ferrite material. It can be permanently magnetized either clockwise or anti-clockwise about its axis just as a vertical bar magnet can be magnetized. We can then turn a magnetic core into a bit of digital memory by letting these two magnetization states correspond to 0 and 1. It provides non-volatile storage. The core needs no continuous power to retain its data.

It is a system of storing information through the alignment of small grains in a magnetic material. Once the grains have been aligned by an external magnetic field, the information remains stored for long periods of time. This type of memory is used in the hard drives of computers as well as in magnetic tape.

Figure 2.2 shows how data is stored on the surface of magnetic storage medium.

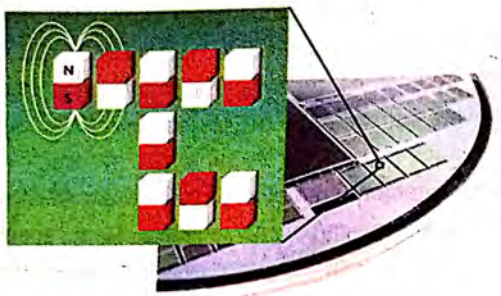


Figure 2.2 Magnetic memory storage mechanism

2.2.2 Volatile and Non-Volatile memory

Memory, on the basis of retention of data, can be divided into two types i.e. volatile and non-volatile memory.

a. Volatile memory

Volatile memory is computer memory that requires power (electricity) to maintain the stored information. Volatile memory retains the information as long as power supply remains on, but when power supply goes off or interrupted, the stored data is lost. It is also known as temporary memory. Examples of such memory are RAM (Random access memory) and Registers.

b. Non-Volatile memory

Non-volatile memory is a permanent memory that can retain the stored information even if power supply is off. Examples of non-volatile memory include ROM (Read-only memory), flash memory, magnetic storage devices (e.g. hard disks and magnetic tape), optical disks, and blue-ray disk. Non-volatile memory is typically used for secondary storage, or long-term storage for future use.

2.2.3 Fundamental types of Main Memory

Fundamentally Main or Primary memory is classified into three types.

a. Internal processor memory
b. RAM
c. ROM

a. Internal processor memory

These are directly accessible to the CPU and are extremely fast. The following are the two main types of Internal processor memories.

i. Cache memory
ii. Registers

Cache lies in between the CPU and main memory while registers are associated with the arithmetic logic units.

i. Cache Memory

Cache (pronounced as cash) memory is extremely fast Static RAM (SRAM) that is built into a computer's central processing unit (CPU), or located next to it on a separate chip. The CPU uses cache memory to store instructions that are repeatedly required to run programs, improving overall system speed. This memory is mainly used to store some active portion of main memory (RAM). When any information is required by the processor, first it will look up in the cache memory, and if it is not available in the cache then it will fetch it from the RAM. Figure 2.3 shows cache memory interface in the computer. There are three levels of cache memory.

- L1 (Level 1) Cache
- L2 (Level 2) Cache
- L3 (Level 3) Cache

cache

evel 1 cache is built into the actual processor core. It is a piece of high speed emory, which operates at the same speed as the CPU. It is directly accessed y the computer's processor and holds data that the processor needs to execute instructions. It is the fastest memory and closest to the CPU but very expensive and small in size (typically 8, 16, 20, 32, 64 or 128 Kbytes).

L2 cache

Level 2 cache pulls information from the system's main memory (RAM), which is then accessed by the L1 cache. It is reasonably fast memory, bigger in size and less expensive than L1 cache. It is normally 64 KB to 16 MB. The purpose of the L2 cache is to constantly read in slightly larger quantities of data from RAM, so that these are available to the L1 cache.

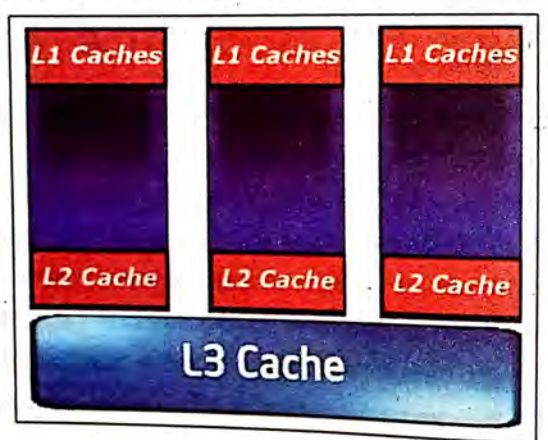


Figure 2.3 Cache memory interface

L3 cache

Level 3 cache is specialized memory that works hand-in-hand with L1 and L2 cache to improve computer performance. L3 cache is the biggest cache

memory that caters to the needs of the microprocessor by anticipating data requests so that processing instructions are provided without delay. L3 cache is faster than random access memory (RAM), and is designed to prevent bottlenecks in performance.

CPU first looks for the instructions in L1 cache, then it checks L2 and L3 cache respectively. L3 cache can be far larger than L1 and L2, and even though it is slower, it is still faster than RAM.

The architecture for multi-level cache continues to evolve. L1 and L2 caches are commonly incorporated into the CPU while L3 cache has typically been built into the motherboard.

Fetching instructions from cache is faster than calling upon system RAM and a good cache design greatly improves system performance.

ii. Registers

Registers are small memory units. There are a large number of registers inside the processor. There function is to temporarily store binary information and pass it to the other parts of the processor or main memory during the execution of program instructions. Some commonly used registers inside the microprocessors are accumulator, instruction register, program counter and memory address registers. They store the operands and the result of an operation. The number of registers varies from processor to processor. The more is the number the faster is the instruction execution.

The main registers are:

- **Accumulator register (AC)**, stores the results of arithmetic and logical operations.
- **Status register (also called PSW, Processor Status Word)**, holds system status indicators (carry digits, overflow).
- **Instruction register (IR)**, contains the current instruction being processed.

- **Program counter (PC)**, contains the address of the next instruction to process.
- **Buffer register**, temporarily stores data from the memory.

b. RAM (Random Access Memory)

Random Access Memory (RAM) is the common type of computer memory. It is the Read and Write (R/W) memory of a computer. The User can write information to it and read information from it. RAM is a volatile memory; it means information written to it can be accessed as long as power is on and when the power is off, it cannot be accessed. RAM holds data and processing instructions temporarily until the CPU needs them.

In RAM, transistors make up the individual storage cells which can each "remember" an amount of data. Physically, RAM consists of small electronic chips which are mounted in modules (small printed circuit boards). These modules are installed in the Computer's motherboard using sockets. Different types of RAM modules are shown in Figure 2.4.

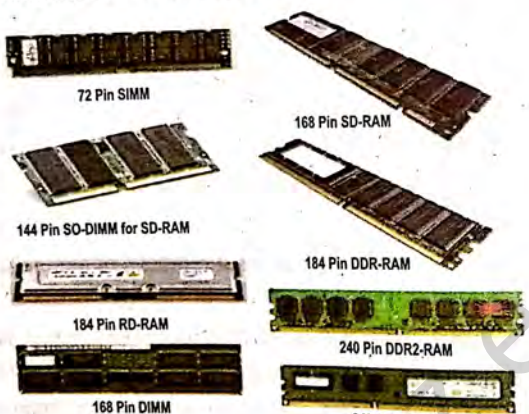


Figure 2.4 Different types of RAM Modules

Types of RAM

There are two basic types of RAM.

i. Static RAM (SRAM)
ii. Dynamic RAM (DRAM)

i. Static RAM (SRAM)

(SRAM) is a type of semiconductor memory where the word "Static" indicates that it does not need to be periodically refreshed to retain its data. SRAM is more expensive, but faster and significantly less power hungry than DRAM. Due to a more complex internal structure, SRAM is less dense than DRAM and is therefore not used for high-capacity, low-cost applications such as the main memory in personal computers. Static RAM is mainly used to make the CPU's cache.

ii. Dynamic RAM

DRAM is a type of semiconductor memory where the word "Dynamic" indicates that it needs to be periodically refreshed to retain its data. It stores each bit of data in a separate capacitor within an integrated circuit. The capacitor can be either charged or discharged; these two states are taken to represent the two values of a bit, conventionally called 0 and 1. In personal computers DRAMs are used as internal memory because of their simple structure that allows high storage and low cost as compared to SRAM. There are two main types of DRAM.

- SDRAM
- DDR SDRAM

Figure 2.5 SDRAM

SDRAM stands for Synchronous Dynamic Random Access Memory. SDRAM is a high speed semiconductor memory. It is an improved form of the older DRAM (Dynamic Random Access Memory). SDRAM operates synchronously, which means that it operates in sync with the

ystem data bus. Therefore, it can operate at much greater speeds than non-synchronous RAM.

Figure 2.6 DDR3 SDRAM

DDR SDRAM (Double Data Rate SDRAM) is an improved SDRAM which allows a computer to transfer data at twice the speed. It has improved memory clock speed as compared to simple SDRAM. It reads or writes two consecutive words per clock cycle.

There are many types of DDR SDRAMs used for computers today, including **DDR1** RAM (Double Data Rate), **DDR2** RAM and **DDR3** RAM ranging in speed from 100 MHz to 2000 MHz. SDRAM comes in sizes of 512 MB to 4GB for use in today's computers. Figure 2.5 shows SDRAM.

DDR2 and DDR3 RAMs are used in today's computers. DDR2 reads or writes 4 words of data per clock cycle whereas DDR3 reads or writes 8 data words per clock cycle. Figure 2.6 shows DDR3 SDRAM.

c. ROM (Read Only Memory)

ROM (Read only memory) is non volatile memory, i.e., the information stored in it, is not lost even if the power supply goes off. It is used for the permanent storage of information. It also possesses random access property. Information cannot be written into a ROM by the users/programmers. In other words the contents of ROMs are decided by the manufactures. Figure 2.7 shows different types of ROM chips.

Figure 2.7 Different types of ROM Chips

Types of ROM

The ROM is classified into the following types.

i. Programmable Read Only Memory (PROM)
ii. Erasable Programmable Read Only Memory (EPROM)
iii. Electrically Erasable Programmable Read Only Memory EEPROM

i. PROM

It is a type of ROM which can be programmed once and then can never be changed. PROM is manufactured blank and then it is programmed just once by "blowing" its fuses. This process is irreversible. Once a bit position is blown, it can never be un-blown. The data is fed into it using a PROM programs.

ii. EPROM

EPROM is an erasable PROM. The stored data in EPROM can be erased by exposing it to Ultra Violet (UV) light for about 20 minutes. When it is exposed to UV light, the entire data is erased.

iii. EEPROM

EEPROM (Electrically Erasable PROM) is a chip that can be erased and reprogrammed on the board. It can be erased within a few milliseconds. There is a limit on the number of times the EEPROM can be reprogrammed, i.e.; usually around 10,000 times. Flash drive is a special type of EEPROM.

2.3 SECONDARY STORAGE

Secondary storage is used to hold data or information permanently. It is also called auxiliary storage, external storage or backing storage. It lies outside the CPU. The computer usually uses its input/output channels to access secondary storage and transfers the desired data using intermediate area in primary storage. Secondary storage does not lose the data when the device is powered off and it is non-volatile. Some examples of secondary storage

devices are Hard Disk drive, CD, DVD, Blue Ray Disk, Flash memory and Memory cards.

2.3.1 Secondary Storage Devices

Secondary storage devices are used for storing the data permanently. These devices have the following characteristics.

- They are non-volatile as the data is not lost when power goes off.
- The capacity of these devices is very high. It goes to terabytes.
- They are cost effective as compared to the main memory.
- They are reusable as data can be erased and stored any time the user requires.
- Depending on their characteristics, these are sequential and random or direct access.

Various types of Secondary Storage Devices are Magnetic tapes, Magnetic disks, Optical disks, Flash memory and Memory cards.

2.3.2 Sequential Access and Direct Access Storage

Secondary storage can be divided into two main categories as for as its storing or accessing the data mechanism is concerned. These are Sequential Access and Direct or Random Access.

a. Sequential Access Storage

Sequential access is a storage system where the data is stored and read in a fixed or linear order. This order is pre-determined and follows a logical progression. Some types of sequential access are unavoidable, such as when playing back a cassette. Common example of this type of device is an audio or video cassette.

The main advantage of sequential, as compared to random access memory, is that it is usually much cheaper to produce.

The main drawback of this type of memory is that it usually takes longer to physically access particular piece of data. This is because the computer either has to run through all the data in sequential order until it find the correct piece, like looking for information in a book with no index. Magnetic Tape is an example of sequential memory device.

b. Direct Access Storage

Direct access, also called Random access is a storage system where the data is stored and read directly from storage devices. In this system all data items are addressed independently. In direct access storage devices, such as a magnetic disk, bits of data are stored at precise locations, enabling the computer to retrieve information directly without having to scan a series of records. Magnetic disks, Compact disks and all latest memory devices have direct storage access mechanism. Direct access is efficient as compared to sequential access. The only drawback is that these devices are costly as compared to sequential access devices.

2.3.3 Types of Secondary Storage Devices

Secondary storage devices are classified into the following types.

a. Magnetic Tapes
b. Magnetic Disks
c. Optical Disks
d. Chip Memory

a. Magnetic Tapes

Magnetic tape has been used for **data storage** for over 50 years. Magnetic Tape is a sequential access storage device used for data collection, backup and archiving. It consists of a thin tape with a coating of a fine magnetic material, used for recording analog or digital data. A device that stores computer data on magnetic tape is a tape drive. Magnetic Tapes generally

transfer data a bit slower than hard drives; however magnetic tapes are cheaper and are more durable. These devices are usually used for taking backup of data. The major drawback of tape is its sequential format. Locating a specific record requires reading every record before it or searching for markers that identify predefined partitions. Also updating requires copying files from the original tape to a blank tape and adding the new data in between while copying. Tapes are used for storing large amount of data. Modern tapes can store data up to 5 Terabytes. It is used with minicomputers and mainframes for backups and archives.

Figure 2.8 Magnetic Tape with cartridge

b. Magnetic Disks

The most common type of secondary storage devices are **magnetic disks**. These are made of either flexible plastic material (Old Floppy disks) or rigid metal (Hard Disks). Magnetic disks are coated with a magnetic substance. Each surface of the disk is subdivided into concentric rings called **tracks**. Disks with bigger capacity have more tracks. In larger computers, one stores the same amount of data in each track and keeps several disks mounted on a shaft on top of each other as a **disk pack**. At least one read-write head is assigned for each surface. The read-write heads are mounted on a device

called the **access mechanism**, which positions them on the cylinder in which the appropriate data item is to be located. Some common types of magnetic disks are Floppy disks, Zip disks and Hard disks.

i. Floppy disks and Zip disks

Floppy disks are old type of magnetic storages. These disks were very popular during the 1980 and early 1990s as portable storage device. Floppy disks are flexible plastic disks coated with magnetic material on both sides. They are packed inside a plastic jacket for protection. Digital information is stored in floppy disks in the form of small magnetized spots. Floppy disks are inserted in floppy disk drive for reading and writing information. Due to their limited storage size these have been obsolete now days. Maximum storage capacity of a floppy disk was 1.44 MB. Floppy disks in different sizes are shown in Figure 2.9.

Figure 2.9 (a) Floppy Disks

Figure 2.9 (b) Zip disk

Zip disks are also old type of removable storage devices. A zip disk is somewhat like floppy disk, only the size and capacity of disks are different. A zip disk can hold around 100 MB to 250 MB of data. Zip and Floppy disks are almost obsolete now a days because other storage media like Flash memory and CDs are becoming more popular due to their large storage capacity and low cost.

ii. Hard disks

A **hard disk drive** (HDD) is a non-volatile, random access storage device for digital data. It contains rotating platters on a motor-driven spindle within a protective enclosure. Data is magnetically read from and written to the platter by read/write heads that float on a film of air above the platters. Hard disk drives have been the dominant devices for secondary storage of data in general purpose computers since the early 1960s. They have maintained this position because advances in their real recording density have kept pace with the requirements for secondary storage. Today's HDDs operate on high-speed serial interfaces; i.e. Serial ATA (SATA) or serial attached SCSI (SAS).

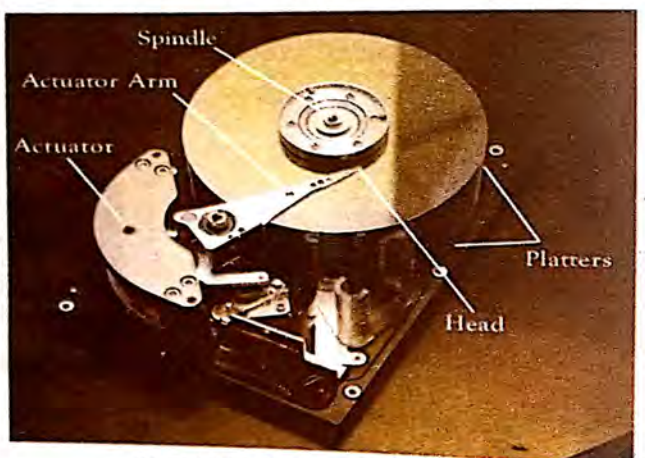


Figure 2.10 Working of Hard disk drive (HDD)

A typical HDD design consists of a spindle that holds flat circular disks, also called platters, which hold the recorded data. The platters in HDDs are spun at speeds varying from 4,200 rpm to 15,000 rpm for high performance servers. Today, most HDDs operate at a speed of 7,200 rpm.

Information is written to and read from a platter as it rotates. The read-and-write head is used to detect and modify the magnetization of the material immediately under it. An actuator arm (or access arm) moves the heads on an arc across the platters as they spin, allowing each head to access almost the entire surface of the platter as it spins. A typical HDD has two electric motors; a disk motor that spins the disks and an actuator (motor) that positions the read/write head assembly across the spinning disks.

The surface of the disk is divided into tracks and sectors before writing data, as shown in Figure 2.11.

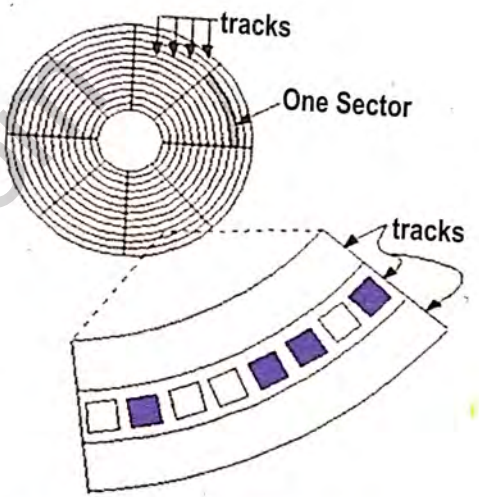


Figure 2.11 Tracks and Sectors in Hard disk

Tracks are concentric circles (circles within circles). The data bits are recorded as tiny magnetic spots on the tracks.

Sectors are the further divisions of tracks, which hold a block of data that is read or written at one time. Modern disks have more sectors in the outer tracks

than the inner ones because the outer radius of the platter is greater than the inner radius.

c. Optical disk

It is a flat, usually circular disk which encodes binary data in the form of pits (binary value of 0 or off, due to lack of reflection when read) and lands (binary value of 1 or on, due to a reflection when read) on a special material (often aluminum) on one of its flat surfaces. The encoding pattern follows a continuous, spiral path covering the entire disc surface and extending from the innermost track to the outermost track. The data is stored on the disc with a laser or stamping machine, and can be accessed when the data path is illuminated with a laser diode in an optical disc drive which spins the disc at speeds of about 200 rpm up to 4000 rpm or more depending on the drive type, disc format, and the distance of the read head from the center of the disc (inner tracks are read at a faster disc speed). The one side of an optical disc usually has a printed label, generally made of paper but sometimes printed or stamped onto the disc itself. The other side of the disc contains the actual data and is typically coated with a transparent material, usually lacquer. Unlike the 3½-inch floppy disk, most optical discs do not have an integrated protective casing and are therefore susceptible to data transfer problems due to scratches, fingerprints, and other environmental problems. Optical discs are usually between 7.6 and 30 cm (3 to 12 in) in diameter, with 12 cm (4.75 in) being the most common size. A typical disc is about 1.2 mm (0.05 in) thick, while the track pitch (distance from the center of one track to the center of the next) is typically 1.6 micro meters (µm)

The following are different types of optical disks.

i. CD (Compact Disk)
ii. DVD (Digital Versatile Disk)
iii. Blue Ray Disk (BD)

i. CD (Compact Disk)

A compact disk (CD) is a plastic-fabricated, circular medium for recording, storing, and playing back audio, video, and computer data. Compact disk is an optical disk designed to support one of three recording types: read-only (e.g. CD-ROM), recordable (write-once, e.g. CD-R), and re-recordable (re-writable, e.g. CD-RW). Write-once optical disks commonly have an organic dye recording layer. Rewritable disks typically contain an alloy recording layer. CDs are used for storing music, video, data and programs. A CD can hold about 700 megabyte of data.

A CD drive/player is used for reading/recording the data on the CD as shown in Figure 2.12. The job of CD player is to focus the laser on the track of bumps (also called pits). The laser beam passes through the layer, reflects off the layer and hits the censor that detects changes in light. The bump (pits) scatters the light and the land reflects it into the censor. The change in reflection is transmitted as 0s and 1s into the memory of the computer.

Figure 2.12 CD and CD drive

ii. DVD (Digital Versatile Disk)

DVD is an optical disk technology with a 4 to 16 gigabyte storage for video, audio, or other information. DVDs can be single- or double-sided, and can have two layers on each side. DVD is very similar to CD but has larger data storage capacity. Its data storage capacity is about ten times more than a CD. It has replaced the video tapes that were used in the past for storing movies. A DVD writer or player is used to read the data stored on a DVD. DVD players are compatible with CD which means they can play CDs also. DVDs have the same diameter and thickness as CDs and are made of the same material and manufacturing methods. Data is also stored just like a CD on a spiral track in the form of lands and bumps. Like CDs, DVDs are available as DVD-R and DVD-RW.

DVDs are easy to carry and can store more data in less space compared to CDs. Disadvantage is that DVDs require special drives to read/write data. DVD does not provide enough data storage compared to other latest storage devices used today.

Figure 2.13 DVDs

iii. Blu-Ray Disk (BD)

Blu-ray is an optical disk format designed to store large amount of data. Blu-ray is the successor to DVD. Blu-ray disk drive uses blue laser to read from and write to the disk rather than the red laser of DVD players. Its main

advantage over CD and DVD is that it has storage capacity of 50 GB to 100 GB. It is also faster than CDs and DVDs. The bumps (pits) on the surface of blu-ray that represent digital information are much smaller and very densely packed. This increases the storage capacity of blu-ray. Blu-ray disks are better storage devices for storing movies because they require a lot more storage. Another advantage of blu-ray disk is their durability. They have a special coating that helps to prevent scratches and marks that degrade performance. A blu-ray disk is shown in Figure 2.14.

Blu-ray disks cannot be used on the current CD and DVD players, because those players lack the blue-violet laser required to read the disks. However, Blu-ray players can run CDs and DVDs. Nowadays. most of the motion pictures industry is supporting blu-ray disk. It requires a special blue-ray drive for reading and writing.

Figure 2.14 Blue Ray disk

2.3.4 Chip Memory as Secondary storage

Chip or microchip is a small piece of semi-conducting material (usually silicon). A small circuit called IC (Integrated Circuit) is embedded on it. A typical chip contains millions of electronic components (transistors). Flash memory and memory cards are the two common types of chip memories which are used as portable secondary storage in computers.

a. Flash Memory

It is a non-volatile computer storage chip that can be electrically erased and reprogrammed. It is primarily used in memory cards, USB flash drives, MP3 players and solid-state drives for general storage and transfer of data between computers and other digital products. It is a specific type of EEPROM (electrically erasable programmable read-only memory) that is erased and programmed in large blocks. In early flash the entire chip had to be erased at once. Flash memory has become the dominant technology wherever a significant amount of non-volatile, solid state storage is needed. Example applications include PDAs (personal digital assistants), laptop computers, digital audio players, digital cameras and mobile phones.

Flash Memory Drive (also known as USB flash drive) is a data storage device that includes flash memory with an integrated Universal Serial Bus (USB) interface. USB flash drives are typically removable and re-writable, and physically much smaller than other storage media. Documents, presentations and any other form of data can be stored on a Flash Drive, and has proved a far more effective way of transferring data than burning CD's, and even DVDs. Flash Drives are also known as USB Memory Pens, USB Pen Drives, and USB Memory Sticks.

Figure 2.15 Flash Memory drives

Advantages of Flash Memory

- The obvious initial appeal and great advantage of Flash Memory is its portability. Users can place a number of files and applications in Flash memory.

- It is faster in read and write compared to traditional hard disk drives.
- Its physical size is smaller as compared to other portable devices.
- It is less prone to damage.
- It is cheaper than traditional drives in small storage capacities.
- It uses less power than traditional hard disk drives.
- Flash Memory is much more durable than other forms of computer memory.
- Extremes in pressure or temperature change would not normally affect Flash Memory.
- Adding or deleting files in Flash Memory is quick and tidy.

Disadvantages of Flash Memory

- Flash Memory has a limited number of write and erase cycles.
- Most flash drives do not have a write-protection mechanism.
- Due to small in size, these devices can easily be lost.
- Currently costs a lot more per gigabyte as compared to traditional hard drives for large storage capacities.

b. Flash Memory Cards

A Flash Memory Card is an electronic flash memory data storage device used for storing data such as text, pictures, audio, and video. They are commonly used in many electronic devices, including digital cameras, mobile phones, laptops, MP3 players and video game consoles. They are small, re-recordable, and able to retain data without power. They come in various sizes and with

Figure 2.16 Flash Memory Cards

different storage capacity.

Advantages of Memory Cards

- Memory cards have non-volatile memory, which keeps data stable on the card. Data on them are not threatened by loss of power, and need not be periodically refreshed.
- They are solid state media hence free from mechanical difficulties or damages.
- The new generation memory cards are smaller, lighter and compact with higher storage capacity.
- They require less amount of power.
- They are highly portable. They can be easily used in number of small, lightweight and low-power devices.
- They do not produce any noise while reading/writing.
- They have relatively large storage space compared to old backup devices.
- They can easily fit in memory card slot in different devices and are easily removable.
- They can be used in different devices such as cameras, computers or mobile phones.

Disadvantages of Memory Cards

- They can break easily.
- They can be lost, misplaced or smashed.
- Memory cards may be affected by electronic corruption and make entire card unreadable.
- Sometimes work slow.
- Cannot be attached or read by the computer /devices without proper hardware.
- Can get corrupted if not handled carefully.

SUMMARY

- Computer memory is one of the important and compulsory components of every computer system.
- Secondary memory (also called auxiliary memory) holds data and programs not currently in use and provides long-term storage.
- Primary or Main memory holds instructions and data when a program is being executed.
- Bit or binary digit is the basic unit of information in computing. A bit is the smallest amount of memory a computer can recognize. A bit can hold only one of two values, either '0' or '1'.
- Byte is a unit of data that is eight bits long. A byte is the unit most computers use to represent a character such as an alphabet, a number, or a special symbol.
- Main memory or Primary memory is the part of the computer that holds data and instructions for processing.
- Magnetic core memory was the most widely used form of digital computer memory based on a very simple idea. A core, a ring of magnetic material, stores one bit by the direction of its magnetization. A magnetic core is a ring of ferrite material.
- Volatile memory is computer memory that requires power (electricity) to maintain the stored information.
- Non-volatile memory is a permanent memory that can retain the stored information even if the power supply in off.
- Cache (pronounced as cash) memory is extremely fast Static RAM (SRAM) that is built into a computer's central processing unit (CPU), or located next to it on a separate chip.
- Registers are small memory units. There are a number of registers inside the processor.

Random Access Memory (RAM) is the common type of computer memory. It is the Read and Write (R/W) memory of a computer.

ROM (Read only memory) is non volatile memory, i.e., the information stored in it, is not lost even if the power supply goes off.

- Secondary storage is used to hold data/information, to be transferred for use during processing as and when required, and for storing data/programs permanently for future use.
- Sequential access is a storage system where the data is stored and read in a fixed or linear order.
- Direct access, also called Random access is a storage system where the data is stored and read directly from storage devices.
- Magnetic Tape is a sequential access storage device used for data collection, backup and archiving.
- Magnetic storage refers to the storage of data on a magnetized medium.
- A hard disk drive (HDD) is a non-volatile, random access storage device for digital data. It contains rotating platters on a motor-driven spindle within a protective enclosure.
- Optical disk is a flat, usually circular disc which encodes binary data in the form of and lands on a special material on one of its flat surfaces.
- A compact disk (CD) is a plastic-fabricated, circular medium for recording, storing, and playing back audio, video, and computer data.
- Blu-ray is an optical disk format designed to store large amount of data.
- Flash Memory is a non-volatile computer storage chip that can be electrically erased and reprogrammed. It is primarily used in memory cards and USB flash drives.

EXERCISE

Q1. Select the best choice for the following MCQs.

i. _____ memory holds data and programs not currently in use and provides long-term storage.
A. Primary B. Secondary
C. Main C. Internal

ii. _____ is the smallest amount of memory a computer can hold?
A. Byte B. KB
C. Bit C. MB

iii. Which of the following is the fastest memory?
A. RAM B.ROM
C. Cache memory D. PROM

iv. How much is 1 Mega Byte memory equal to?
A. 1024 K Bytes B. 1000 K Bytes
C. 1024 K Bits D.1024 G Bytes

v. Which material is used to make memory chips?
A. Iron B. Gold
C. Silver D. Silicon

vi. Which of the following is volatile memory?
A. RAM B. ROM
C. PROM D. EEPROM

vii. Which of the following is called internal processor memory?
A. RAM B. ROM
C. Cache D. DRAM

viii. _____ has the highest storage capacity.

A. DVD B. Blu-ray Disk

C. CD D. Zip disk

ix. _____ is a type of optical storage?

A. Hard disk B. Blu-ray Disk

C. Floppy disk D. Zip disk

x. Which of the following is a sequential access storage device?

A. Magnetic disk B. Blu-Ray disk

C. Magnetic tape D. Zip disk

Q2. Give short answers to the following questions.

i. What is computer memory?

ii. Define bit, byte and memory word.

iii. What is the importance of cache memory in a computer?

iv. Give some uses of secondary memory.

v. What is the role of registers in computer?

vi. Differentiate between DRAM and SRAM.

vii. Give few characteristics of secondary storage devices.

viii. Differentiate between the following.

a) Chip memory and Magnetic memory

b) Cache and Register

c) Volatile and non-volatile memory

d) Magnetic tapes and Magnetic disks

e) EPROM and EEPROM

Q3. Give detailed answers to the following questions.

i. Briefly explain the processor internal memory and its types.

ii. Explain RAM and ROM along with their types in detail.

iii. What is meant by secondary storage devices also explain the difference between Sequential access and Random access.

iv. Describe the following along with their advantages and disadvantages:

a) Magnetic tapes

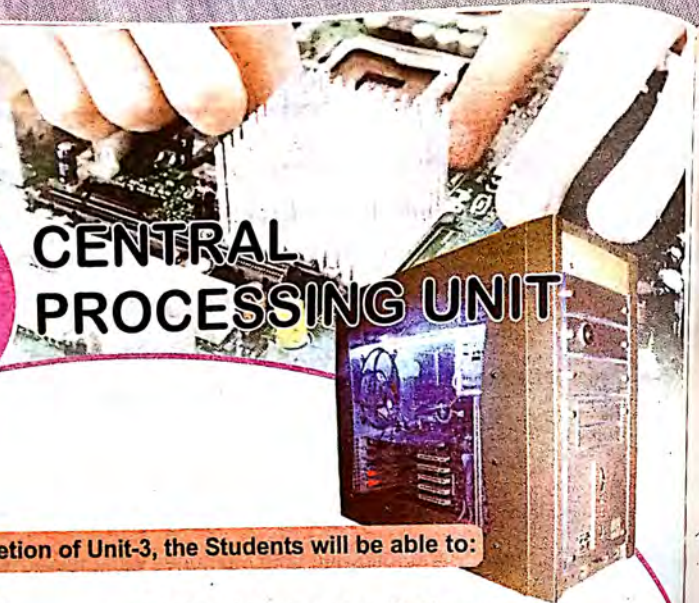
b) Magnetic disks

c) Optical disks(CD, DVD, Blue Ray)

v. Describe the following chip Memories with their advantages and disadvantages.

a) Flash Memory

b) Memory Cards



UNIT 3

CENTRAL PROCESSING UNIT

After the completion of Unit-3, the Students will be able to:

- *define CPU and its components (ALU, CU, Registers, Cache and Internal Buses).*
- *describe the functions of general purpose and special purpose registers.*
- *explain system bus and its types.*
- *define instruction and its types.*
- *explain instruction format.*
- *describe instruction cycle (Fetch, Decode and Execute).*
- *describe CISC and RISC architecture.*
- *differentiate between Intel and AMD processors.*

3.1 CPU (CENTRAL PROCESSING UNIT)

Central Processing Unit (CPU) is the integral part of any computer system. It is the brain of computer system. Just like human brain which controls all the activities of human body, the CPU controls all the operations of the computer. CPU is connected to all parts of the Computer. CPU not only execute instructions but also controls the storage of data, input output activities and functions of different devices attached. CPU is also called microprocessor or processor.

3.1.1 Basic Components of CPU

CPU consists of the following basic components.

a. Arithmetic and Logic Unit (ALU)
b. Control Unit (CU)
c. Registers
d. Cache
e. Internal Buses

a. Arithmetic and Logic Unit (ALU)

Arithmetic Logic Unit is the main processing unit of CPU. It performs arithmetic and logic operations on data. Arithmetic means addition, subtraction, multiplication, division and logical operation is the comparison between two data items. ALU processes the data and then gives back the results. The results of an operation are stored in registers (temporary storage locations). Now a days CPUs have more than one ALUs that can do the calculation simultaneously in order to improve the efficiency of computer system.

b. Control Unit (CU)

Control Unit manages the functions performed by different parts of the computer. It coordinates and controls the overall computer system, just like the

brain controls the human body. It executes the program instructions, controls and directs the input, informs ALU for processing, arranges the storage and directs the data to the output device.

Control unit is responsible for directing the flow of instructions and data within the CPU. It directs the operation of the other units by providing timing and control signals. The control unit contains the necessary logic to interpret instructions and to generate the signals necessary for the execution of those instructions. The descriptive words "fetch" and "execute" are used to describe the actions of the control unit. It fetches an instruction by sending an address and a read command to the memory unit. The instruction at that memory address is transferred to the control unit for decoding. It then generates the necessary signals to execute the instruction.

c. Registers

Registers are small memory devices available in the CPU. These are used to store data temporarily. CPU registers are at the top of the memory hierarchy, and provide the fastest way for a CPU to access data. Each register is designed for a special purpose and the size of each varies. Registers are measured by the number of bits they can hold, like 8-bits, 16 bits or a 32-bits register. Processor contains different kinds of registers and is classified according to their content or instructions. CPU registers are divided into two main types.

- General Purpose Registers
- Special Purpose Registers

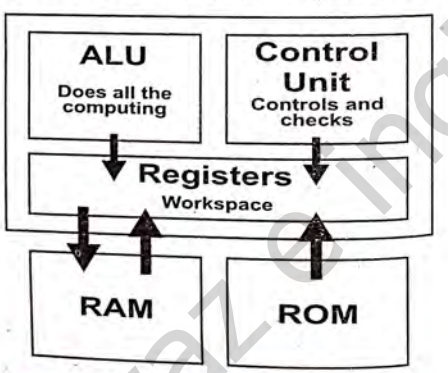


Figure 3.1 CPU Registers

d. Cache Memory

It is the small amount of memory located between main memory and processor. Cache memory is also known as high speed buffer or on chip memory. The microprocessor stores a copy of most frequently used data and instructions in the cache memory. The microprocessor when desires the data, it first looks in to the cache memory, if not found there then it will ask for the same from the main memory. This will result in the better efficiency of the microprocessor speed and its usage.

There are different levels of cache memory.

Level 1 (L1) Cache memory resides inside the microprocessor and is very fast from the other memories. Microprocessor first checks the Level 1 Cache memory.

Level 2 (L2) Cache memory lies just outside the microprocessor, it is slow as compared to Level 1 cache but fast from rest of the memories. If data or instruction not found in Level 1 cache memory then microprocessor will look in to Level 2 cache memory.

Now days modern microprocessor has **Level 3 cache** on the motherboard.

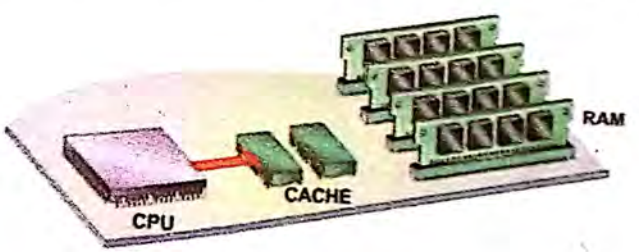


Figure 3.2 Cache memory

e. Internal Buses

Bus is a subsystem that transfers data between computer components inside a computer. Internal bus connects all the components of computer to the

motherboard. An internal bus enables communication between internal components such as a computer video card and memory.

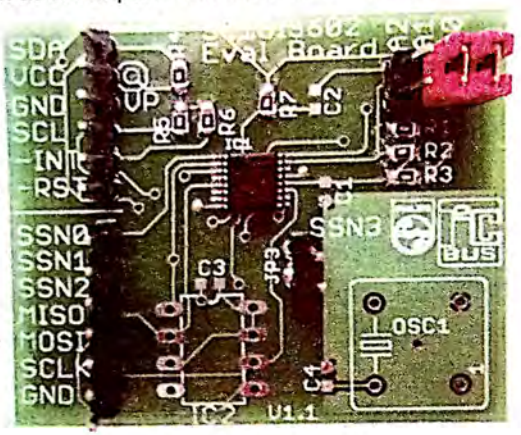


Figure 3.3 internal buses

Modern computer buses can use both parallel and serial-bit connections. Parallel buses are those which carry data in parallel on multiple wires (Conventional PCI, Extended ISA, PCI-104) and serial buses are those that carry data in serial-bit form (PCI Express, SATA). The buses size in computers are from 8-bits to 128 bits.

3.1.2 Types of Registers

Registers are categorized into two types according to their purpose and function.

- General Purpose Registers
- Special Purpose Registers

a. General Purpose Registers

General purpose registers are used to store data as well as addresses. They are combined data and address registers. These registers are used for

arithmetic and data movement. Typically these registers are 8-32 bit registers. Following are the commonly used general purpose registers.

i. Accumulator (AX)
ii. Data Register (DX)
iii. Base Register (BX)
iv. Counter Register (CX)

i. Accumulator (AX)

Accumulator is a general purpose register and is used by CPU for performing arithmetic and logic operations and to hold the result of those operations. The accumulator is initially set to zero, and then each number in turn is added to the value in the accumulator. It consists of two 8-bit registers (AH and AL) which can be combined together and used as a one 16-bit register.

Bits 15.....0

16-bit AX register	
8-bit AH register	8-bit AL register

ii. Base Register (BX)

The Base Register can perform arithmetic and data movement and it has some special addressing abilities. BX register can hold a memory address that points to another variable. It usually contains a data pointer. It consists of two 8-bit registers (BH and BL) which can be combined together and used as a one 16-bit register.

Bits 15.....0

16-bit BX register	
8-bit BH register	8-bit BL register

iii. Counter Register (CX)

The Counter Register acts as a counter for repeating or looping instructions. The instructions given are automatically repeated and will decrement the value of CX and quits when it is equal to 0. It consists of two 8-bit registers (CH and CL) which can be combined and used as a 16-bit register CX.

Bits 15.....0

16-bit CX register	
8-bit CH register	8-bit CL register

iv. Data Register (DX)

Data Register has a special role in multiply and divide operations. It works like a buffer and holds anything that is copied from the memory ready for the processor to use it. It also consists of two 8-bit registers (DH and DL) and can be combined to work as a 16-bit register. In Input/Output (I/O) operations DX register can be used as a port number.

Bits 15.....0

16-bit DX register	
8-bit DH register	8-bit DL register

b. Special Purpose Registers

These registers hold the state of a program. They include program counter, instruction register, memory address register and memory buffer registers. These are used by control unit to control the operations of CPU and by the operating system programs to control the execution of the programs. Following are the special purpose registers.

i. Instruction Register (IR)

Instruction register is a part of control unit, which stores the instructions currently being executed. Each instruction to be executed is loaded into the instruction register. It is also known as current instruction register (CIR) because it holds the current instruction being executed.

ii. Memory Address Register (MAR)

Memory Address Register holds the memory address, the memory address from which data will be provided to the CPU or will have the address to which data will be sent and then stored. It basically holds the memory location of data that needs to be accessed. When reading from memory, the data addressed by MAR is fed into the MDR (Memory Data Register) and then is used by the CPU. When writing to memory, the CPU writes data from Data Register to the memory location whose address is stored in MAR. So, in both reading and writing, it is holding the address of the memory location where the data is to be read or stored.

iii. Memory Buffer Register (MBR)

The Memory Buffer Register actually holds the contents of the memory which are to be moved from memory to other components or from components to the memory. In order to store a word it must be transferred to the MBR and then from here it will go to the specific memory location. It works as a buffer allowing the processor and memory units to act independently.

iv. Program Counter (PC)

Program Counter is also known as Instruction Pointer. It is a register in a computer processor that contains the address (location) of the instruction being executed at the current time. As each instruction gets fetched, the program counter increases its stored value by 1. After each instruction is fetched, the program counter points to the next instruction in the sequence.

3.1.3 System Bus

A bus is a data communication path over which information is transferred a byte or word at a time. System bus connects the central processing unit to main memory on the motherboard. The majority of system buses are made up of 50 to 100 distinct lines for communication. The system bus consists of three types of buses.

a. Data Bus
b. Address Bus
c. Control Bus

a. Data Bus

Data bus is the bidirectional bus. It can communicate in two ways, but in one direction at a time. It handles the transfer of data and instructions. The data bus is used to transfer instructions from memory to the CPU for execution. It carries data (operands) to and from the CPU and memory as required. It is also used to transfer data between memory and I/O devices during input output operations. A typical data bus is 32-bits wide. This means that up to 32-bits of data can travel through a data bus every second. New computers have 64-bit data buses and even more.

b. Address Bus

Address bus carries addresses not data. An address is defined as a label, symbol, or other set of characters used to designate a location or register where information is stored. Before data or instructions can be written into or read from memory by the CPU or I/O sections, an address must be transmitted to memory over the address bus. The number of lines on the bus determines the number of addressable memory elements. For example an 8-bit bus can represent 2^8 i.e. 256 unique addresses. A 16-bit bus can address 65536 unique addresses.

c. Control Bus

The control bus is used by the CPU to direct and monitor the actions of the other functional areas of the computer. It is used to transmit a variety of individual signals (read, write, interrupt, acknowledge) necessary to control and coordinate the operations of the computer. The size of control bus is from 8 to 16 bits.

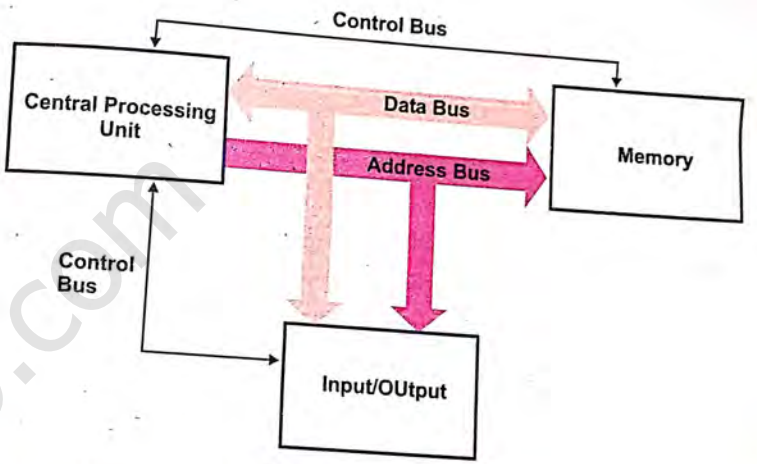


Figure 3.4 System Buses

3.2 CPU OPERATIONS

A central processing unit (CPU) is the hardware within a computer system which carries out the instructions of a computer program by performing the basic arithmetical, logical, and input/output operations of the system. The fundamental operation of most CPUs, regardless of the physical form they have, is to execute a sequence of stored instructions called a program. The program is represented by a series of instructions that are kept in some kind of

computer memory. There are four steps that CPUs use in their operation, these are fetch, decode, execute and store.

3.2.1 Instructions and their types

An instruction (or instruction code) is a group of bits that tells the computer to perform a specific operation. Instruction is an elementary operation that the processor can accomplish. Instructions are stored in the main memory, waiting to be processed by the processor. An instruction has two fields:

- **Operation code**, which represents the action that the processor execute.
- **Operand code**, which defines the parameters of the action. The operand code depends on the operation. It can be data or a memory address.

Operation code	Operand code

There are different types of instructions.

a. Data Transfer Instructions
b. Data Processing Instructions
c. Program Control Instructions
d. Miscellaneous Instructions

a. Data Transfer Instructions

Most of the operations of the CPU are data transferring. These instructions are used when the data needs to be moved from memory location to register. These instructions transfer data from one location in the computer to another location without changing the data content. The most common transfers are between:

- registers and memory,
- registers and I/O,
- registers to registers.

Examples of some common data transfer instructions are MOV, LOAD and STORE.

- **MOVE (MOV)** instruction transfers data from a memory location to a register, register to memory and register to register. This is also used to obtain the data to perform a computation on it later, or to store the result of a computation.

  Example: MOV A, B (Move the contents of register A to B)
- **LOAD (LD)** instruction loads particular register contents from memory.

  Example: LD A (Load the data to register A from memory)
- **STORE (STO)** instruction stores information from register to memory location.

b. Data Processing Instructions

These instructions are related to the arithmetic and logic operations. The arithmetic or logic operations are performed on the values of two registers and the result is also placed in a register. Data manipulation instructions can be divided into three basic types, i.e. arithmetic, logical and shift instructions.

i. Arithmetic Instructions

The four basic operations are ADD, SUB, MUL and DIV. An arithmetic instruction may operate on fixed-point data, binary or decimal data. The other possible operations include a variety of single-operand instructions, for example ABSOLUTE, NEGATE, INCREMENT, DECREMENT.

The execution of arithmetic instructions requires bringing the operands in the operational registers so that the data can be processed by ALU. Such functionality is implemented generally within instruction execution steps.

ii. Logical Instructions

AND, OR, NOT, XOR operate on binary data stored in registers.

iii. Shift Instructions

Shift operation is used for transfer of bits either to the left or to the right of an operand.

c. Program Control Instructions

These instructions specify conditions for altering the sequence of program execution or in other words the content of PC (program counter) register. Program control or transfer of control is a way of altering the order in which statements are executed. There are a number of instructions used like JMP (Jump) and LOOP.

- The **JMP** instruction jumps to begin the execution at another location.
- The **LOOP** instruction is used when number of statements are to be repeated.

3.2.2 Instruction Format

An instruction format defines the layout of the bits of an instruction. An instruction format must include an Op-code (Operation-Code) and zero or more Operands. The Op-code will always be present.

- Op-Code
- Operand

Op-Code field of an instruction is a group of bits that define various processor operations such as LOAD, STORE, ADD, and SHIFT to be performed on some data stored in registers or memory.

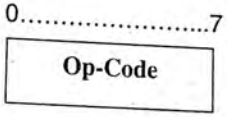
Operand address field can be data, or can refer to data – i.e. address of data, or can be labels, which may be the address of an instruction to be executed next.

Different instruction formats are used. A few of them are explained below.

- Zero-Address Instruction
- One-Address Instruction
- Two-Address Instruction

a. Zero Address Instruction

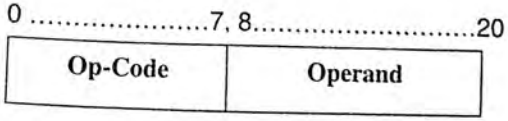
The Zero Address instruction format requires only op-code, having no operand to work with. Example of the Zero Address instruction format is HALT, STOP, which do not have any address.



Example: STOP

b. One Address Instruction

One Address instruction format requires one op-code and one operand. Example of the one address instruction format is LDA (Load Accumulator), JMP (Jump) etc. These instructions require one address to do the operation. Like JMP requires one address in order to jump to that specific address location.



Example: JMP AX

c. Two Address Instruction

Two Address instruction format requires one op-code and two operands. Example of such instruction format is the MOV (Move), which moves data from the memory location to the register and from register to the memory location.

0.....7, 8.....19, 20.....31 bits

Op-Code	Operand	Operand

Example: ADD A, B

3.2.3 Instruction Cycle

Instruction cycle (sometimes called fetch-and-execute cycle, fetch-decode-execute cycle) is the basic operation cycle of a computer. It is the process by which a computer retrieves a program instruction from its memory, determines what actions the instruction requires, and carries out those actions. This cycle is repeated continuously by the central processing unit (CPU), from booting of computer till it is shut down.

There are typically four stages of an instruction cycle that the CPU carries out:

a. **Fetch** the instruction from memory
b. **Decode** the instruction
c. **Execute** the instruction
d. **Store** the result

a. Fetch the instruction

The instruction is fetched from the memory address that is currently in the Program Counter (PC), and store it in the Instruction Register (IR).

b. Decode the instruction

The instruction decoder interprets the instruction. If the instruction has an indirect address, the effective address is read from main memory, and any

required data is fetched from main memory to be processed and then placed into data registers. During this phase the instruction inside the IR (instruction register) gets decoded.

c. Execute the instruction

The CU passes the decoded information as a sequence of control signals to the relevant function units of the CPU to perform the actions required by the instruction such as reading values from registers, passing them to the ALU to perform mathematical or logic functions on them, and writing the result back to a register.

d. Store results

The result generated by the operation is stored in the main memory, or sent to an output device. But this condition is not always required.

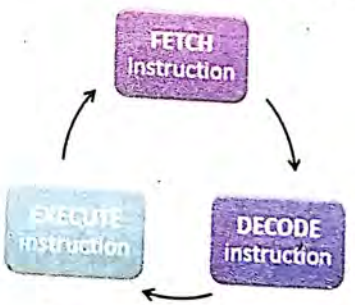


Figure 3.5 Instruction Cycle

3.2.4 CISC and RISC architecture

There are two major types of CPUs, which are classified according to the instruction set philosophy adopted by their designers. They are:

a. CISC (complex instruction set computer)
b. RISC (Reduced instruction set computer)

a. CISC (Complex Instruction Set Computer)

Complex Instruction Set Computer (CISC) is processor architecture. The instructions which the processor could execute were built into the chip. In common CISC chips are relatively slow per instruction. CISC have a large amount of different and complex instructions. CISC architecture was a bit complex because of the instructions used at the hardware level. The more complex the instruction set, the greater the overhead of decoding an instruction. CISC emphasizes on hardware. Examples of CISC processors are the Motorola 680x0 families and Intel 486 and Pentium series.

b. RISC (Reduced Instruction Set Computer)

Reduced Instruction Set Computer (RISC) is a microprocessor architecture that is designed to perform a smaller number of instructions. RISC architecture was developed around mid 1980 as a reaction to the CISC chips. It is designed to perform smaller number of instructions in order to operate on a higher speed. RISC has limited and simple instruction set. The simplicity of RISC allows more freedom to choose how to use the space on a microprocessor.

Larger set of instructions make the microprocessor more complicated and slower in operation. Operating System and application programmers will find it easier to work with smaller instruction set. One of the drawbacks of the RISC is that it puts a lot of burden on software due to its smaller size of instruction set. RISC emphasizes on software. Examples of RISC processor are IBM PowerPC, Sun SPARC and some mobiles.

3.2.5 Intel and AMD Processors

A processor controls every function in a computer. **Intel** and **AMD** (Advanced Micro Devices) are the primary manufacturers of processors. They make processors for desktop computers, laptops, notebooks and mobile devices.

Different types of processors perform different functions at different speeds, depending on what kind of system they run. Each type of processor has different functionality, but similarities do exist among various types.

Both Intel and AMD make processors for a variety of systems. Intel makes the **Core**, **Pentium** and **Celeron** families of processors, matched by the **Phenom**, **Athlon** and **Sempron** processors from AMD.

Difference between Intel P4 and AMD Athlon Processors

Pentium 4: The Pentium 4 brand refers to Intel's line of central processing units (CPUs) introduced in November 20, 2000. With Pentium 4, Intel introduced a new processor architecture known as NetBurst which featured a very deep instruction pipeline that helped these processors to achieve very high clock speeds (up to 3.8 GHz). The Pentium 4 line of processors contains both 32 bit and 64 bit processors. The typical speed of these processors ranges from 400 MHz to 1066 MHz.

AMD Athlon: Athlon is the brand name applied to a series of x86-compatible microprocessors designed and manufactured by Advanced Micro Devices (AMD). The original Athlon (now called Athlon Classic) was the first seventh generation x86 processor. Typical speed for these processors ranges from 1333 MHz to 2.33 GHz and their bus speed lies in between 100 and 200 MHz. The original Athlon processors were 32 bit and the later Athlon64 and 64 bit processors.

	Pentium 4	Athlon
Clock Speeds (MHz)	1300 – 3800	1333 – 2333
Front Side Bus Speeds (MHz)	400 – 1066	100 – 200
Cache Size (KB)	256 – 2048	64 – 512
Bus Width (bits)	32, 64	32, 64

SUMMARY

- Central processing unit (CPU) is the integral part of any computer system. It is the brain of computer system.
- Arithmetic logic unit is the main processing unit of CPU. It performs the arithmetic and logic operations on data.
- Control unit manages the functions performed by different parts of the computer. It coordinates and controls the computer system, just like the brain controls the human body.
- Registers are small memory devices available in the CPU. These are used to store data temporarily.
- Cache memory is the small amount of memory located between main memory and Processor. Cache memory is also known as high speed buffer or on chip memory.
- Bus is a subsystem that transfers data between computer components inside a computer.
- General purpose registers are used to store data as well as addresses.
- Accumulator is a general purpose register and is used by CPU for performing arithmetic and logic operations and to hold the result of those operations.
- The base register can perform arithmetic and data movement and it has some special addressing abilities.

- The counter register acts as a counter for repeating or looping instructions.
- Data register has a special role in multiply and divide operations. It works like a buffer and holds anything that is copied from the memory ready for the processor to use it.
- Special purpose registers are used to hold the state of a program. They include program counter, instruction register, memory address register and memory buffer registers.
- Instruction register is a part of control unit, which stores the instructions currently being executed.
- Memory address register holds the memory address, the memory address from which data will be provided to the CPU or will have the address to which data will be sent and then stored.
- Memory buffer register holds the contents of the memory which are to be moved from memory to other components or from components to the memory.
- Program counter is also known as instruction pointer, it is a processor register that holds either the address of the instruction being executed or the address of the next instruction to be executed.
- Data bus is the bidirectional bus. It can communicate in two ways, but in one direction at a time.
- Address bus carries addresses not data.

- The control bus is used by the CPU to direct and monitor the actions of the other functional areas of the computer.
- An instruction (or instruction code) is a group of bits that tells the computer to perform a specific operation.
- An instruction format defines the layout of the bits of an instruction. An instruction format must include an op-code (operation-code) and zero or more operands.
- Instruction cycle (sometimes called fetch-and-execute cycle, fetch-decode-execute cycle, or FDX) is the basic operation cycle of a computer.
- Complex Instruction Set Computer (CISC) is processor architecture.
- Reduced Instruction Set Computer (RISC) is a microprocessor that is designed to perform a smaller number of types of computer instructions.

EXERCISE

Q1. Select the best choice for the following MCQs.

i. Which of the following performs the arithmetic and logic operations on data?

A. ALU
B. Control unit
C. Bus
D. Memory unit

ii. _____ coordinates and controls the computer system, just like the brain controls the human body.

A. Bus
B. Control unit
C. Output unit
D. Register

iii. Where are the logical operations performed in the CPU?

A. CU
B. Register
C. ALU
D. Memory

iv. _____ is a small memory device available in the CPU to store data temporarily.

A. CU
B. Register
C. ALU
D. Memory

v. _____is the small amount of memory located between main memory and Processor.

A. RAM
B. ROM
C. Cache
D. PROM

vi. Which of the following cache memories resides inside the microprocessor and is very fast from the other memories?

A. L1 cache
B. L2 cache
C. L3 cache
D. L4 cache

vii. _____ Register can perform arithmetic and data movement and it has some special addressing abilities.

A. Base register B. Memory buffer register
C. Data register D. Counter register

viii. Which of the following register has a special role in multiply and divide operations?

A. Base register B. Memory buffer register
C. Data register D. Counter register

ix. _____ register holds either the address of the instruction being executed or the address of the next instruction to be executed.

A. Program counter B. Memory buffer register
C. Data register D. Counter register

x. System bus connects the Central Processing Unit to _____ on the motherboard.

A. Register B. Main memory
C. ALU D. Input unit

xi. Which of the following steps, in instruction cycle, interprets the instruction?

A. Fetch B. Decode
C. Execute D. Write-back

xii. _____ instruction is used when number of statements is to be repeated.

A. LD B. LOOP
C. JMP D. MOV

xiii. _____ is a microprocessor architecture that is designed to perform a smaller number of types of computer instructions.

A. RISC B. CISC
C. DISK D. LIST

xiv. How many op-codes do a Zero-Address instruction has?

A. 1 B. 2
C. 3 D. 0

xv. Which of the following is not an arithmetic instruction?

A. DIV B. MUL
C. SUB D. JMP

Q2. Give short answers to the following questions.

i. What is the function of ALU in the computer?
ii. What is the function of control unit in the computer?
iii. What is a microprocessor?
iv. Define system bus.
v. Write short note on Memory Buffer Register (MBR).
vi. What is CPU operation?
vii. What is meant by an instruction?
viii. Differentiate between op-code and operand?
ix. Show computer instruction format with the help of a diagram and label its parts.
x. Differentiate between CISC and RISC processor architecture.

Q3. Give detailed answers to the following questions.

i. What is CPU? Describe basic components of CPU in detail.
ii. What is a register? Explain different types of registers.
iii. What is a system bus? Explain different types of buses used in computers.
iv. Explain different types of CPU instructions. Also give examples.
v. What is Instruction cycle? Explain different phases of CPU instruction cycle.

UNIT 4

INSIDE SYSTEM UNIT

After the completion of Unit - 4, the Students will be able to:

- differentiate between CPU and system unit.
- identify computer casing and its types.
- explore the system unit:
  - Power Supply
  - Motherboard with its various parts
- describe the ports (Serial, Parallel, PS/2, USB and Fire wire).
- identify expansion cards (sound, Video, Modem and Network).
- describe memory chips (SIMM, DIMM, SDRAM and DDR).

4.1 COMPUTER CASING/SYSTEM UNIT

It is a rectangular box (casing) with many components that make the entire computer system. System unit components include the motherboard, processor, expansion cards, expansion slots, power supply, disk drives, memory modules, ports, and connectors. The motherboard is the main part of the system unit which contains many different types of chips, or small pieces of semi-conducting material, on which one or more integrated circuits (IC) are etched. System units are available in different shapes and sizes.

4.1.1 CPU and System unit

Sometimes people erroneously refer the system unit as CPU but these are two different things. A computer **System unit** is the case with the motherboard and all the other parts while **CPU** is the Central Processing Unit, a chip on the motherboard that does all the processing.

The CPU chip is installed in a slot on motherboard which is placed inside the casing of the system unit.

Figure 4.1 CPU

Figure 4.2 System Unit with other important components

4.1.2 Computer Casings

A computer case also known as computer chassis, cabinet, box, tower, enclosure, housing, system unit or simply case is the enclosure that contains most of the components of computer system. Cases are usually constructed from steel or aluminum. Plastic and other materials such as wood or Lego are also used.

Types of Computer Casings

There are two common types of Computer casings.

a. Desktop Casing
b. Tower Casing

a. Desktop Casing

Desktop casing is the old type of casing which is designed to keep on the desk and usually monitor is placed over it. Figure 4.3 a.

b. Tower Casing

Tower casing is the modern type of casing which is more attractive and common. Monitor is kept side by side with the tower casing. Figure 4.3 b.

Figure 4.3 a. Desktop Casing

Figure 4.3 b. Tower Casing

4.1.3 Exploring the System Unit

System unit contains the following two main parts.

a. Power Supply
b. Motherboard

a. Power Supply

A power supply unit is the component that supplies power to the other components of a computer system. Power supply changes alternating current (AC) to low-voltage direct current (DC) to operate the processor and peripheral devices. Several direct-current voltages are required, and they must be regulated with some accuracy to provide stable operation of the computer. Computer power supplies may have short circuit protection, overpower (overload) protection, over voltage protection, under voltage protection, over current protection, and over temperature protection. Today most power supplies follow Advance Technology Extended (ATX) standard.

Figure 4.4 Power Supply

b. Motherboard

Motherboard is the main circuit board in computer system that hold main component of the system unit. It is mounted inside the casing. It is securely attached via small screws through pre-drilled holes. Several different types of chips (e.g., CPU and memory chips) can be found on the motherboard. The motherboard also contains expansion slots into which other circuit boards can be inserted for the expansion of the computer system. Other devices such as hard disk, sound, video controller and peripheral devices may be connected to motherboard through plug-in cards or via cables. Modern computers integrate these peripheral into motherboard. Most modern motherboard may include the following:

- One or more slots for CPU
- Slots for main memory
- Integrated Graphics Cards
- PCI Slots
- PCI Express Slots
- IDE Connector (for Hard Disk, CD Drive)
- SATA Connector
- Connecters for peripheral devices (mouse, keyboard, speaker, Mic etc)

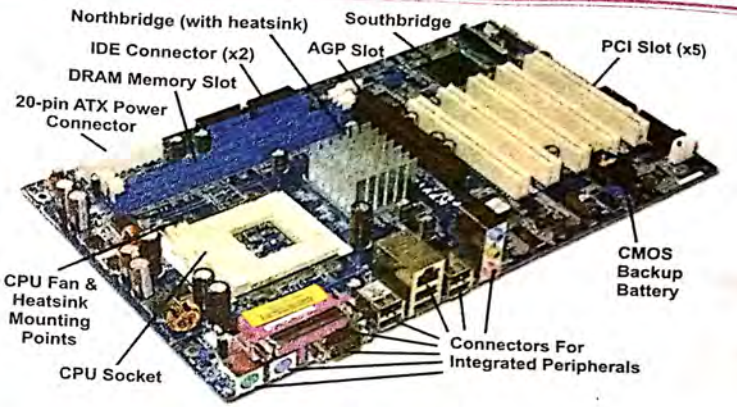


Figure 4.5 A Motherboard

Some important components on motherboard

1. Basic Input Output System (BIOS)

Basic Input Output System (BIOS) also known as the System BIOS or simply BIOS is the firmware built into the computer system. Firmware is a fixed, usually small program that controls various electronic devices. BIOS is the first program run by a computer when it is powered on. The main function of the BIOS is to load and start an operating system (OS). The first job of BIOS is to check and initialize system devices such as the video card, keyboard, mouse, hard disk and other hardware. BIOS then locates OS on hard disk or CD or flash memory drive. After loading and executing the OS, BIOS gives control to the system. This process is called booting or booting up the system.

Using BIOS a user can:

- Configure hardware
- Set the system clock
- Enable or disable system components
- Select bootable device sequence
- Set password for system and user login

Many PC manufacturers today use flash-memory cards to hold BIOS information. This allows users to update the BIOS version on computers after a vendor releases an update. This system was designed to solve problems with the original BIOS or to add new functionality.

2. Ports

In computer hardware, a port connects peripheral devices to the computer system. A port is a piece of equipment to which a plug or cable is connected. Common computer ports include:

- Serial Ports
- Parallel Port
- PS/2 Mouse Port
- PS/2 Keyboard Port
- VGA Port
- USB (Universal Serial Bus)
- Ethernet LAN Port
- Audio Ports

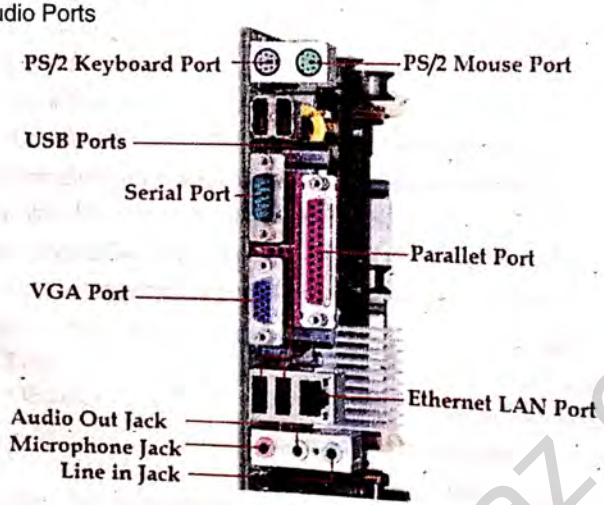


Figure 4.6 Ports

3. Expansion Slots

These are openings or sockets in a computer motherboard where a circuit board or expansion card can be inserted to add new functionalities to the computer. Nearly all computers contain expansion slots. The devices inserted into the expansion slots are called expansion boards, cards, add-ins or add-ons. The common standard of expansion slots includes AGP, PCI and PCI Express.

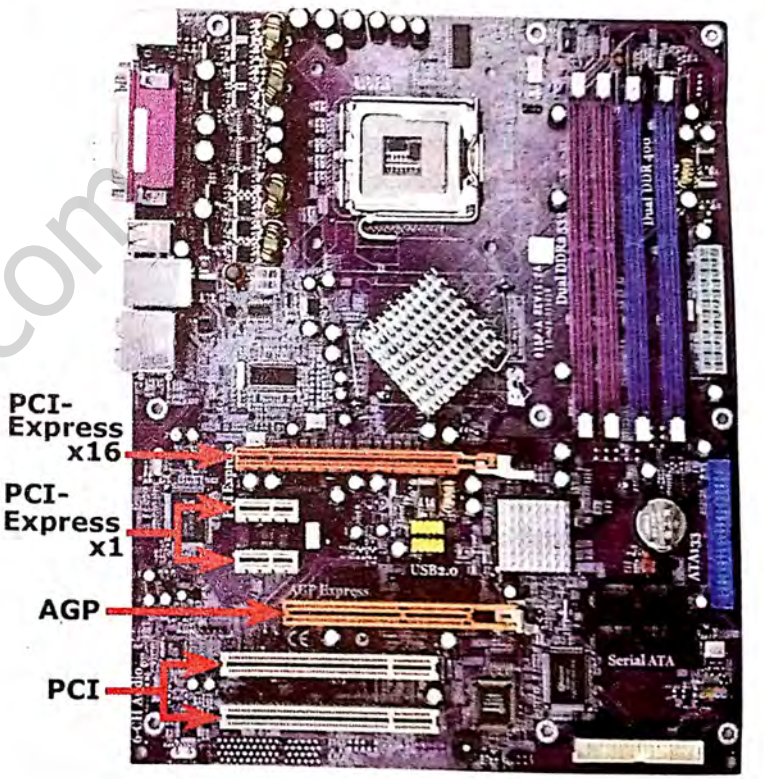


Figure 4.7 Expansion Slots

i. Accelerated Graphics Port (AGP)

The Accelerated Graphics Port (AGP) is a high-speed point-to-point channel (pathway), primarily used for 3D computer graphics. The AGP enable computer to have a dedicated way to communicate with the graphics card, as compared to Peripheral Component Interconnect (PCI). The main advantage of AGP over PCI is that it provides dedicated pathway between the slot and the processor while PCI bandwidth is shared by various devices.

ii. Peripheral Component Interconnect (PCI)

The Peripheral Component Interconnect (PCI) is a computer bus (an electric pathway) for attaching hardware device in a computer. These devices can be Integrated Circuits (ICs) fitted onto the main board or an expansion card that fits into a slot. Typically PCI cards used in computers include networks cards, sound cards, MODEM, extra ports such USB or serial, TV tuner cards and disk controllers. PCI is still used in some computers but is superseded by PCI Express.

iii. PCI Express Slot

Peripheral Component Interconnect Express (PCI Express), abbreviated as PCIe, is a computer card expansion standard developed by Intel, Dell, IBM and HP in 2004 to replace older PCI and AGP standards. PCIe preserves compatibility with PCI. PCIe has many improvements over conventional PCI, which includes more bandwidth (6400MB/s whereas PCI has 133MB/s and AGP has 2100MB/s), maximum system bus throughput, good error detection and reporting mechanism and hot plugging. It is the latest standard expansion slot used in micro and laptop computers. PCIe also supports latest sound cards, TV tuner cards, Fire-wire cards, etc.

4. Ribbon Cable

A ribbon cable also known as multi-wire planar cable is a cable with many conducting wires running parallel to each other on the same flat plane. As a result the cable is wide and flat as ribbon. Ribbon cables are usually used for internal peripheral of computer, such as hard drives, CD drives and floppy drives.

The following are the main types of ribbon cables.

a. IDE Cable
b. SATA Cable
c. FD Cable

i. IDE Cable

IDE short for Integrated Drive Electronics is more commonly known as ATA/ATAPI (Advance Technology Attachment/ ATA Packet Interface) or PATA (Parallel ATA) is a ribbon cable standard used for connecting hard drives developed by Western Digital. Original IDE was designed only for hard drives. ATAPI a new version was developed to connect CD-ROM, tapes drives and Zip drive. IDE has largely been replaced by Serial ATA (SATA) in newer systems.

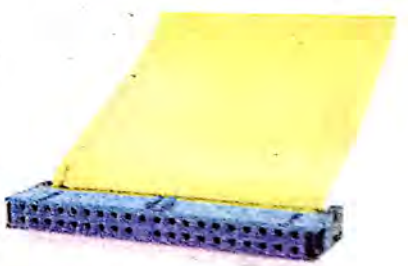


Figure 4.8 IDE Cable

ii. SATA Cable

SATA (Serial Advanced Technology Attachment) is a new technology cable for connecting storage drives to computer. It was designed to replace IDE bus interface. SATA bus interface is used in all the modern laptop and desktop computers. SATA drives communicate with high speed. These cables transfer data at high rates (from 1.5 to 6 gigabytes per second). SATA1, SATA2 and SATA3 interfaces provide communications at rates of 1.5 GB/Sec, 3 GB/Sec and 6 GB/Sec respectively.

Figure 4.9 SATA Cables

iii. FD Cable

FD (Floppy Disk) cable was used in the past to connect floppy drives to the motherboard. Floppy drives are almost obsolete nowadays. Due to this reason FD cable is no more used with modern microcomputers.

Figure 4.10 FD Cable

5. Memory Slots

A computer memory slot is a socket or opening in computer main board in which the main memory is installed. The number and type of memory slots varies from motherboard to motherboard, but at least two slots are available on every motherboard.

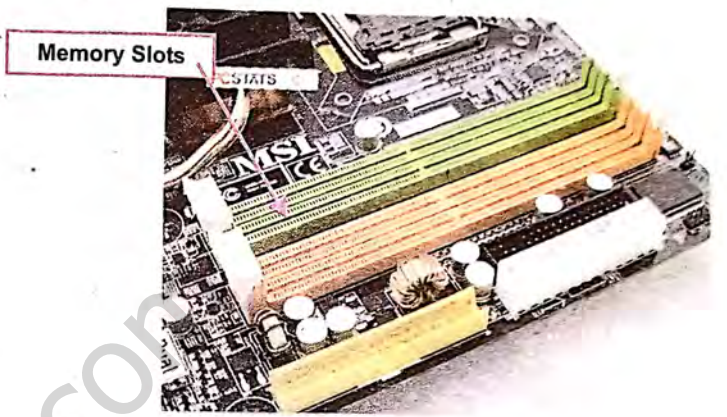


Figure 4.11 Memory Slots

6. Disk Controller

Disk controller is the circuit which enables the CPU to communicate with disk drives like hard disk and compact disk. Old disk controllers were implemented on a separate controller card. Modern disk controllers are integrated into the disk drive itself. For example, EIDE and SATA hard drives have their disk controller circuit inside the drives.

7. Cooling System

Cooling system is used to maintain proper temperature inside the system unit. Various hardware such as CPU, video card or even the hard drive generate heat inside the system unit. The objective of cooling is to maintain an optimal operating temperature and this can be achieved through the introduction of

heat sinks and fans. If the temperature inside the system unit reaches a certain point, it can damage the parts. A fan is fixed on top of the microprocessor to cool it down. Heat sinks are also used to dissipate heat from the surface area of the motherboard. Many computers are designed to turn themselves off if the temperature exceeds certain level.

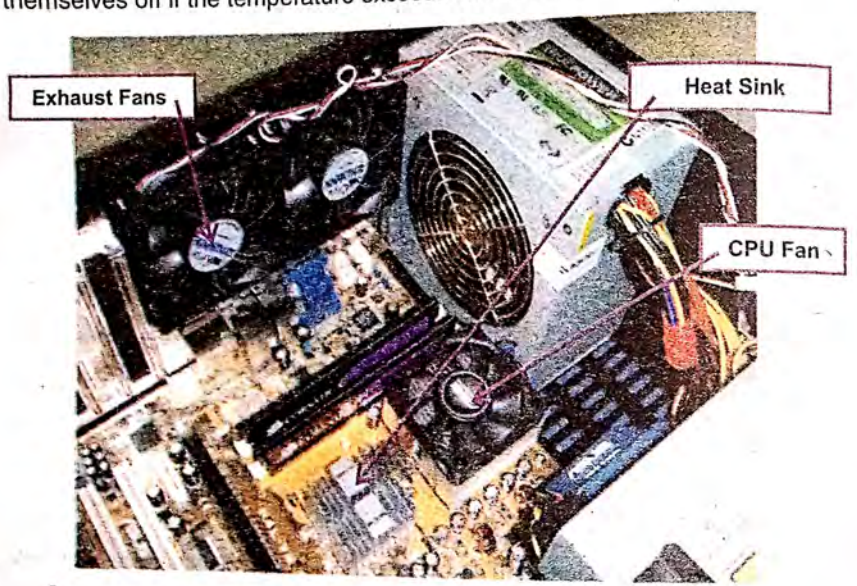


Figure 4.12 Cooling System

8. Computer Bus

Computer Bus is an electrical pathway or channel though which the processor communicates with internal and external device attached to the computer. Bus transfers data and instruction from and to processor from various devices. It connects all internal components to the main memory and Central Processing Unit (CPU). The size of the computer bus is important because it determines that how much data can be transferred at a time. Its speed is measured in the MHz and GHz.

The three types of computer buses are:

Data bus connects the CPU, memory and the other hardware devices on the motherboard.

Address bus connects the CPU and RAM.

Control bus is used to send control signals to different components of the computer system.

4.2 PORTS AND SLOTS ON MOTHERBOARD

Slots and Ports are physical connection points on the motherboard that allow the hardware of a computer to be expanded. A **Port** is a socket while a **Slot** is an opening for circuit boards.

4.2.1 Types of Ports

Ports are connectors used to connect external cables and devices to the motherboard. The following are some common types of ports.

a. **Serial Ports**
b. **Parallel Ports**
c. **PS/2 Port**
d. **USB Port**
e. **Fire Wire Port**

a. Serial Ports

A serial port is a serial communication physical interface through which information transfers in or out one bit at a time. These ports were used in old types of computers to connect devices like modems. Serial ports have 9 or 25 pins in which one pin is used for transmitting data and the rest are used to transmit control signals. These ports are called COM1, COM2 and COM3. These ports have been replaced with USB ports in modern computers.

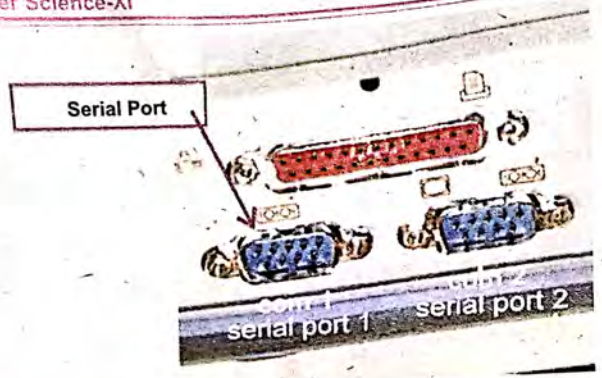


Figure 4.13 Serial Ports

b. Parallel Ports

A parallel port is a parallel communication physical interface. It is also known as a printer port. Parallel ports can transmit multiple bits over several wires at a time. These ports have 25 pins in which 8 pins transmit one byte of information and the others are used for transmitting control signals. Parallel ports are named as LPT1, LPT2 and LPT3. In today's modern computers parallel ports have been replaced with USB ports.

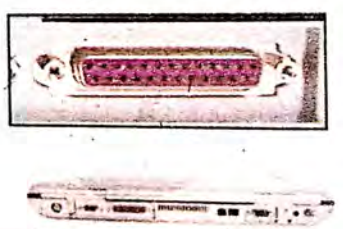


Figure 4.14 Parallel Port

c. PS/2 Port

The PS/2 connectors are used for connecting keyboard and mouse to a IBM compatible personal computer. Its name comes from the IBM Personal System/s series of personal computers which were introduced in 1987. The PS/2 mouse connector replaced the older serial mouse connector, while PS/2

keyboard connector replaced the larger keyboard connector used in the IBM PC/AT design.

The purple PS/2 connector is used for keyboard and green is used for mouse.

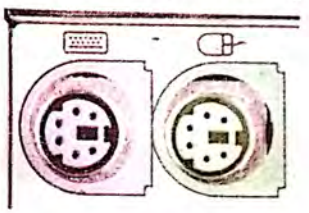


Figure 4.15 PS/2 Ports

d. USB Port

USB (Universal Serial Bus) is a serial port which provides a fast serial transmission between devices and computers. It is the most commonly used port in modern computers for connecting a large variety of devices to the computer such as printers, scanners, cameras, mouse, keyboard and USB flash drives. A computer has many USB ports and these are plug-and-play ports. Plug-and-play ports automatically detect and determine what type of device is attached to the computer. When a computer detects a plug-and-play device it automatically installs the driver for it or prompts the user to install it. USB has replaced old serial and parallel ports in computer systems.

Figure 4.16 USB Port

e. Fire wire Port

Fire wire is a high speed port which is used to connect video devices such as video Cameras, Camcorders, etc. to the computer system. Fire wire port has four or six pins. In a six pin connection, 2 extra pins are used to provide

electric power. Laptop computers have 4-pin fire wire port because they do not provide electric power to devices connected to it.

Figure 4.17 Fire wire Ports

4.2.2 Types of Expansion Cards

Expansion cards are circuit boards which are inserted into expansion slots on the motherboard. These cards provide new enhancements to the computer system such as sound, video, Internet access and network access.

Four common types of expansion cards are:

a. Sound Card
b. Video Card
c. Modem Card
d. Network Interface Card

a. Sound Card

Sound card also known as an audio card is an internal expansion card that facilitates the input and output of audio signals to and from a computer. A sound card plays voice as well as music files, and can handle various audio file formats. The typical sound card has an interface available at the back of the computer with various input and output ports.

Figure 4.18 Sound Card

b. Video Card

A video card also known as video adapter, graphics accelerator card, display card or graphics card is an expansion card whose function is to generate output images to a display unit. Some cards contain dual GPUs for additional performance. Because graphics cards work hard they generate heat. For this reason most high-performance video cards utilize built-in fans or heat sinks to pull heat away from the GPU.

Figure 4.19 Video Card

c. Modem Card

The term modem is derived from modulator and demodulator. The main purpose of modem is to convert digital data into analog signals before sending it over the transmission line and convert it to digital signal on the receiving computer.

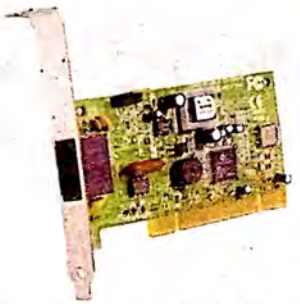


Figure 4.20 MODEM Card

d. Network Interface Card (NIC)

A network interface card also known as network interface controller, network adapter and LAN adapter is computer hardware component that connect a computer to a computer network. Usually NIC is installed as expansion card in the expansion slot, but most modern computers have built-in network interface cards on the motherboard.

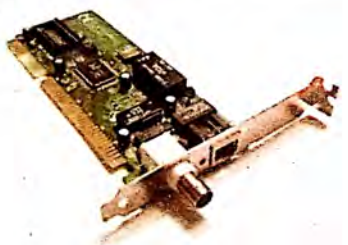


Figure 4.21 NIC

4.2.3 Memory Chips

Memory chips are integrated circuits that can either temporarily or permanently store data and code for processing. RAM chips (SIMM, DIMM, SDRAM, and DDR-SDRAM) are the computer's temporary workspace, while flash memory chips are permanent. ROM and PROM chips can never be changed, while EPROMs and EEPROMs can be modified.

The following are some common types of memory chips.

a. Single In-line Memory Module (SIMM)

A SIMM or single in-line memory module is type of RAM used in the computers from the early 1980s to the late 1990s. SIMMs were introduced in two flavors, 30 pin and 72 pin. 30-pin SIMMs provides 9 bits of data and was used in 286, 386, 486 models of computers and in some Macintosh models. The second variant, 72 pins SIMMs provides 32 bits of data and was used in 486, Pentium, Pentium Pro and even some Pentium II systems. SIMMs had storage capacity ranging from 56KB to 32MB.

Figure 4.22 SIMMS

b. Dual In-line Memory Module (DIMM)

DIMM (Dual in-line memory module) resides on a computer's motherboard. It is the upgraded form of SIMM. It has more storage capacity and operates at faster speeds than SIMM. One DIMM module can do the job of two SIMM modules. A DIMM memory module has a 168-pin connector and can transfer data at a rate of 64 bits.

DIMM memory modules allow multiple lines of communication within a computer. DIMM connectors link up to different circuits as opposed to a SIMM, which can only produce a single line of communication. Capacities of DIMMs range from 64MB to 512MB.

Figure 4.23 A DIMM

c. Synchronous Dynamic Random Access Memory (SDRAM)

SDRAM also known as single data rate (SDR) SDRAM, is dynamic random access memory (DRAM). SDRAM is a high speed semiconductor memory. It is an improved form of the older DRAM (Dynamic Random Access Memory). SDRAM operates synchronously, which means that it operates in sync with the system data bus. Therefore, it can operate at much greater speeds than non-synchronous RAM. SDRAM transmits data at the same clock speed as the CPU's internal clock, allowing for faster and more efficient data transfer. SDRAM is commonly used in modern computers and new generations like DDR (also known as DDR1), DDR2 and DDR3 are available in the market.

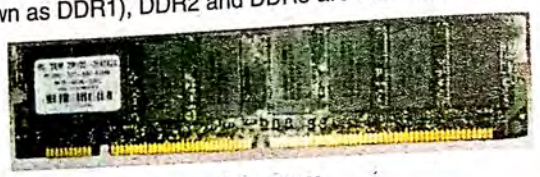


Figure 4.24 SDRAM

d. Double Data Rate Synchronous Random Access Memory (DDR SDRAM)

DDR SDRAM is type of SDRAM. The name "double data rate" refers to the fact that a DDR SDRAM can achieves nearly twice the bandwidth of a single data rate (SDR) SDRAM running at the same speed. It is improved SDRAM which allows a computer to transfer data at twice the speed. It has improved memory clock speed as compared to simple SDRAM. It reads or writes two consecutive words per clock cycle.

Figure 4.25 DDR SDRAM

SUMMARY

- The System Unit is core of a computer system. Usually it is a rectangular box with many electronic components that make the entire system.
- A computer case also known as computer chassis, cabinet, box, tower, enclosure, housing, system unit or simply case is the enclosure that contains most of the components of computer system.
- A power supply unit is the component that supplies power to the other components of a computer system.
- Motherboard is the main circuit board in computer system that hold main component of the system unit.
- Basic Input Output System (BIOS) also known as the System BIOS or simply BIOS is the firmware built into the computer system.
- A port is a piece of equipment to which a plug or cable is connected.
- Expansion slot is an opening or socket in a computer mainboard where a circuit board or expansion card can be inserted to add new functionalities to the computer.
- The Accelerated Graphics Port (AGP) is a high-speed point-to-point channel (pathway), primarily used for 3D computer graphics.
- The Peripheral Component Interconnect (PCI) is a computer bus (an electric pathway) for attaching hardware device in a computer.
- A ribbon cable also known as multi-wire planar cable is a cable with many conducting wires running parallel to each other on the same flat plane.

- SATA (Serial Advanced Technology Attachment) is a new technology cable for connecting storage drives to computer.
- A computer memory slot is a socket or opening in computer main board in which the main memory chip is installed.
- Disk controller is the circuit which enables the CPU to communicate with disk drives.
- Cooling system is used to maintain proper temperature inside the system unit.
- Computer Bus is an electrical pathway or channel through which the processor communicates with internal and external devices attached to the computer.
- A serial port is a serial communication interface through which information transfers in or out one bit at a time.
- A parallel port is a parallel communication interface.
- USB (Universal Serial Bus) is a serial port which provides a fast serial transmission between devices and computers.
- Fire wire is a high speed port which is used to connect video devices such as video Cameras, Camcorders. to the computer system.
- Sound card also known as an audio card, is an internal expansion card that facilitates the input and output of audio signals to and from a computer.

- A video card also known as video adapter, graphics accelerator card, display card or graphics card is an expansion card whose function is to generate output images to a display unit.
- A network interface card also known as network interface controller, network adapter and LAN adapter is computer hardware component that connect a computer to a computer network.
- Memory chips are integrated circuits that can either temporarily or permanently store data and code for processing.
- A SIMM or single in-line memory module is type of RAM.
- DIMM (Dual in-line memory module) is the upgraded form of SIMM.
- SDRAM (Single Data rate RAM) is a high speed semiconductor memory.
- DDR SDRAM (Double Data rate SDRAM) is twice the bandwidth of a single data rate (SDR) SDRAM.

EXERCISE

Q1. Select the best choice for the following MCQs.

i. _____ changes alternating current (AC) to low-voltage direct current (DC) to operate the processor and peripheral devices.
A. Motherboard
B. Power Supply
C. Output Unit
D. Register

ii. Which of the following is the firmware built into the computer system?
A. Slot
B. RAM
C. Port
D. BIOS

iii. _____ are openings or sockets in a computer motherboard where a circuit board or expansion card can be inserted to add new functionalities to the computer.
A. BIOS
B. Ports
C. Power Supplies
D. Expansion Slots

iv. Which of the following port is a high-speed point-to-point channel (pathway), primarily used for 3D computer graphics?
A. AGP
B. PCI
C. PCIe
D. ISA

v. _____ is a new technology cable for connecting storage drives to computer.
A. IDE
B. PCIe
C. FD
D. SATA

vi. Which of the following is the fastest slot?
A. AGP
B. PCI
C. PCIe
D. ISA

vii. _____ is the circuit which enables the CPU to communicate with disk drives.
A. Memory
B. Disk controller
C. Bus
D. Port

viii. _____ is the most commonly used port in modern computers for connecting a large variety of devices to the computer.
A. USB
B. PS/2
C. Fire wire
D. LPT1

ix. Which of the following cards facilitates the input and output of audio signals to and from a computer?
A. Video Card
B. Modem Card
C. Sound card
D. Network Interface Card

x. What does SIMM stand for?
A. System in-line memory module
B. Synchronous in-line memory module
C. Single in-line memory module
D. Serial in-line memory module

Q2. Give short answers to the following questions.

i. Differentiate between CPU and System unit.
ii. Define two main types of computer casings.
iii. List different parts of a motherboard.
iv. What is role of BIOS in computer system?
v. Differentiate between a port and a slot.
vi. Name different types of data cables with their purpose of use.
vii. Why cooling system is important for a computer?
viii. Differentiate between SIMM and DIMM.

Q3. Give detailed answers to the following questions.

i. Discuss different types of expansion cards.
ii. What is port? Explain different types of ports in computers.
iii. Explain different types of ribbon cables.
iv. Discuss different types of memory chips.
v. What is Bus? Explain different types of buses in computers.
vi. Write note on SDRAM and DDR SDRAM.

UNIT 5

NETWORK COMMUNICATION AND PROTOCOLS

After the completion of Unit - 5, the Students will be able to:

- explain basic network components (Sender, Receiver and Medium).
- explain modes of communication (simplex, half-duplex and full-duplex).
- describe communication media (Guided and Un-guided).
- explain communication devices (Switch, Router and Gateway).
- explain network architecture (Client, Server and Peer-to-Peer).
- explain network types (LAN, MAN, WAN and VPN).
- explain network topologies (Star, Ring, Bus and Mesh).
- identify the purpose of communication standards.
- understand OSI Model and concepts of its layers.
- provide examples of protocols and devices at each layer of OSI Model.
- describe TCP/IP protocol suite used for communication over the Internet.
- compare the TCP suite with OSI Model.
- differentiate between circuit switching and packet switching.
- describe IP addressing schemes (Classes, Masks and Subnets).

5.1 COMPUTER NETWORK

A network is a collection of computers or nodes that communicate with each other on a shared network medium. A computer network is a collection of two or more connected computers to share the resources and data. When these computers are joined in a network, people can share different files and devices such as modems, printers and tape drives. A typical computer network is shown in Figure 5.1.

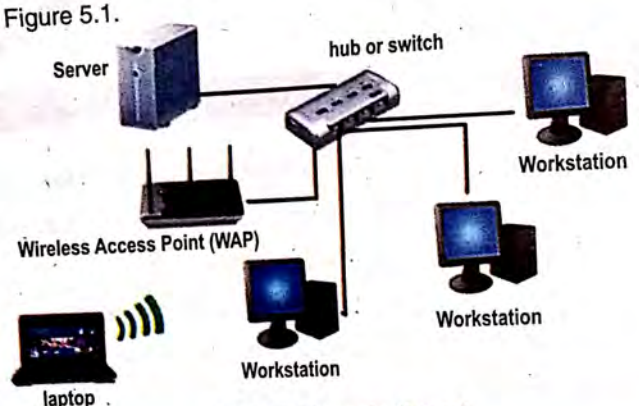


Figure 5.1 Computer Network

5.1.1 Basic Data Communication Components

The data communication is the movement or transmission of data between two devices or computers. OR, it is the transfer of data between two points either in analog or digital form via a communication medium.

A data communication system consists of five basic components.

a. Sender
b. Message
c. Medium
d. Protocol
e. Receiver

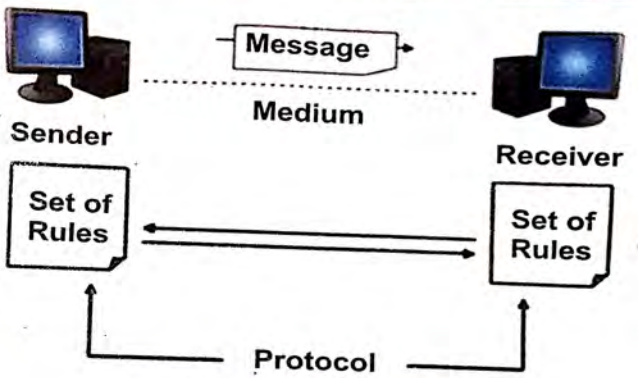


Figure 5.2 Basic Network components

a. Sender

Sender or Transmitter is a device that sends the message. It may be a computer, workstation, telephone handset or video camera. The transmitter converts the electrical signal into a form that is suitable for transmission through the physical channel or transmission medium. For example, TV broadcast, there is a specific frequency range for each channel. Hence the sender (TV broadcast station) must translate the information signal to be sent into the appropriate frequency range that matches the frequency assigned to the sender. Thus the signals transmitted by multiple channels do not interfere with another.

b. Message

Message is the data or information that is to be transmitted. Message can be number, video, text or any combination of these.

c. Medium

Medium is the physical path that message uses to travel from source to destination. It can be fiber optic cable, coaxial cables, twisted pair cable and even can be wireless media. Medium is also called a channel. Telephone

system, Internet, and many other electronic systems use wires. Television and radio can use electromagnetic radiations (wireless medium).

d. Receiver

Receiver is the device which receives transmitted message. It can be a computer, workstation, telephone handset or television set.
The data received from the transmission medium may not be in proper form to be accepted to the receiver and it must be converted to appropriate form before it is received. There are five receiving steps in the process of communication; i.e. Receive, Understand, Accept, Use, and Give a Feedback. Without these steps communication process may not be completed and successful.

e. Protocol

A protocol is a set of rules that governs data communications. It represents an agreement between the communicating devices. Without a protocol, two devices connected may not able to communicate with each other.

5.1.2 Modes of Communication

Modes of data transmission refer to the methods or ways information is transmitted from one place to another. Following are the different categories of data transmission modes which are:

a. Simplex, half-duplex and full-duplex
b. Synchronous and Asynchronous

a. Simplex, half-duplex and full-duplex

i. Simplex mode

In Simplex mode, the communication takes place in only one direction. In this mode, a node can only send data and cannot receive or it can only receive data but cannot send. In this mode communication is uni-directional, for

example communication from a central computer to a dumb terminal. The communication can only take place in one direction and it is not possible for the receiver to send data back. Another example of simplex transmission would be data being sent to an electronic notice board such as those found in train stations and airports.

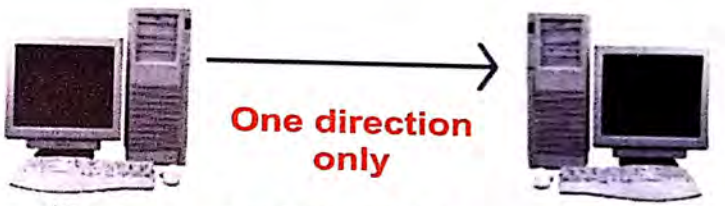


Figure 5.3 Simplex Mode

ii. Half-Duplex mode

In half-duplex mode, each station can both transmit and receive data, but not at the same time. Each end of the communications link acts as sender and receiver. An example of this type of communication is the use of walkie-talkies, where each of the persons communicating must indicate when they have finished speaking.

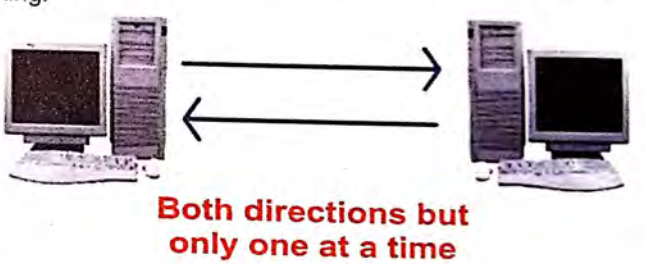


Figure 5.4 Half-duplex Mode

iii. Full-Duplex mode

In full-duplex mode, both stations can send and receive the data simultaneously, for example two or more computers connected to a network device such as a switch that provides full duplex activity. It is the fastest bi-directional mode of communication. The full-duplex mode is like a two way

eet, with traffic flowing in both directions at the same time. In full-duplex ode, signals going in one direction share the capacity bandwidth of the ıedium with signals going in the other direction. This sharing can occur in two vays, either the link must contain two physically separate transmission paths, ɔne for sending and the other for receiving; or the capacity of the channel is divided between signals traveling in both directions.

One common example of full-duplex communication is the telephone network. When two people are communicating by a telephone line, both can talk and listen at the same time.

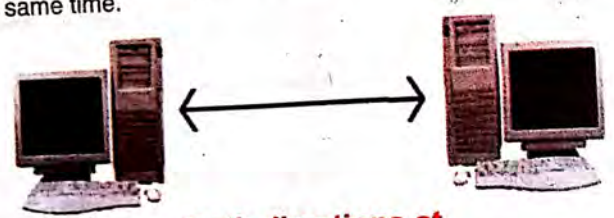


Figure 5.5 Full-duplex Mode

b. Synchronous and Asynchronous

Another way of classifying data communications flow is as synchronous or asynchronous.

i. Synchronous Transmission

In synchronous transmission, large volumes of information can be transmitted at a time. In this type of transmission, data is transmitted block-by-block or word-by-word simultaneously. Each block may contain several bytes of data. In synchronous transmission, a special communication device known as synchronized clock is required to schedule the transmission of information. With synchronous transmission, large blocks of bytes are transmitted at regular intervals without any start/stop signals. Synchronous transmission requires that both the sending and receiving devices be synchronized before data is transmitted. Synchronous transmission requires more expensive

equipment but provides greater speed and accuracy than asynchronous transmission. This type of transmission is appropriate for computer systems that need to transmit great quantities of data quickly.

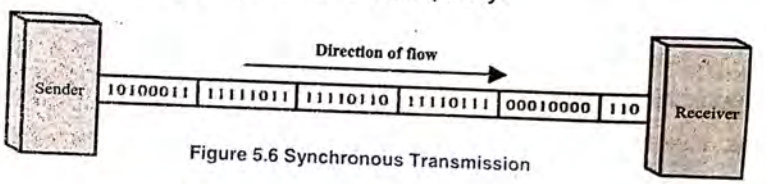


Figure 5.6 Synchronous Transmission

ii. Asynchronous Transmission

In asynchronous transmission, data is transmitted one byte at a 'time'. This type of transmission is most commonly used by microcomputers. The data is transmitted character-by-character. In asynchronous transmission, transmission does not occur at predetermined or regular intervals (i.e., not synchronized). A sending device can transmit bytes at any time, and the receiving device must be ready to accept them as they arrive. A start bit marks the beginning of a byte and a stop bit marks the end of the byte. An additional bit called a parity bit is sometimes included at the end of each byte to allow for error checking. Asynchronous transmission usually involves communications in which data can be transmitted intermittently instead of in a steady stream. It is so named because the timing of the signal is not important. Asynchronous transmission is relatively slow.

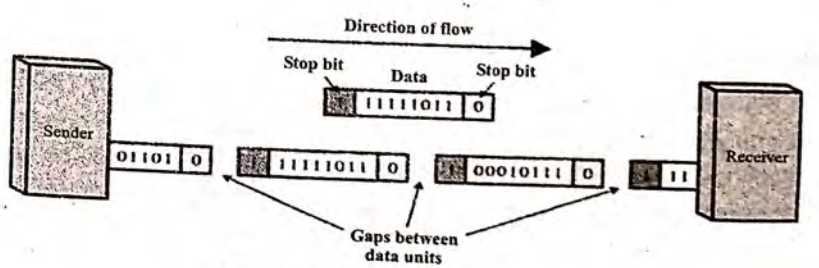


Figure 5.7 Asynchronous Transmission

5.1.3 Communication Media

Communication media are the links that provide paths for communicating devices. It is an important part of communication model. Transmission medium should provide communication with good quality.
Communication media can be classified into two main types.

a. Guided Communication Media
b. Unguided Communication Media

a. Guided Communication Media

Guided media are the physical links in which signals are confined along a narrow path. These are also called bounded media. Three common types of bounded media are:

i. Twisted Pair Cable
ii. Coaxial Cable
iii. Fiber Optic Cable

i. Twisted Pair Cable

Twisted Pair Cable is formed of two insulated copper wires twisted together. The wires are twisted with each other to minimize interference from other twisted pairs cable. Twisted wire pairs have fewer bandwidths than coaxial cable or optical fiber cable.
There are two types of twisted pair cables; shielded and unshielded.

Unshielded Twisted Pair (UTP) Cable:

UTP is the most commonly used networking wire. It is inexpensive, flexible, and light, thus making it very easy to work with. The quality of UTP may vary from telephone-grade wire to extremely high-speed cable. The cable has four pairs of wires inside the jacket. The unshielded twisted pair provides a bandwidth of 100 Kbps (Cat 1) to 1000 Mbps (Cat 7).The standard connector for unshielded twisted pair cabling is an RJ-45 connector.

Shielded Twisted Pair (STP) Cable

The difference between the UTP and STP is that the STP uses metallic shield wrapped to protect the wire from interference. Shielded cables can help to extend the maximum distance of the cables. Data rate of STP is from 16 to 155 Mbps. It costs more than UTP.

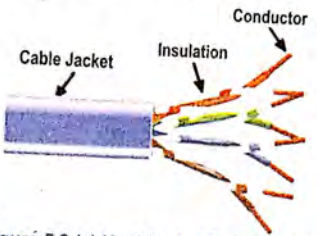


Figure 5.8 (a) Unshielded Twisted Pair Cable

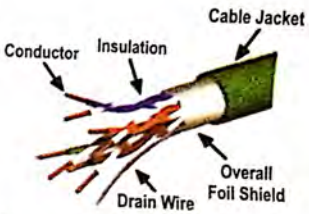


Figure 5.8 (b) Shielded Twisted Pair Cable

ii. Coaxial Cable (Coax)

A Coaxial Cable (Coax) has a central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid, or a combination of the two. The outer metallic wrapping is a second conductor to complete the circuit and shield against noise. This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover.
Because coaxial cables have very little distortion and are less prone to interference, they have low error rates. Although coaxial cabling is difficult to install, it is highly resistant to signal interference. In addition, it can support greater cable lengths between network devices than twisted pair cable.

Figure 5.9 Coaxial Cable

iii. Optical Fiber Cable

An optical fiber consists of a very narrow strand or fiber of glass called the core. The core is surrounded by a concentric layer of glass called Cladding. The cladding is covered by a protective coating of plastic jacket. It transmits signals in the form of light rather than electronic signals. This eliminates the problem of electrical interference. The Fiber optic uses total internal reflection to guide light signals through a channel. A glass or plastic core is surrounded by a cladding of less dense glass or plastic. The difference in the density of the two materials causes the beam of light moving through the core. No light escapes the glass core because of this reflective cladding.

The fiber-optic cable is becoming more popular. Now a days, telephone, Internet and television companies are replacing their existing cables with fiber optic cables. Fiber optic cable has bandwidth more than 2 Gbps (Gigabytes per Second).

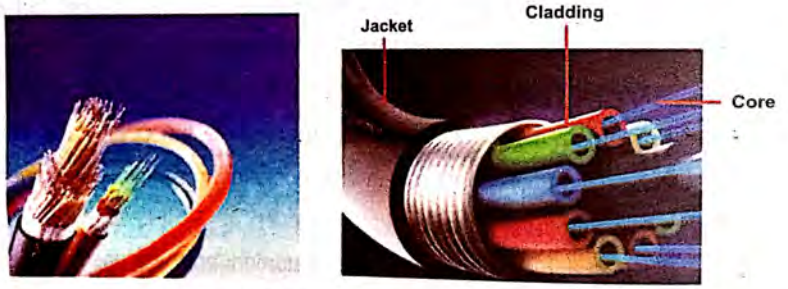


Figure 5.10 (a) Fiber Optic Cable

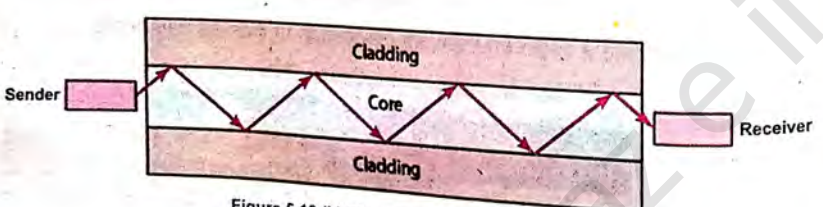


Figure 5.10 (b) Fiber Optic Mechanism

b. Unguided Communication Media

Unguided media also called Wireless media transports signals without using any physical conductor between the two devices communicating. Signals are normally broadcast through the air and thus are available to anyone who has the device capable of receiving them.

The commonly used wireless transmission media are:

i. Radio waves
ii. Micro waves
iii. Infrared waves

i. RADIO WAVES

Radio wave distributes radio signals through the air over long distances such as between cities, regions, and countries, and short distances such as within an office or home. Radio waves are normally multi-directional. When an antenna transmits radio waves, they are propagated in all directions. The multi-directional characteristics of radio waves make them useful for multicasting, in which there is one sender but many receivers. It has frequency between 10 KHz to 1 GHz. Our AM and FM radio stations, cordless phones and televisions are examples of multicasting.

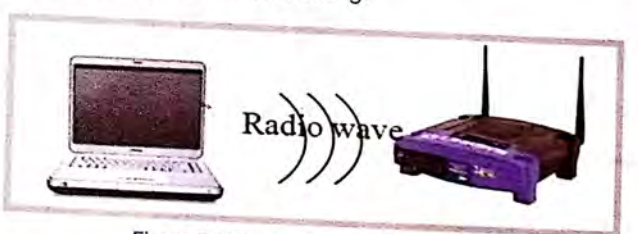


Figure 5.11 Radio wave Transmission

ii. MICRO WAVES

Micro wave is a wireless transmission technology that travels at high frequency than radio waves and provides high throughput as a wireless network media. Micro wave transmission requires the sender to be in line of

sight of the receiver. Electronic waves with frequencies between 1 GHz to 300 GHz are normally called microwaves. Micro waves are used to transmit wireless signals across a few miles. Unlike radio waves, microwaves are unidirectional, in which the sending and receiving antennas need to be aligned. Microwave stations or antennas are usually installed on the high towers or buildings. Microwaves propagation is line-of-sight therefore towers with mounted antennas need to be in direct sight of each other. Mobile telephone companies use microwave technology.

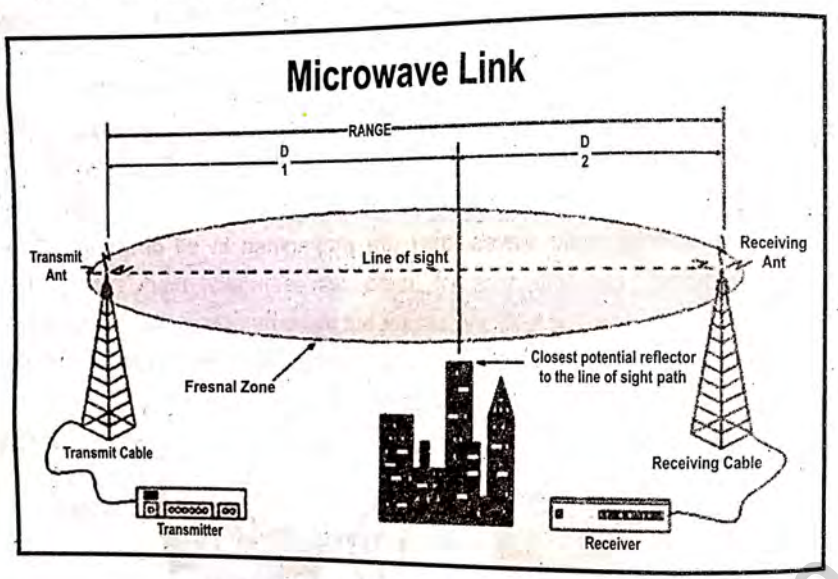


Figure 5.12 Microwave transmission

For long distance communication **Satellite Microwave** technology is used. A communications satellite is a device that receives microwave signals from an earth-based station, amplifies the signals, and broadcasts the signals back over a wide area to any number of earth-based stations. Satellite micro wave transmission is used to transmit signals throughout the world.

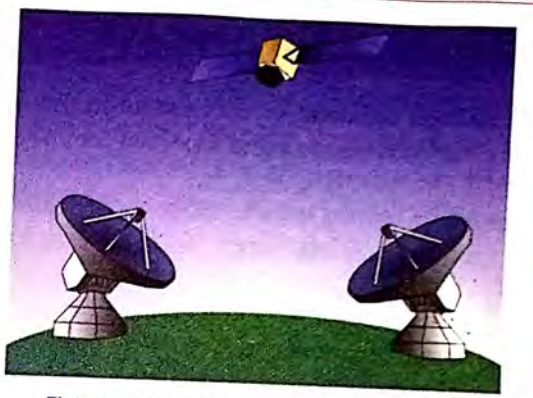


Figure 5.13 Satellite Transmission System

iii. Infrared

Infrared is a short-distance wireless transmission medium that sends signals using infrared light waves. Infrared frequencies are just below visible light. These high frequencies allow high speed data transmission. This technology is similar to the use of a remote control for a TV. Infrared transmission can be affected by objects obstructing sender or receiver.

Infrared is used in devices such as the mouse, wireless keyboard and printers. With infrared, computers can transfer files and other digital data bi-directionally. Infrared adapters are installed in many laptops, handheld personal devices and mobile phones.

Figure 5.14 Infrared

5.1.4 Communication Devices

Communication devices are used for communication between the computers or other devices. The following are some important communication devices.

a. Switch
b. Router
c. Gateway

a. Switch

A network switch or hub is a device that connects network nodes to a central location. Switch is also called layer 2 device because it operates on OSI data link layer. Switch does not generally encompass unintelligent device such as hubs and repeaters. Network switches appear nearly identical to network hubs but a switch generally contains more intelligence than a hub because it maintains MAC table. Unlike hubs, network switches are capable of inspecting data packets as they are received determining the source and destination device of each packet and forwarding them.

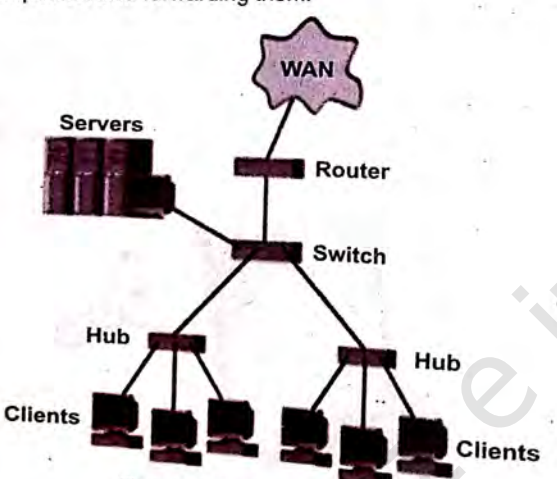


Figure 5.15 Communication Devices

b. Router

Router is a device that forwards data packets across different networks. A router performs traffic directing functions on the Internet. A router is a microprocessor controlled device that is connected to two or more data lines from different networks. When a data packet comes in, the router reads the destination address in the packet. Using information in its routing table it directs the packet to the next network. A data packet is typically passed from node to node until it reaches the destination. Router operates on Network layer of OSI Model. Routing can be static or dynamic. Router determines the best route for the packets to destination.

A router normally connects LANs and WANs in the Internet with the help of routing table. For example a router can be used to distribute one Internet connection to many computers in a University or College LAN.

c. Gateway

A gateway is a hardware device or a computer running software that allows communication between networks with dissimilar network protocols or architectures. The gateway has an interface to each of the networks to which it is connected. Generally, congestion on connected networks is avoided by keeping local traffic confined to the network on which it originates, except when the packets are destined for another network. The gateway has the responsibility of acting as the switch that allows such packets to go from one network to another.

Gateways are very intelligent devices. A gateway can translate information between different network data formats or network architectures. It can translate TCP/IP to AppleTalk so computers supporting TCP/IP can communicate with Apple brand computers. Most gateways operate at the application layer, but can operate at the network or session layer of the OSI model. Gateways will start at the lower level and strip information until it gets

to the required level and repackage the information and work its way back toward the hardware layer of the OSI model.

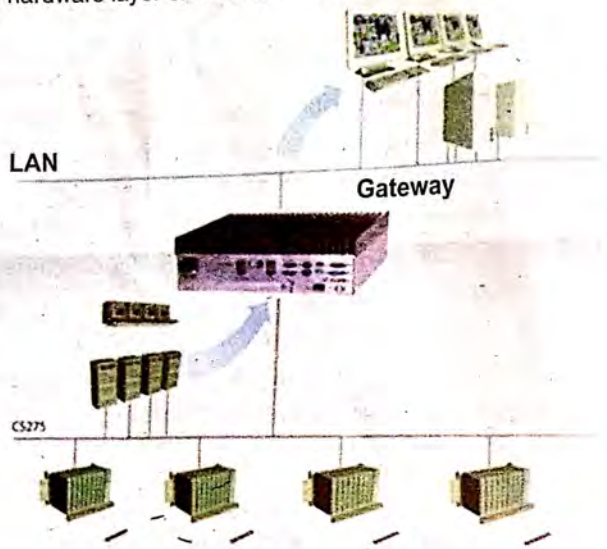


Figure 5.16 Network Gateway

5.1.5 Network Architecture

A computer network is a collection of computers and devices interconnected by communications channels that facilitate communications among users and allow users to share resources and data. Network Architecture is the complete framework of any computer network. It refers to the logical and structural layout of the network, consisting of the hardware, software, connectivity, communication protocols and mode of transmission, such as wired or wireless.

The following are some important network architectures.

a. Client Server Network Architecture
b. Peer to Peer Network Architecture

a. Client/Server Network Architecture

Server is a powerful computer that provides centralized administration of the network and serves up the resources that are available on the network, such as printers and files.

Client on the other hand is a network device that participates in a client/server relationship by requesting a service from a server. It may be a computer that allows a user or users to log on to the network and take advantage of the resources available on the network.

The client/server Architecture is particularly recommended for networks requiring a high degree of reliability. The term Client/server refers to the concept of sharing the work involved in processing data between the client computer and the server computer.

The client begins the exchange by requesting data from the server. The server responds by sending one or more streams of data to the client. In addition to the actual data transfer, this exchange may also require control information, such as user authentication and the identification of a data file to be transferred.

Example:

One example of a client/server network is a corporate environment where employees use a company e-mail server to send, receive and store e-mail. The e-mail client on an employee computer issues a request to the e-mail server for any unread mail. The server responds by sending the requested e-mail to the client. Data transfer from a client to a server is referred to as an upload and data from a server to a client as a download.

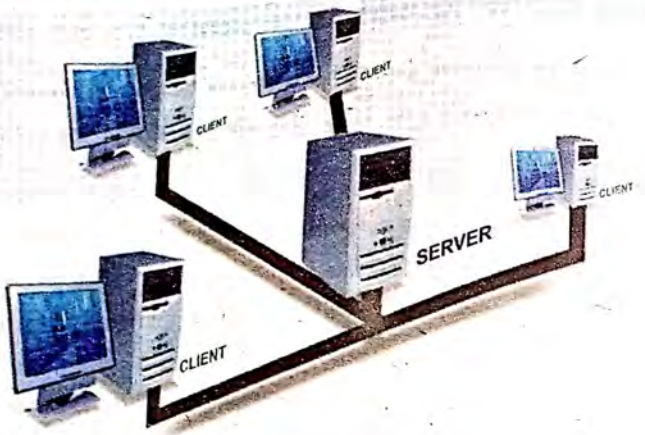


Figure 5.17 Client/Server Network

Advantages of a client/server network

- **Centralized Resources:** Server is the centre of the network and it can manage resources that are common to all users.
- **Improved security:** Server provides better security to network users.
- **Scalable network:** It is possible to remove or add clients without affecting the operation of the network and without the need for major changes.
- **Flexibility:** New technology can be easily integrated into the system.
- **Interoperability:** All components (client/network/server) work together.

Disadvantages of a client/server network

- **Expensive:** Requires high initial investment in dedicated server.
- **Maintenance:** Large networks will require a staff to ensure efficient operation and maintenance.
- **Dependence:** When server goes down, operations will cease across the network.

Most LANs consist of many clients and a few servers. While one server always controls user logons, other servers can specialize in providing certain types of resources.

b. Peer-to-Peer Network Architecture

In peer-to-peer networking there are no dedicated servers or hierarchy among the computers. Peers i.e. computers are equally privileged nodes in the network. Peer-to-peer network allow users to share resources and files located on their computers and to access shared resources found on other computers. In a peer-to-peer network, all computers have equal status and therefore known as peers. They all have the same abilities to use the resources available on the network. Peer-to-peer networks are designed primarily for small to medium local area networks. Nearly all modern desktop operating systems, such as Macintosh OSX, Linux, and Windows, can support peer-to-peer network. A peer computer basically acts as both a client and a server computer.

The only requirements for building a peer-to-peer network include installing an operating system on the PCs that supports peer-to-peer networking and then physically connecting the PCs through some medium.

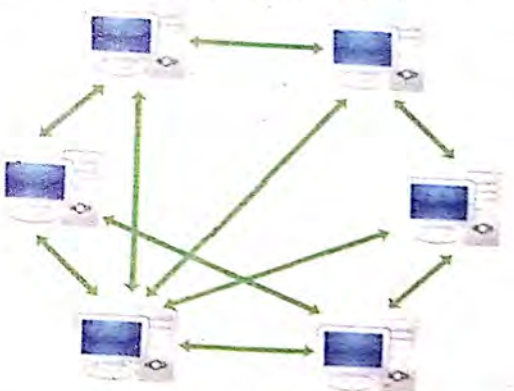


Figure 5.18 Peer-to-peer Network

Advantages of a peer-to-peer network

- **Less initial expense**: No need for a dedicated server.
- **Setup:** An operating system (such as Windows) already in place may only need to be reconfigured for peer-to-peer operations.

Disadvantages of a peer-to-peer network

- **Decentralization:** No central storage for files and applications.
- **Less Secure:** Does not provide the security available as on a client/server network.

5.1.6 Network Types

Network can be classified into following types.

a. Local Area Network (LAN)
b. Metropolitan Area Network (MAN)
c. Wide Area Network (WAN)
d. Virtual Private Network (VPN)

a. LAN (Local Area Network)

LAN (Local Area Network) is a network that connects computers and devices in a limited geographical area like home, school, and office building. Each computer or device on the network is called a node. LANs are most likely to be based on Ethernet technology. A LAN is useful for sharing resources like files, printers, games or other applications. A LAN can be wired or wireless. A wired LAN requires Ethernet cable to physically connect all computers on the network to a central device called a switch or hub. A wireless LAN uses radio waves to communicate.

Data transfer speeds over a local area network can reach up to 10 Mbps (such as for an Ethernet network) and 1 Gbps (as with FDDI or Gigabit Ethernet). A local area network can reach as many as 100, or even 1000, users.

A local area network's linkages usually are accomplished with either telephone, coaxial, or fiber-optic cables.
There are two basic reasons for developing a LAN:

- Information sharing: This refers to having users who access the same data files, exchange information via electronic mail, or search the Internet for information. The main benefit of information sharing is improved decision making, which makes it generally more important than resource sharing.
- Resource sharing: It refers to one computer sharing a hardware device (e.g., a printer) or a software package with other computers on the network. The main benefit of resource sharing is cost savings.

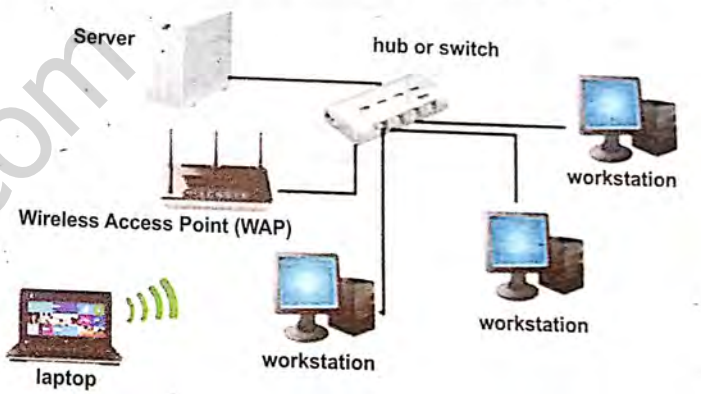


Figure 5.19 Local Area Network

b. MAN (Metropolitan Area Network)

A metropolitan area network is a computer network that usually spans a city or in a large metropolitan area. MAN usually interconnects a number of local area networks (LANs) using a high-capacity backbone technology. MAN might be owned and managed by a single organization.

Metropolitan Area Network connects multiple geographically nearby LANs to one another (over an area of up to a few dozen kilometers). Recent use of MAN technology has been the rapid development of cellular phone systems.

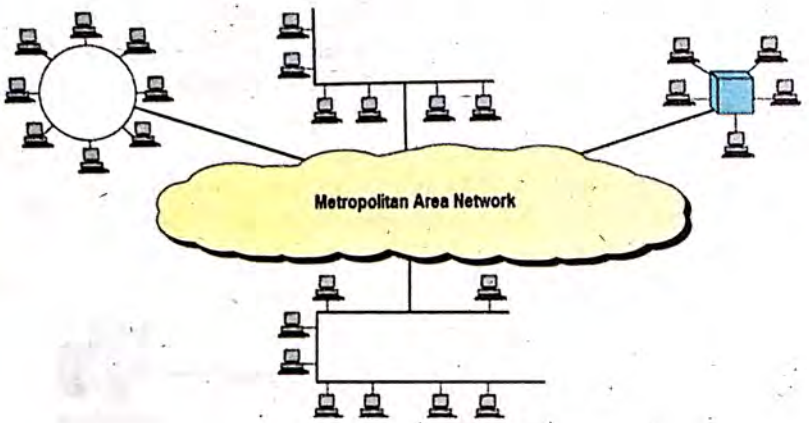


Figure 5.20 Metropolitan Area Network

c. WAN (Wide Area Networks)

WAN (Wide Area Network) covers large distance for communication between computers. Its nodes may span cities, states, or even countries. It interconnects many LANs and MANs. WAN uses fiber optics, microwaves and satellites technology for communication. For example, nationwide ATM (Automated Teller Machines) used in banking represent a common application of a wide area network.

The most well-known WAN is the **Internet**, which may cover the entire globe. Most WANs (like the Internet) are not owned by any one organization but rather exist under collective or distributed ownership and management.

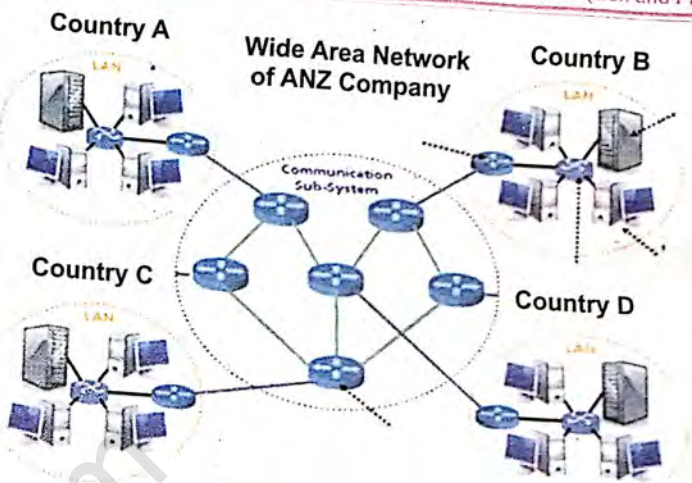


Figure 5.21 Wide Area Network

d. VPN (Virtual Private Network)

A virtual private network (VPN) is a network that uses a public telecommunication infrastructure, such as the Internet or a private network owned by a service provider to provide remote offices or individual users with secure access to their organization's network. A virtual private network can be contrasted with an expensive system of owned or leased lines that can only be used by one organization. The goal of a VPN is to provide the organization with the same capabilities, but at a much lower cost.

A VPN works by using the shared public infrastructure while maintaining privacy through security procedures.

Large corporations, educational institutions, and government agencies use VPN technology to enable remote users to securely connect to a private network. In order to gain access to the private network, a user must be authenticated using a unique identification and a password.

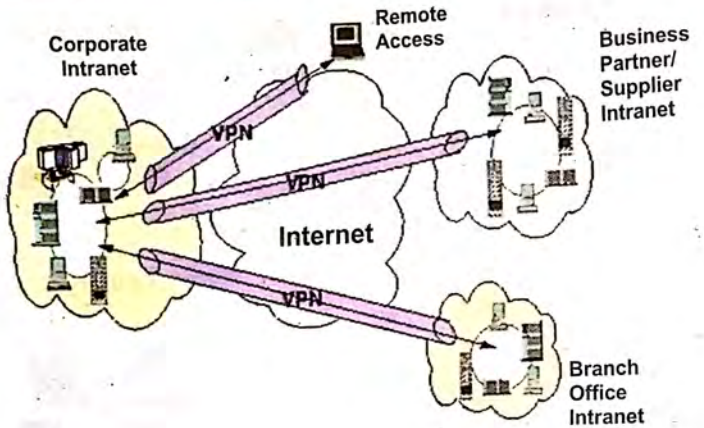


Figure 5.22 Virtual Private Network

5.1.7 Network Topologies

Network Topology refers to the physical layout and connectivity of computers in a network. Network topologies are categorized into the following four basic types.

a. Star
b. Ring
c. Bus
d. Mesh

a. Star Topology

In a star topology all the nodes (server, workstations, peripherals) on the network are connected directly to a centralized connectivity device called a hub, switch, or router. Each computer is connected with its own cable to a port on the hub. Data on a star network passes through the hub, switch, or router

before continuing to its destination. The hub, switch, or router manages and controls all functions of the network. It also acts as a repeater for the data flow. This configuration is common with twisted pair cable; however, it can also be used with coaxial cable or fiber optic cable.

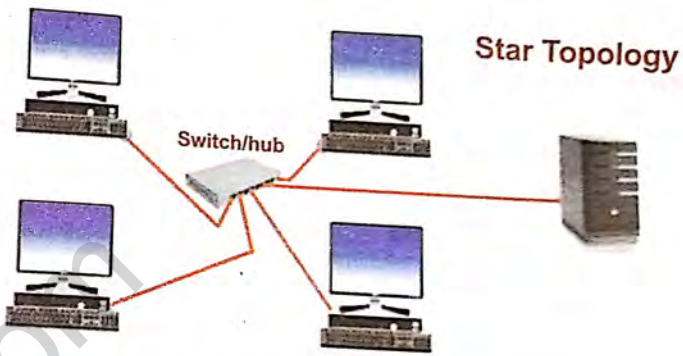


Figure 5.23 Star Topology

Advantages of a Star Topology

- Centralized management. It helps in monitoring the network.
- Easy to install and configure.
- No disruptions to the network when connecting or removing devices.
- Easy to detect faults and to remove parts.
- Failure of one node or link doesn't affect the rest of network.

Disadvantages of a Star Topology

- Requires more cable than a Bus topology.
- If the hub, switch, or concentrator fails, nodes attached become disable.
- More expensive than linear bus topologies because of the cost of the hubs.

b. Ring Topology

In a ring topology, every node is logically connected to two other preceding and succeeding nodes, forming a ring. Traffic flows through the entire ring until it reaches its destination.

Data packets travel in a single direction around the ring from one network device to the next. Each network device acts as a repeater, meaning it regenerates the signal the packets they receive and then send them on to the next computer in the ring.

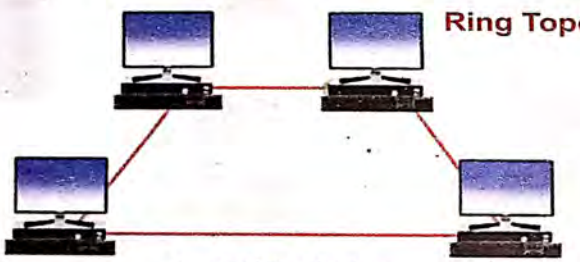


Figure 5.24 Ring Topology

Advantages of Ring Topology

- Even when the load on the network increases, its performance is better than that of Bus topology.
- There is no need for network server to control the connectivity between workstations.
- Additional components do not affect the performance of network.
- Each computer has equal access to resources.

Disadvantages of Ring Topology

- Each packet of data must pass through all the computers between source and destination. This makes it slower than Star topology.
- If one workstation or port goes down, the entire network gets affected.

- Network is highly dependent on the wire which connects different components.
- Ring topologies can be difficult to troubleshoot.
- Adding or removing computers from this type of topology can disrupt the operation of the network.

c. Bus Topology

In the bus topology, each node (computer, server or peripheral device) is attached to a single common cable. This topology type is considered a passive topology because the computers on a bus just sit and listen. When they "hear" data on the wire that belongs to them, they accept that data. When they are ready to transmit, they make sure no one else on the bus is transmitting and then they send their packets of information on the network.

Bus network typically uses coaxial networking cable hooked in to each computer using a T-connector. Each end of the network is terminated using a terminator specific to a cable.

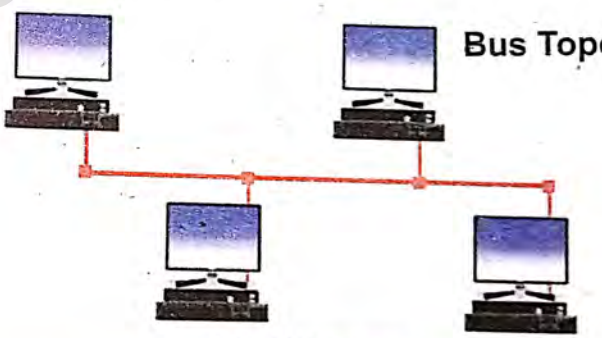


Figure 5.25 Bus Topology

Advantages of a Bus Topology

- Bus topology costs very less.
- Easy to connect a computer or peripheral to a linear bus.

- Requires less cable length than a other topologies.
- It is easy to set-up and extend bus network.
- Linear Bus network is mostly used in small networks.

Disadvantages of a Bus Topology

- Entire network shuts down if there is a break in the main cable. Loose and detached connections may also affect the entire network.
- There is a limit on central cable length and number of nodes that can be connected.
- Proper termination is required to dump signals. Use of terminators is must.
- It is difficult to detect and troubleshoot fault at individual station.
- It is not suitable for networks with heavy traffic.

d. Mesh Topology

In a mesh network topology, each of the network node, computer and other devices, are interconnected with one another.

In a full mesh, every device in the network is connected to every other device. In reality, a partial mesh is commonly used in backbone environments to provide fault-tolerant connections between critical servers and network devices. Unlike each of the previous topologies, messages sent on a mesh network can take any of several possible paths from source to destination. This type of topology is very expensive as there are many redundant connections, thus it is not mostly used in computer networks. It is commonly used in wireless networks. Flooding or routing technique is used in mesh topology.

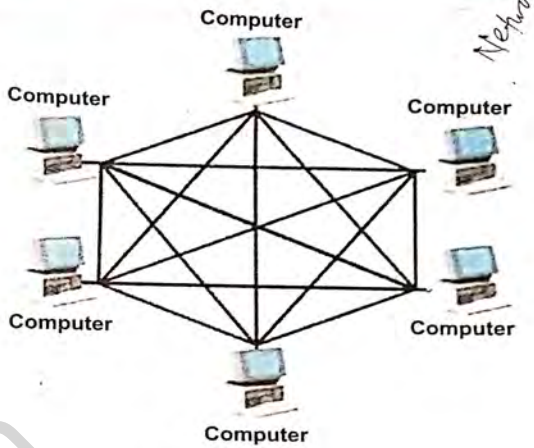


Figure 5.26 Mesh Topology

Advantages of Mesh topology

- Data can be transmitted from different devices simultaneously. This topology can withstand high traffic.
- Even if one of the components fails there is always an alternative link present. So data transfer doesn't get affected.
- Expansion and modification in topology can be done without disrupting other nodes.

Disadvantages of Mesh topology

- There are high chances of redundancy in many of the network connections.
- Overall cost of this network is too high as compared to other network topologies.
- Set-up and maintenance of this topology is very difficult. Even administration of the network is challenging.

5.2 DATA COMMUNICATION STANDARDS

Data communication standards, also called Network protocols, are set of rules that coordinate the exchange of information in Computer networks.

5.2.1 Purpose of Communication Standards

Communication Standards provide guidelines (also called rules or protocols) to manufacturers, vendors, government agencies, and other service providers to ensure the kind of interconnectivity of networks for communication. These standards define how computers identify one another on a network, the form that the data should take in during transmission, and how this information is processed once it reaches its final destination. Some examples of communication standards are TCP/IP (for UNIX, Windows NT, Windows 95 and other platforms), IPX (for Novell NetWare), DECnet (for networking Digital Equipment Corp. computers), AppleTalk (for Macintosh computers), and NetBIOS/NetBEUI (for LAN Manager and Windows NT networks).

5.2.2 Open System Interconnection (OSI) Model

OSI Model is developed by International Standards Organization (ISO), which is a multinational body dedicated to worldwide agreements on International Standards. An OSI model covers all aspects of Network Communication. It is an Open System because it allows two different systems to communicate over their primary network.

The OSI model deals with the following:

- How a device on a network transmits its data and how it knows when and where to send.
- How a node on a network receives its data and how it know where to search.
- How nodes using different languages communicate with each other.
- How nodes on a network are physically connected to each other.

- How different protocols work with devices on a network to arrange data.

OSI MODEL LAYERS

The OSI model defines a networking framework for implementing protocols in seven different layers. Control is passed from one layer to the next, starting at the application layer in one station, and proceeding to the bottom layer, over the channel to the next station and back up the hierarchy.

The OSI model divides communications into seven different layers, where each include multiple hardware standards, protocols, or, other types of services. The OSI model has following seven layers.

- Physical Layer
- Data Link Layer
- Network Layer
- Transport Layer
- Session Layer
- Presentation Layer
- Application Layer

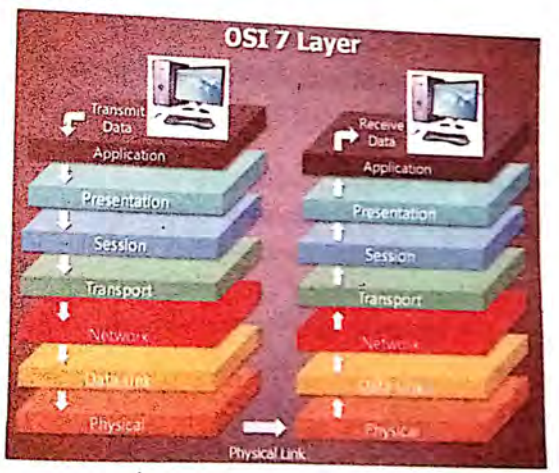


Figure 5.27 OSI Model Layers

Layer 1: PHYSICAL LAYER

The physical layer, the lowest layer of the OSI model, is concerned with the transmission and reception of the unstructured raw bit stream over a physical medium. It describes the electrical/optical, mechanical, and functional interfaces to the physical medium, and carries the signals for all of the higher layers. It provides the following functions.

- Defines physical means of sending data over network devices.
- Defines the characteristics of the physical medium.
- Transmission and receipt of data from the physical medium is managed at this layer.
- Interfaces between network medium and devices.
- Defines optical, electrical and mechanical characteristics.
- Conversion of the raw bit stream into electrical impulse, light or radio signal.
- Manages the encoding and decoding of data.
- Determines whether the encoded bits will be transmitted by baseband (digital) or broadband (analog) signaling.

Layer 2: DATA LINK LAYER

The data link layer provides reliable transmission of data across a physical link. Data link layer is used by hubs and switches for their operation. The *data link* layer is concerned with physical addressing, network topology, physical link management, error notification, ordered delivery of frames, and flow control.

The data link layer provides:

- Segmentation of upper layer datagrams into frames in sizes that can be handled by the communications hardware.

- Bit Ordering. The data link layer organizes the pattern of data bits into frames before transmission. The frame formatting issues such as stop and start bits, bit order, parity and other functions are also handled.

Layer 3: NETWORK LAYER

This layer allows the data called packets or datagram to go from one physical network to another. This layer also has its own addressing scheme (network logical address) so that devices can communicate with other devices across multiple networks. Consequently, this layer is also responsible for path determination.

The network layer establishes the route between the sender and receiver across switching points, which are typically routers. The most ubiquitous example of this layer is the IP protocol in TCP/IP. It provides the following functions.

- Translates logical addresses, or names, into physical addresses.
- Management of connectivity and routing between hosts or networks.
- Determines how data are transferred between network devices
- Routes packets according to unique network device addresses
- Provides flow and congestion control to prevent network resource depletion
- Responsible for addressing, determining routes for sending and managing network problems such as packet switching, data congestion and routines.

Layer 4: TRANSPORT LAYER

As its name implies, it handles the transparent transport of data segments between network devices. It is responsible for flow control, error control, data segmentation, and communication reliability.

The transport layer ensures that messages are delivered error-free, in sequence, and with no losses or duplications.

The transport layer provides the following functions.

- Accepts a message from the (session) layer above it, splits the message into smaller units, and passes the smaller units down to the network layer. The transport layer at the destination station reassembles the message.
- Manages reliable end-to-end message delivery with acknowledgments in network.
- Tells the transmitting station to "back-off" when no message buffers are available.
- Provides reliable and sequential packet delivery through error recovery and flow control mechanisms.
- Provides connectionless oriented packet delivery.

Layer 5: SESSION LAYER

The session layer sets up, coordinates, and terminates conversations, exchanges, and dialogues between the applications running on different stations. It provides:

- Session establishment, maintenance and termination: allows two application processes (on different machines) to establish, use and terminate a connection, called a session.
- Session support: performs the functions that allow these processes to communicate over the network, performing security, name recognition, logging.

It also marks significant parts of the transmitted data with checkpoints to allow fast recovery in the event of a connection failure.

In most modern Internet applications, the *session*, *presentation* and *application* layers are usually combined inside the application itself, thus, web browser performs all functions of the *session*, *presentation* and *application* layers.

Layer 6: PRESENTATION LAYER

The presentation layer converts incoming and outgoing data from one presentation format to another (for example, from a text stream into a popup window with the newly arrived text). The presentation layer is sometimes called as the syntax layer. It can be viewed as the translator for the network. The presentation layer provides the following functions.

- Character code translation: for example, ASCII to EBCDIC.
- Data compression: reduces the number of bits that need to be transmitted on the network.
- Data encryption: encrypt data for security purposes. For example, password encryption.
- Specifies architecture-independent data transfer format.

Layer 7: APPLICATION LAYER

The application layer serves as the user interface for users and application processes to access network services. The application layer is responsible for displaying data and images to the user in a human-recognizable format. It provides an interface with the presentation layer. Everything at this layer is application-specific. This layer performs the following functions.

- Resource sharing
- Remote file access
- Network management
- Directory services
- Electronic messaging (such as e-mail)

5.2.3 Examples of Devices and Protocols on Layers of OSI Model

The following are some common network devices and protocols and where they are implemented in the OSI model.

OSI LAYER	DEVICES	PROTOCOLS
APPLICATION layer 7	Gateway	SNMP, SMTP, FTP, TELNET, HTTP, NCP, SMB, AppleTalk, FTAM, X.400,X.500, DAP,DNS
PRESENTATION layer 6	Gateway	NCP, AFP, TDI, XDR, SSL, ISO 8823 TLS, PAP, X.226
SESSION layer 5	Gateway	NetBIOS, ASP, ADSP, ZIP, ISO 8327, X.225, SAP, SDP
TRANSPORT layer 4	Gateway	NetBEUI, TCP, SPX, NWlink, UDP, RTP, SCTP, TP0, TP1, TP2, TP3, TP4, OSPF, SPX, RIP, ATP, NBP, AEP, RTMP
NETWORK layer 3	Routers, layer 3 (or IP) switches.	IP, IPX, NWlink, NetBEUI, ICMP, IPsec, ARP, RIP, BGP, X.25 (PLP), CLNP, DDP, IGRP
DATA LINK layer 2	Bridges and switches, Ethernet incorporates both this layer and the Physical layer.	X.25 (LAPB., Token Bus, IEEE 802.3 framing, Ethernet II framing, LocalTalk, TokenTalk, EtherTalk, Apple Remote Access, PPP, HDLC, Q.921
PHYSICAL layer 1	Hubs, repeaters, network adapters, Parallel SCSI buses. Various physical-layers Ethernet incorporates both this layer and the data-link layer. Token ring, FDDI, and IEEE 802.11.	X.25 (X.21bis), EIA/TIA-232, EIA/TIA-449, EIA-530, G.703

5.3 TCP/IP

Communications between computers on a network is done through protocol suits. The most widely used and most widely available protocol suite is TCP/IP protocol suite. TCP/IP is an industry standard suite of protocols designed for local and wide area networks. It was developed by the United States

Department of Defense (DoD) Advanced Research Projects Agency (ARPA) in 1969 for a research sharing project called ARPANET. Internet was built on the foundation of the original ARPANET project.

5.3.1 TCP/IP Protocol Suite Architecture

A protocol suite is a group of protocols that all work together to allow software or hardware to perform a function. The **TCP/IP** protocol suite is a good example of it. The three important points associated with TCP/IP protocol suit are:

a. TCP/IP Architecture
b. TCP/IP PORTS
c. TCP/IP Applications

a. TCP/IP Architecture

TCP/IP protocol suit consists of a layered architecture where each layer depicts some functionality which can be carried out by a protocol. Each layer usually has more than one protocol options to carry out the responsibility that the layer adheres to. It is named from two of the most important protocols in it. That is Transmission Control Protocol and Internet Protocol. TCP/IP is normally considered to be a 4 layer system. The TCP/IP model breaks down into the following four layers.

- Application Layer
- Transport Layer
- Internet Layer
- Network Access Layer

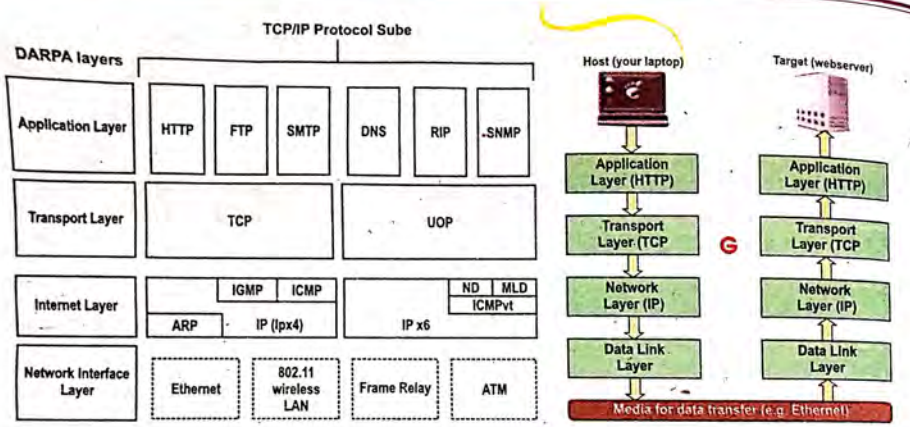


Figure 5.28 The architecture of the TCP/IP protocol suite

All application data, whether it is an e-mail, a file, an instant message, a video or voice call, is divided into data segments and encapsulated in Transport Layer PDU's (TCP or UDP segments). The Transport Layer PDU's (Protocol data Unit) are then encapsulated in Internet Layer's Internet Protocol packets. The Internet Protocol packets are then divided into frames at the Network Access layer and transmitted across the physical media (copper wires, fiber optic cables or the air) to the next station in the network. Figure 5.28 shows the architecture of the TCP/IP protocol suite.

Application Layer

This is the top layer of TCP/IP protocol suite. This layer includes applications or processes that use transport layer protocols to deliver the data to destination computers.

Transport Layer

The Transport Layer provides the means for the transport of data segments across the Internet. The Transport Layer is concerned with host-to-host communication. Transmission Control Protocol provides reliable, connection-

oriented transport of data between two endpoints (sockets) on two computers that use Internet Protocol to communicate.

Internet Layer

The Internet Layer provides a global logical addressing scheme, a process for packetization of data, another process for routing packets to their destination and for providing connectivity between networks. The Internet Layer is concerned with network to network communication. The main protocol used at this layer is IP.

Network Access Layer

The Network Access Layer provides access to the physical network. The data is transmitted and received across the physical network in network access layer. This layer combines the Physical and Data link layers and routes the data between devices on the same network. It also manages the exchange of data between the network and other devices.

b. TCP/IP PORTS

Every computer or device on the Internet must have a unique number assigned to it called the IP address. This IP address is used to recognize each particular computer out of the millions of other computers connected to the Internet. The information sent over the Internet to a particular computer is received by using TCP or UDP ports. There are a total of 65,535 TCP Ports and another 65,535 UDP ports. The Internet Assigned Numbers Authority (**IANA**) is responsible for assigning TCP and UDP port numbers to specific uses.

For instance, port 23 is used for telnet services, HTTP uses port 80 for providing web browsing service and FTP servers use TCP ports 20 and 21 to send and receive information. There are some ports that are assigned, some reserved and many unassigned which may be utilized by application programs.

The port numbers are divided into three ranges:

- The Well Known Ports.
- The Registered Ports.
- The Dynamic and/or Private Ports.

WELL KNOWN PORT NUMBERS

Well-known ports (0-1023) are used for the major Internet applications, such as Web and e-mail. For example, all port 80 packets (HTTP packets) are directed to and processed by a Web server.

REGISTERED PORT NUMBERS

Registered ports are assigned to applications that are mostly vendor specific, such as Skype and BitTorrent. The Registered Ports are in the range 1024-49151.

DYNAMIC PORT NUMBERS

The Dynamic and/or Private Ports are those in the range 49152–65535. These ports are not used by any defined application.

c. TCP/IP Applications

All modern operating systems support TCP/IP, and most large private networks rely on TCP/IP for much of their traffic. A technology used for connecting dissimilar systems. Many TCP/IP application protocols were designed to access and transfer data between dissimilar systems. These protocols include HTTP, FTP, and Telnet. TCP/IP provides a robust, scalable, cross-platform client/server framework.

The TCP/IP is used by the following applications.

- Web browsers (Internet Explorer, Firefox, Safari, Opera etc.)
- Web Servers
- File Servers
- Terminal Servers

- Online games
- File Transfer applications (WS-FTP etc.)
- Microsoft Windows Update
- Anti-Virus applications

5.3.2 Comparison of TCP/IP and OSI Models

TCP/IP and OSI Model can be compared keeping in view the following characteristics.

SIMILARITIES

The main similarities between the two models include the following:

- They share similar architecture. - Both of the models share a similar architecture. This can be illustrated by the fact that both of them are constructed with layers.
- They share a common application layer: - Both of the models share a common "application layer". However in practice this layer includes different services depending upon each model.
- Both models have comparable transport and network layers: - This can be illustrated by the fact that whatever functions are performed between the presentation and network layer of the OSI model similar functions are performed at the Transport layer of the TCP/IP model.
- Knowledge of both models is required by networking professionals.
- Both models assume that packets are switched. Basically this means that individual packets may take differing paths in order to reach the same destination.
- Both the models are based on the concept of stack of independent protocols.

DIFFERENCES

The main differences between the two models are as follows:

- TCP/IP combines the presentation and session layer issues into its application layer.
- OSI is a reference model and TCP/IP is an implementation of OSI model.
- TCP/IP Protocols are considered to be standard around which the internet has developed. The OSI model however is a "generic, protocol-independent standard."
- TCP/IP combines the OSI data link and physical layers into the network access layer.
- TCP/IP appears to be simpler model and this is mainly due to the fact that it has fewer layers.
- The OSI model consists of 7 architectural layers whereas the TCP/IP only has 4 layers.
- In the TCP/IP model of the Internet, protocols are deliberately not as rigidly designed into strict layers as the OSI model.
- The TCP/IP protocol suite comes prior to the OSI model. ISO first introduce the idea of TCP/IP suite. After some time the idea of OSI model comes into existence. So the TCP/IP suite is older than OSI model.
- The TCP/IP suite is based on protocols whereas the OSI model is layer based model.

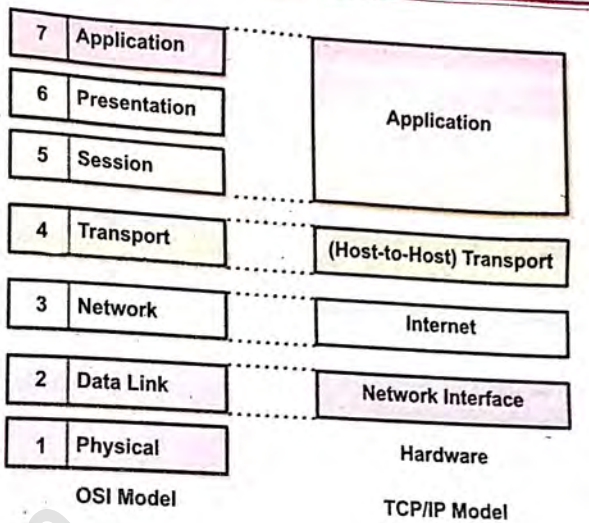


Figure 5.29 OSI Model Versus TCP Model

5.3.3 Packet Switching and Circuit Switching

Packet Switching

Packet switching is a network communication method in which the data get transmitted in blocks, regardless of type and content, called packets based on the destination address in each packet. When received, packets are reassembled in the proper sequence to make up the message. In this kind of switching, the media capacity is used optimally, and the response time is lesser.

Circuit Switching

Circuit switching is a scheme in which the network sets up a dedicated point-to-point connection between nodes and terminals before the communication starts, just like the nodes were already connected.

Difference between Circuit and Packet Switching

	Packet switching	Circuit switching
1	Bandwidth is allocated dynamically.	Fixed bandwidth allocation.
2	May be more economical as not needed dedicated circuit.	Costs more for hardware.
3	The packet needs to be re-transmitted every time when it gets lost, damaged before it is received in this method.	Once connection is established, communication is fast and almost errorless.
4	It can be used for telephony, DSL services and other data transmission services.	This concept is mainly used in telephony systems.
5	It is best used for sending data over the network and audio and video signals can also be sent over the network in the form of packets.	This is best used for transmission of audio signals and not suitable for data transmission.
6	It is usually a connection less service.	This type of switching is connection oriented and may be connectionless also.
7	The Internet being the most common example.	The most common example of a circuit switching network is the telephone system,PBX.

5.3.4 IP Addressing

An Internet Protocol address (IP address) is a number that is used to identify a device, for example a computer, a printer, etc. on the network. Each device on a network must have a unique IP address to communicate with other network devices. A **host** (usually a computer) is a device that sends or receives information on the network. Network devices transmit the data across the network. These devices include hubs, switches and routers. On a LAN, each

host and network device must have an IP address within the same network to be able to communicate with each other.

An IP address can be **static** or **dynamic**. A static IP address will never change and it is a permanent Internet address. A dynamic IP address is a temporary address that is assigned each time a computer or device accesses the Internet. The address is made up of 32 binary bits, which can be divided into a network portion and host portion with the help of a subnet mask. The 32 binary bits are broken into four octets (1 octet = 8 bits). Each octet is represented in decimal and separated by a period (dot). For this reason, an IP address is expressed in dotted decimal format (e.g., 172.16.81.100). The value in each octet ranges from 0 to 255 in decimal, or 00000000 - 11111111 in binary.

The following IP address is an example which shows an IP address represented in both binary and decimal formats.

10. 1. 23. 19 (decimal)
00001010.00000001.00010111.00010011 (binary)

These octets can be broken down to provide an addressing scheme that can support/accommodate large and small networks.

a. Classes of IP Addresses

Given an IP address, its class can be determined from the three high-order bits. Figure 5.30 shows the significance in the three high order bits and the range of addresses that fall into each class.

There are five different classes of an IP address, from A to E.

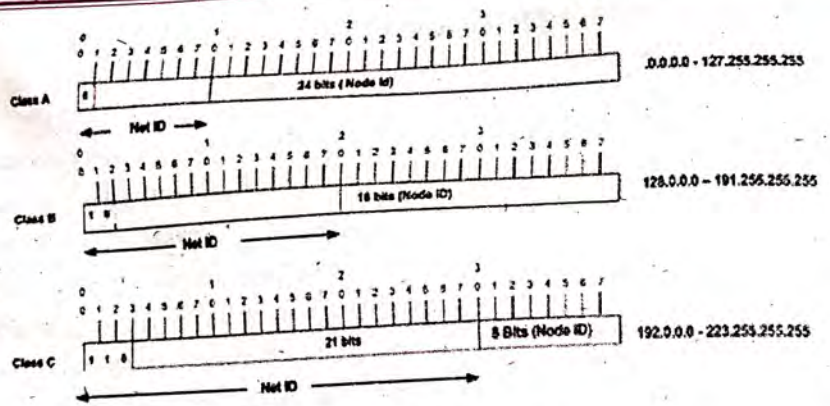
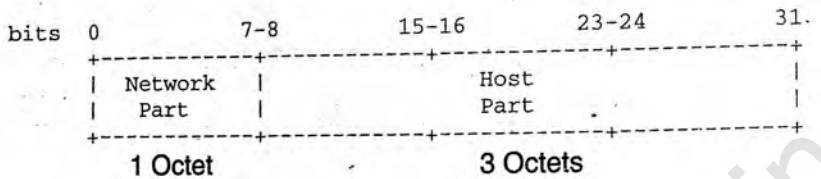


Figure 5.30 Classes of IP Addresses

Class A

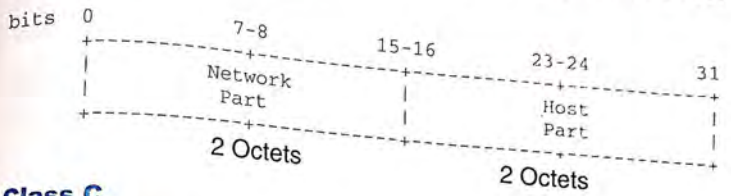
Class A is used for the large networks and is implemented by large companies with many network devices. Binary address for the class A starts with 0. Its range is between 1 to 126 and the default subnet mask of this class is 255.0.0.0. Its Network part consists of 1 octet and Host part consists of 3 octets. An example of the class A is 100.10.11.1.



Class B

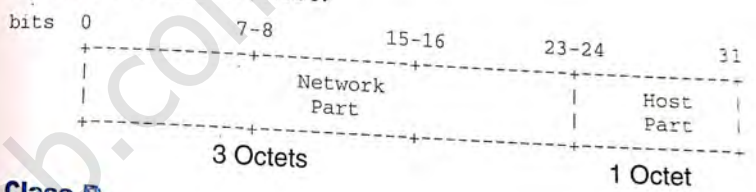
Class B addresses scheme is used for the medium sized networks. The binary address for the class B starts with 10. The range of the IP address in the class B is between 128 to 191 and the default subnet mask of this class B is

255.255.0.0. Its Network part consists of 2 octets and Host part also consists of 2 octets. An example of the class B address is 150.101.110.120. .



Class C

Class C is used for the small networks. The binary address for the class C starts with 110. The range addresses in the class C is between 192 to 223 and the default subnet mask for this class is 255.255.255. Its Network part consists of 3 octets and Host part consists of 1 octet. An example of the Class C IP address is 210.190.100.150.



Class D

Class D is for special use for multicasting. The binary addresses for the class D starts with 1110 and the IP address ranges from 224 to 239. An example of the class D IP address is 230.150.110.11

Class E

Class E is under experimental research. The binary address can start with 1111 and the decimal can be in range from 240 to 255. An example of the class E IP address is 245.101.110.110

b. Subnet Masks

Subnet Mask indicates the network portion of an IP address. Like the IP address, the subnet mask is a dotted-decimal number. Usually all hosts within a LAN use the same subnet mask. Subnet mask is a 32-bit combination used to describe which portion of an address refers to the subnet and which part refers to the host. Figure 5.31 shows default subnet masks for usable IP addresses that are mapped to the first three classes of IP addresses.

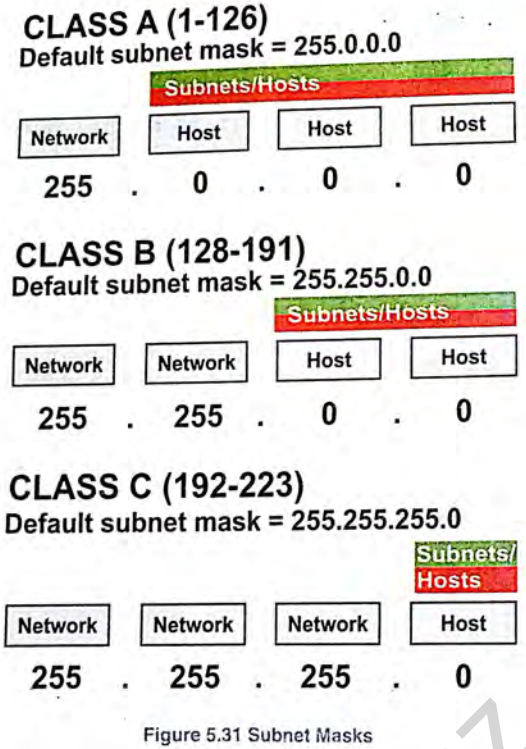


Figure 5.31 Subnet Masks

SUMMARY

- A network is a collection of independent computers or nodes that communicate with each other on a shared network medium.
- Sender or Transmitter is a device that sends the message.
- Message is the data or information that is to be communicated.
- Medium is the physical path that message uses to travel from source to destination.
- Receiver is the device which receives transmitted message.
- A protocol is a set of rules that governs data communications.
- In Simplex mode, the communication takes place in only one direction.
- In half-duplex mode, each station can transmit and receive data, but not at the same time.
- In Full-duplex mode, both stations can send and receive the data simultaneously
- In synchronous transmission, large volumes of information can be transmitted block-by-block or word-by-word simultaneously.
- In asynchronous transmission, data is transmitted one byte at a 'time'.
- Guided media are the physical links in which signals are confined along a narrow path.
- Unguided media also called Wireless media transports signals without using any physical conductor between the two devices communicating.

- Radio wave wireless transmission medium distributes radio signals through the air over long distances such as between cities, regions, and countries, and short distances such as within an office or home.
- Micro wave is a wireless transmission technology that travels at high frequency than radio waves and provide throughput as a wireless network media.
- Infrared is a short-distance wireless transmission medium that sends signals using infrared light waves.
- A network switch or hub is a device that connects network nodes to a central location.
- Router is a device that forwards data packets across different networks.
- A gateway is a hardware device or a computer running software that allows communication between networks with dissimilar network protocols or architectures.
- Server is a powerful computer that provides centralized administration of the network and serves up the resources, such as printers and files, etc.
- Client is a network device that participates in a client/server relationship by requesting a service from a server.
- In peer-to-peer networking there are no dedicated servers or hierarchy among the computers.
- LAN (Local Area Network) is a network that connects computers and devices in a limited geographical area like home, school, and office building, etc.
- A metropolitan area network is a computer network that usually spans a city or in a large metropolitan area.

- WAN (Wide Area Network) covers large distance for communication between computers.
- A virtual private network (VPN) is a network that uses a public telecommunication infrastructure to provide remote offices or individual users with secure access to their organization's network.
- Network Topology refers to the physical layout and connectivity of computers in a network.
- In a star topology all the nodes (server, workstations, peripherals, etc.) on the network are connected directly to a centralized connectivity device called a hub, switch, or router.
- In a ring topology, every node is logically connected to two other nodes, forming a ring. Traffic flows through the entire ring until it reaches its destination.
- In the bus topology, each node (computer, server, peripheral etc.) attaches to a common cable.
- In a mesh network topology, each of the network node, computer and other devices, are interconnected with one another.
- Communication Standards provide guidelines (also called rules or protocols) to manufacturers, vendors, government agencies, and other service providers to ensure the kind of interconnectivity of networks for communication.
- OSI model defines a networking framework for implementing protocols in seven different layers.
- Application layer serves as the user interface for users and application processes to access network services.

- Presentation layer converts incoming and outgoing data from one presentation format to another (for example, from a text stream into a popup window with the newly arrived text).
- Session layer sets up, coordinates, and terminates conversations, exchanges, and dialogues between the applications running on different stations.
- Transport layer handles the transparent transport of data segments between network devices.
- Network layer allows the data called packets or datagram to go from one physical network to another.
- Data link layer provides reliable transmission of data across a physical link.
- Physical layer is concerned with the transmission and reception of the unstructured raw bit stream over a physical medium.
- TCP/IP is an industry standard suite of protocols designed for local and wide area networks.
- Packet switching is a network communication method in which the data get transmitted in blocks, regardless of type and content, called packets based on the destination address in each packet.
- Circuit switching is a scheme in which the network sets up a dedicated point-to-point connection between nodes and terminals before the communication starts, just like the nodes were already connected.
- An Internet Protocol address (IP address) is a number that is used to identify a device, for example a computer, a printer, etc. on the network.
- Subnet Mask indicates the network portion of an IP address.

EXERCISE

Q1. Select the best choice for the following MCQs.

i. A collection of two or more connected computers to share the resources and data is called a _____.
   A. Route B. Network
   C. Path D. Medium

ii. In which communication mode data can be sent and received in both directions but not at the same time?
   A. Simplex B. Full-duplex
   C. Half-duplex D. Duplex

iii. _____ is the data or information that is to be communicated over the network.
   A. Message B. Sender
   C. Medium D. Receiver

iv. _____ is a set of rules that governs data communications.
   A. Message B. Sender
   C. Medium D. Protocol

v. In _____ mode, both stations can send and receive the data simultaneously.
   A. Simplex B. Full-duplex
   C. Half-duplex D. Duplex

vi. In which type of transmission data is transmitted one byte at a 'time'.
   A. Simplex B. Synchronous
   C. Asynchronous D. Duplex

vii. _____ Cable is formed of two insulated copper wires twisted together.

A. Coaxial B. Fiber Optic
C. CAT5 D. Twisted Pair

viii. Which of the following network devices is used to forward data packets across different networks?

A. Switch B. Router
B. Gateway D. Modem

ix. In _____ networking there are no dedicated servers or hierarchy among the computers.

A. Peer-to-Peer B. Server
C. LAN D. WAN

x. _____ works by using the shared public infrastructure while maintaining privacy through security procedures.

A. LAN B. WAN
C. VPN D. MAN

xi. Which of the following topology is most expensive to implement?

A. Star topology B. Bus topology
C. Ring topology D. Mesh topology

xii. How many layers does the OSI model consist of?

A. 4 B. 5
B. 8 D. 7

xiii. Which layer of OSI Model decides which physical path-way the data should take to reach the destination?

A. Data link layer B. Transport layer
C. Network layer D. Session layer

xiv. Which layer performs security, name recognition, logging and similar functions?

A. Transport layer B. Presentation layer
C. Network layer D. Session layer

xv. In _____ topology, each node (computer, server, peripheral etc.) attaches to a common cable.

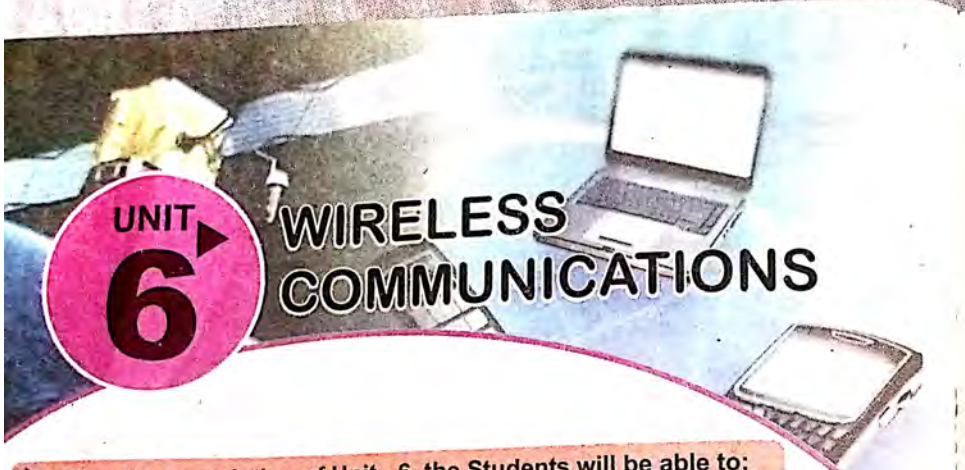
A. Star B. Tree
C. Ring D. Mesh

Q2. Give short answers to the following questions.

i. Show all the modes of data communication with the help of a diagram.
ii. Differentiate between synchronous and asynchronous transmission.
iii. Differentiate between guided and unguided media.
iv. Differentiate between LAN and WAN.
v. What is OSI Model?
vi. Compare TCP/IP Model with OSI Model.
vii. Differentiate between circuit switched and packet switched networks.
viii. Briefly describe IP Addressing.

Q3. Give detailed answers to the following questions.

i. Explain various modes of data communication.
ii. What is guided media? Explain different types of guided media.
iii. Explain Radio wave and Microwave communications.
iv. Write notes on switch, router and gateway.
v. Explain in detail Client/Server and Peer-to-Peer networks.
vi. Define network topology and explain its types.
vii. Describe the seven layers of OSI Model.
viii. What is TCP/IP? Explain TCP/IP Protocol Suite.



UNIT 6 WIRELESS COMMUNICATIONS

After the completion of Unit - 6, the Students will be able to:

- *explain a wireless network.*
- *explain the advantages and disadvantages of wireless networks.*
- *define radio signals, radio transceiver, access point and line of sight communication.*
- *differentiate between short distance and long distance wireless communication.*
- *explain the types of short distance wireless technologies (Wi-Fi, WiMax, Bluetooth and Infra-red).*
- *explain the types of long distance wireless communication (Cellular Communication and Global Positioning System).*
- *explain requirements of mobile communication.*
- *identify features and limitations of mobile communication system.*
- *explain the architecture for communication over mobile devices.*

6.1 INTRODUCTION

Wireless communication is an important area in telecommunications and networking. Wireless communication is a term used to describe communications between two or more devices without any physical connection. The widespread use of mobile telephone, various satellite services, and now the wireless Internet and wireless LAN's are generating incredible changes in telecommunications and networking. The use of mobile phones which may be cellular, cordless and satellite phones as well as wireless local area networks (WLANs) are increasing day by day. Wireless networks gain so much popularity in the recent years that we will soon reach the point where the number of worldwide wireless subscribers will be higher than the number of wireline subscribers. This popularity is due to its advantages compared to wireline systems. The most significant of these advantages is the freedom from cables, which enables the users to communicate anywhere at anytime. For example, you can contact your friend by dialing his mobile phone number in a variety of geographical locations, thus overcoming the disability of fixed telephony.

6.1.1 Wireless Network

Wireless network is a network set up by using radio signal frequency to communicate among computers and other network devices. Sometimes it is also referred to as WLAN (Wireless LAN). This network is getting popular nowadays due to its easy setup feature and no cabling involved. User can connect computers anywhere in the office/home without the need for wires. Wireless networks use radio waves and/or microwaves to maintain communication channels between computers or devices. They connect computers such as laptops and mobile phones to the Internet or to our business network and its applications.

The two main components of a wireless network are wireless router or access point and wireless clients.

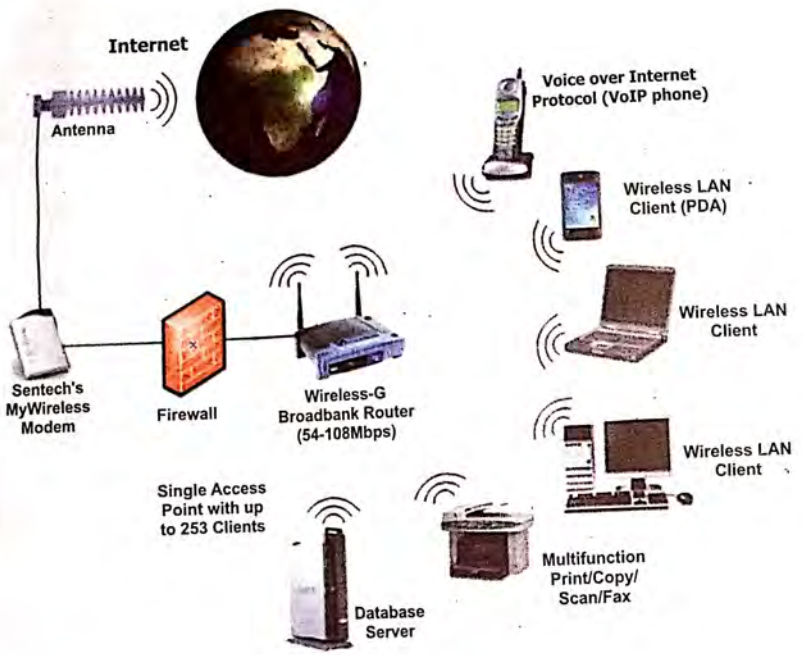


Figure 6.1 Wireless Network

Access points act as a central transmitter and receiver of wireless radio signals including Wi-Fi and are used to support public internet hot spots.

A computer or a device equipped with a wireless LAN network adaptor is known as **wireless client**. These can communicate directly with each other or through a wireless access point.

6.1.2 Advantages and disadvantages of Wireless Networks

A wireless network offers the following advantages and disadvantages

Advantages of Wireless networks

- **Manageability** – Users can be easily connected to a different wireless network without having to change the physical connection.
- **Security** – Traffic of a wireless network can be filtered or simply blocked. Advancement in wireless networks provide robust security protections.
- **Mobility** – We are no longer tied to a specific location, as were with a wired connection. With a laptop computer or mobile device, access can be available at different locations.
- **Fast setup** - If a computer has a wireless adapter, locating a wireless network is very simple and in some cases, user can connect automatically to networks within the range.
- **Cost** - Setting up a wireless network can be much more cost effective than buying and installing cables. Because wireless networks eliminate or reduce wiring costs.
- **Expandability** - Adding new computers to a wireless network is very easy. We can easily expand wireless network with existing equipment, while a wired network might require additional wiring.
- **Productivity.** Wireless access to the Internet and to company's key applications and resources, helps staff to get the job done and encourages collaboration.
- **Last mile data delivery:** Wireless connections can be a very suitable replacement for wired connections in areas where it may be difficult or expensive to extend the cable network to every location.

Disadvantages of Wireless networks

- A common disadvantage of the wireless network is security. A malicious individual can tap into a wireless network relatively easier than a wired network.
- Another disadvantage is about its coverage that somewhere users might face problems of range of signals also some routers allow limited access.
- Sometimes their speed can be slower than wired networks because of their signals dropage problem.
- Wireless network is usually inexpensive but sometimes it is more expensive to install than wired network.
- Because wireless networks use radio signals and similar techniques for transmission, they are susceptible to interference from fluorescent lights and other electronic devices.
- The machinery in factories often produces electromagnetic interference (EMI), which can drastically reduce the data throughput in a wireless network.
- Because of the interference caused by electrical devices and the items blocking the path of transmission, wireless connections are not as stable as compared to a dedicated cable.
- Due to the limitation of data transfer rates, wireless LAN technologies are not suitable for network backbones.

6.1.3 Important Wireless Communication Terminologies

The following are some important wireless communication terminologies.

a. Radio Signals
b. Radio Transceiver
c. Wireless Access Point
d. Line-of-Sight Communication

a. Radio Signals

Radio signals are electromagnetic waves which are used as a medium in wireless communication. The frequency range of radio signal is between 3 KHz to 1 GHz. Radio waves are generated in two ways naturally and artificially.

b. Radio Transceiver (Transmitter and Receiver)

Radio transceiver is a wireless communication device which is used to send as well as receive data through radio signals. It is a full duplex device that can perform both the functions of sending and receiving data simultaneously. The transceiver is connected to the station by means of a transceiver cable that provides separate paths for sending and receiving the data.

Figure 6.2 Radio Transceiver

c. Wireless Access Point

An Access point is a device that both transmits and receives data (sometimes referred to as a transceiver). It has a built-in network adapter, antenna, and radio transmitter. The access point connects users to other users within the wireless local area network (WLAN) and can also serve as the point of interconnection between the WLAN and a wired network. A single access point can serve multiple users within a defined network area. When people move beyond the range of one access point, they are automatically handed over to

the next one. Wireless Access Point can typically communicate with 30 client systems located within a radius of 100 meter. The older and base model of access points allow a maximum of only 10 or 20 clients but many newer access points support up to 255 clients.

Figure 6.3 Wireless Access Point

d. Line of Sight Communication

A line-of-sight communication uses highly directional transmitter and receiver antennas facing each other to communicate via a narrowly focused radio beam in straight line with very high frequency. The transmission path of a line-of-sight microwave link can be established between two land-based antennas, between a land-based antenna and a satellite-based antenna, or between two satellite antennas. A common example of line of sight communication is infrared (TV remote) for short distance, and for long distance the example is very high frequency Microwavws.

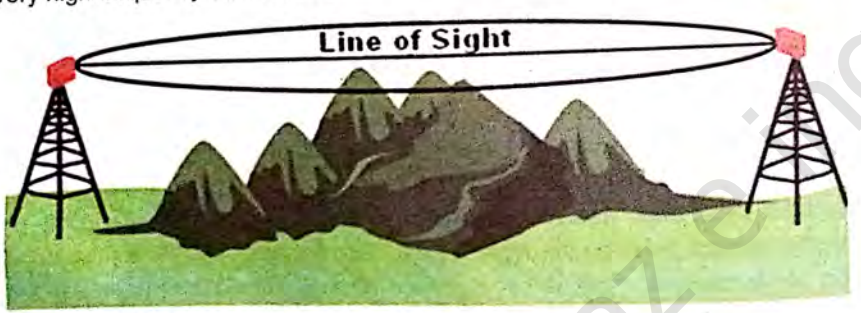


Figure 6.4 Line of sight communication

6.1.4 Short distance and Long distance Wireless Communication

In telecommunications, wireless communication may be used to transfer information over short distances (a few meters as in television remote control) or long distances (thousands or millions of kilometers for radio communications). In short distance communication information is transferred from one station to another in a few meters (e.g. Infrared) or few kilometers (e.g. Wi-Max) range. Short distance communication includes Wi-Fi, Wi-Max, Bluetooth and Infrared. Long distance communication includes cellular communication and satellite communication such as global positioning system (GPS), geostationary earth orbit (GEO), medium earth orbit (MEO) and low earth orbit (LEO).

6.2 SHORT DISTANCE WIRELESS COMMUNICATION TECHNOLOGIES

The following are some common short distance wireless communication technologies.

- Wi-Fi
- WiMax
- Bluetooth
- Infra-red

6.2.1 Wi-Fi

Wi-Fi is short for "*wireless fidelity*. It is a popular wireless networking technology which uses radio waves to provide wireless high-speed Internet and network connections. It uses the 802.11 standard, developed by the Institute of Electrical and Electronics Engineers (IEEE) and released in 1997. A person or business can use a Wi-Fi router or similar device to create a

"**hotspot**" or area in which appropriate devices can be connected wirelessly to a network or gain Internet access.

Wi-Fi router translates data into a radio signal and transmits it using an antenna. It then sends the information to the Internet using a physical, wired Ethernet connection. The process also works in reverse, with the router receiving information from the Internet, translate it into a radio signal and sends it to the computer's wireless adapter. Different electronic devices like computers, mobiles PDAs can be wirelessly connected with Internet access points. The access point or hotspot range is 20 meters indoor and it may be in many square miles by overlapping of multiple access points.

Wi-Fi is supported by many applications and devices including video game consoles, home networks, PDAs, mobile phones, major operating systems, and other types of consumer electronics.

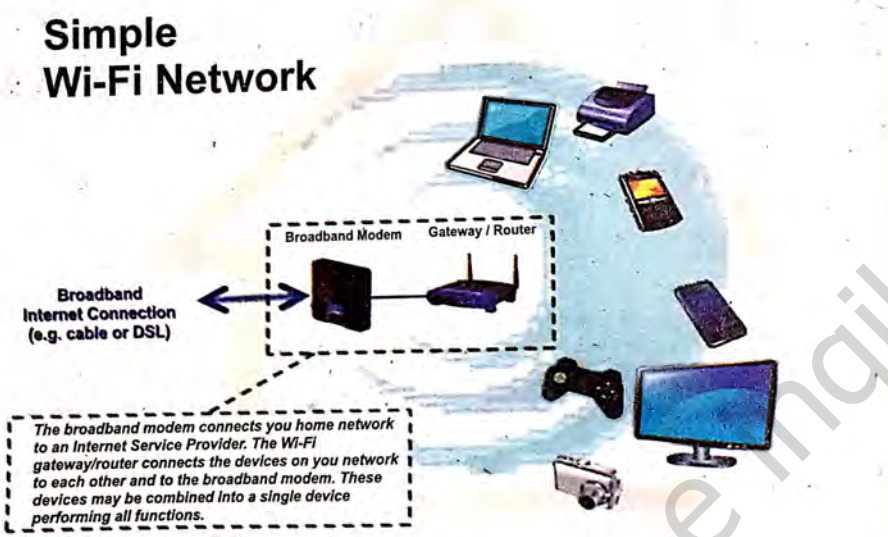


Figure 6.5 Wi-Fi network

6.2.2 WiMAX

WiMAX is an acronym for "Worldwide Interoperability for Microwave Access". WiMax technology is a standard based wireless technology which is used to provide Internet access and multimedia services at very high speed to the end users. WiMAX is an IP based, wireless broadband access technology that provides performance similar to Wi-Fi networks with the coverage and quality of service of cellular networks. It uses IEEE 802.16 standard for communication and can provide broadband wireless access up to 30 miles (50 km) for fixed stations, and 3 - 10 miles (5 - 15 km) for mobile stations.

WiMax technology offers transmission of wireless data via a number of transmission methods; such as portable or fully mobile internet access via point to multipoint links. The WiMax technology offers around 72 mega bits per second without any need for the cable infrastructure.

6.2.3 Bluetooth

Bluetooth is a high-speed, low-power microwave wireless link technology, designed to connect phones, laptops, PDAs and other portable equipment together. Unlike infra-red, Bluetooth does not require line-of-sight positioning of connected units. The technology uses modifications of existing wireless LAN techniques but is most notable for its small size and low cost. Whenever Bluetooth-enabled device come within range of each other, they instantly transfer address information and establish small networks between each other, without the user being involved.

Bluetooth is popular for providing connectivity between non-network devices, such as laptops, mobile phones, telephones, fax machines, PCs, Printers GPS receivers, digital photo camera and video games controllers. The specified maximum data transfer rate is 1 Mbps, but in reality it is much lower.

Wireless signals transmitted with Bluetooth cover short distances, typically up to 30 feet (10 meters). Bluetooth networks have called a piconet or PAN. Piconets contain a minimum of two and a maximum of eight Bluetooth peer devices.

6.2.4 Infrared

Infrared is similar to visible light, but with a longer wavelength. Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation. Infrared waves, having high frequencies, can not penetrate walls. Due to this characteristic, it prevents interference between one system and another system that is a short range communication in one room cannot be affected by another in the next room. Infrared equipment is relatively economical and simple. In Infrared communication the transmitter and receiver must be in line of sight to communicate with each other. Also data rate in this type of communication is very low as compared to other methods of data communication. Some common applications of infrared technology are listed below.

- Car locking systems use Infrared technology for automatic locking and unlocking the doors of cars.
- Modern Computers have infrared enabled mouse, keyboards, and printers.
- Home security systems have infrared enabled burglar alarm.
- Remote control system in TVs, Toys, etc uses infrared technology.

6.3 LONG DISTANCE WIRELESS COMMUNICATION TECHNOLOGIES

The following are some common long distance wireless communication technologies.

- Cellular Communication
- Global Positioning System (GPS)

6.3.1 Cellular Communication

Of all the tremendous advancements in data communications and telecommunications, perhaps the most revolutionary is the development of cellular networks. Cellular technology is the foundation of mobile wireless communications and connects users in locations that are not easily possible by wired networks. Cellular technology is the underlying technology for mobile telephones, personal communication system, wireless Internet and wireless web applications.

In cellular network, multiple low-power transmitters are used. Because the range of such transmitters is small, an area can be divided into cells, each one served by its own antenna. Each cell is allocated a band of frequencies and is served by a base station, consisting of transmitter, receiver, and control unit. Adjacent cells are assigned different frequencies to avoid interference or crosstalk. However, cells sufficiently apart from each other can use the same frequency band.

Early radio systems (FM radio) cover a large area by using a single, high powered transmitter with an antenna mounted on a tall tower. There were no concept of frequency reuse and hence have no interference problem because they use the same frequency. But with this there was a problem of limited user capacity.

Cellular concept, based on frequency reuse solved the problem of user capacity which occurs in radio system. In Cellular communication a single, high power transmitter (large cell) is replaced with many low power transmitters (small cells). The available channels can be reused as many times as necessary as long as the co-channel interference is kept below acceptable levels.

Characteristics of Cellular networks

- Consist of several thousand radio cells, each with a coverage area of between 500 m to 35 km radius.
- Comprised of several access networks and a single core network.
- Usually cover an entire country and serve millions of subscribers.
- Initially designed for speech telephony, but increasingly used for data transmission.
- Support of terminal and personal mobility.
- Examples: GSM and CDMA

6.3.2 Global Positioning System (GPS)

The Global Positioning System (GPS) is a satellite-based navigation system. The GPS system consists of 24 satellites, constructed and operated by the U.S. Department of Defense. It is used for land, sea and air navigation to provide time and locations for vehicles and ships. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS. The 24 satellites are moving around the Earth about 12,000 miles above the Earth surface. They are constantly moving, making two complete orbits in less than 24 hours. These satellites are traveling at speeds of roughly 7,000 miles an hour. GPS satellites are powered by solar energy. They have backup batteries onboard to keep them running, when there is no solar power.

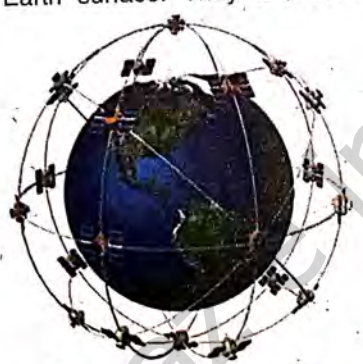


Figure 6.6 GPS satellite orbits

GPS is used to provide accurate location and time information anywhere any time on or near the Earth. GPS can be used for cartography, forestry, mineral exploration, surveying, disaster management, weather forecasting, wildlife habitation management, monitoring the movement of people and things and bringing precise timing to the world.

GPS Segments

GPS has three segments or components.

Space Segment

The space segment consists of a nominal constellation of 24 operating satellites that transmit one-way signals that give the current GPS satellite position and time.

Control Segment

GPS control segment consists of a global network of ground facilities that track the GPS satellites, monitor their transmissions, perform analysis, and send commands and data to the constellation.

User Segment

The user segment consists of the GPS receiver equipment, which receives the signals from the GPS satellites and uses the transmitted information to calculate the user's three-dimensional position and time.

6.3.3 Categories of Satellite Systems

Satellite Systems can be classified based upon their orbits into the following three types.

- Geostationary Earth Orbit (GEO)
- Medium Earth Orbit (MEO)
- Low Earth Orbit (LEO)

a. Geostationary Earth Orbit (GEO)

The Geostationary Earth Orbit is located in the equatorial plane such that the period of rotation equals that of the Earth. Geostationary satellites have the special property of remaining permanently fixed in exactly the same position in the sky, meaning that ground-based antennas do not need to track them but can remain fixed in one direction. Such satellites are called geostationary.

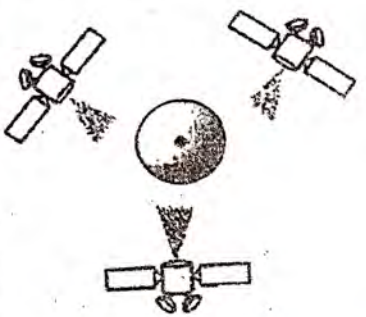


Figure 6.7 Satellites in geostationary orbit

Because orbital speed is based on the distance from the planet, only one orbit can be geostationary. This orbit occurs at the equatorial plane and is approximately 22,000 miles from the surface of the Earth. But one geostationary satellite cannot cover the whole Earth. One satellite in orbit has line-of-sight contact with a vast number of stations, but the curvature of the earth still keeps much of the planet out of sight. It takes a minimum of three satellites equidistant from each other in geostationary Earth orbit (GEO) to provide full global transmission. These three satellites are 120° from each other in geosynchronous orbit around the equator.

b. Medium Earth Orbit (MEO)

Medium or Middle Earth Orbit (MEO) is a satellite system used in telecommunications. MEO satellites orbit the earth between 1,000 and 22,300 miles above the earth's surface. MEOs are mainly used in Geographical Positioning Systems (GPS) and are not stationary in relation to the rotation of the earth. MEO are higher than low earth orbit (LEO) satellites, but lower than geostationary satellites (GEO). Closer to the Earth, satellites in a medium earth orbit move more quickly.

A geostationary orbit is valuable for the constant view it provides, but satellites in a geostationary orbit are parked over the equator, so they do not work well for far northern or southern locations, which are always on the edge of view for a geostationary satellite.

Telstar is the one of the first and most famous experimental satellites, orbited in MEO.

c. Low Earth Orbit (LEO)

In satellite communications systems, a Low Earth Orbit (LEO) satellite operates at heights of between 500 and 2,000 km above the Earth's surface. Low earth orbit satellites can be used for many purposes including satellite communications and surveillance.

LEO satellites can be divided into "Big LEOs" and "Little LEOs." "Little LEOs" provide pager, cellular telephone and location services. "Big LEOs" carry voice and data broadband services to be on Internet in the sky.

LEOs are mostly used for data communication such as e-mail, paging and videoconferencing.

Most of the satellites, the International Space Station, the Space Shuttle, and the Hubble Space Telescope are all in Low Earth Orbit.

6.4 MOBILE DEVICE COMMUNICATION

Mobile communication today is the most powerful catalyst for change in lifestyle of the people all over the world. Mobile communication is evolving as the backbone for business transactions, efficiency and success. It is taking over the role of the PSTN (public switch telephone network). The mobile communications market requires **mobility**. The goal of mobility is anytime and anywhere communications. Mobile communications technology must be able to allow roaming (the ability to provide service to mobile phone users while outside their home system). On the other hand, fixed wireless is simply an alternative to wired communications. The fixed wireless user does not need

mobility. Instead, the fixed wireless user needs cost effective telecommunications from fixed locations. Wireless is an alternative means of providing service. It is sometimes the only means, when the customer is in a remote location.

6.4.1 Requirements of Mobile Communication System

Mobile communication system consists of the following major components that work together to provide mobile service to subscribers.

a. Public switched telephone network (PSTN)
b. Mobile telephone switching office (MTSO)
c. Cell site with antenna system
d. Mobile subscriber unit (MSU)
e. Mobile Station
f. Base Station Subsystem
g. Network and Switching Subsystem
h. Operation Subsystem

a. Public switched telephone network (PSTN)

The PSTN is made up of local networks, the exchange area networks, and the long-haul network that interconnect telephones and other communication devices on a worldwide basis.

b. Mobile Telephone Switching Office (MTSO)

The MTSO is the central office for mobile switching. It houses the mobile switching center (MSC), field monitoring and relay stations for switching calls from cell sites to wire-line central offices (PSTN). In analog cellular networks, the MSC controls the system operation. The MSC controls calls, tracks billing information, and locates cellular subscribers.

c. Cell Site

The term cell site is used to refer to the physical location of radio equipment that provides coverage within a cell. A list of hardware located at a cell site includes power sources, interface equipment, radio frequency transmitters and receivers, and antenna systems.

d. Mobile Subscriber Units (MSUs)

The mobile subscriber unit consists of a control unit and a transceiver that transmits and receives radio transmissions to and from a cell site.

e. Mobile Station (MS)

The MS includes mobile equipment and a subscriber identity module (SIM). The SIM (normally a card) is a subscriber module which stores all the subscriber-related information. When the SIM is inserted into the mobile equipment, the relevant information is checked and a call is then delivered to the mobile station. The mobile equipment is not associated with a caller number - that is contained in the SIM, and hence any mobile equipment could be used by a subscriber by simply inserting the SIM into the unit.

f. Base Station Subsystem (BSS)

The BSS connects to the MS through a radio interface and also connects to the NSS (network and switching subsystem). The BSS consists of a base transceiver station (BTS) located at the antenna site and a base station controller (BSC). A rate adaption unit carries out encoding and speech decoding and rate adaption for transmitting data.

g. Network and Switching Subsystem (NSS)

The NSS is composed of the Mobile Services Switching Center (MSC), the Home Location Register (HLR) and the Visitor Location Register (VLR). The MSC coordinates call set-up to and from mobile users.

The HLR consists of a database which contains subscriber information (e.g. current location).

The VLR temporarily contains administrative information that is relative to whatever mobile is currently in its area.

h. Operation Subsystem (OSS)

There are three areas in the OSS: Network operation and maintenance functions, Subscription management (including charging and billing) and mobile equipment management.

6.4.2 Features and Limitations of Mobile Communication System

a. Features of Mobile Communication System

Mobile Communication technology has helped to make the communication process more convenient and easier. Organizations utilize this communication in day-to-day operations while people personally use mobile communication technology to strengthen social lives.

Mobile or Cellular communication technology offers a number of desirable features:

- The mobile communication provides the mobility. Two aspects of mobility are:
  - (i) User mobility: User communicate (wirelessly) "anytime, anywhere, with anyone".
  - (ii) Device portability: Devices can be connected anytime, anywhere to the network.
- 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 a 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.
- The key characteristic of a mobile network is the ability to re-use frequencies to increase both coverage and capacity.
- The mobile communication provides the handover or handoff which refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another channel. In case of satellite communications it is the process of transferring satellite control responsibility from one earth station to another without loss or interruption of service.
- It is the fastest way to communicate and provide roaming services all around the world which has played a vital role in business, emergencies and management.
- The cost of messaging and talking wirelessly is significantly lower.
- In mobile devices the services of MMS, GPRS and WAP can be used for effective communication.
- The mobile communication system uses the GSM (Global System for Mobile Communication) a standard for, improved spectrum efficiency, international roaming, low-cost mobile sets and base stations (BSs), high-quality speech, compatibility with Integrated Services Digital Network (ISDN) and other telephone company services.
- GSM is expanded over time to improve data communication and higher data rates, first by circuit-switched technique, then packet data transport via GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution of EGPRS).

b. Limitations of Mobile Communication System

The following are the limitations of mobile communication system.

i. Inadequate bandwidth

Mobile Internet access is generally slower than direct cable connections, using technologies such as GPRS (General Packet Radio Service) and EDGE (Enhanced Data Rate for Global Evolution). These networks are usually available within range of commercial cell phone towers. Higher speed wireless LANs are inexpensive, but have very limited range.

ii. Security issues

The privacy issues become more severe with mobile systems. For example, it is much easier for an individual to eavesdrop on mobile calls than on wired calls.

iii. Power issue

When a power outlet or portable generator is not available, mobile computers must rely entirely on battery power. Combined with the compact size of many mobile devices, this often means unusually expensive batteries must be used to obtain the necessary battery life.

iv. Interference

Weather, terrain, and the range from the nearest signal point can all interfere with signal reception. Reception in tunnels, some buildings, and rural areas is often poor.

v. Health hazards

More car accidents are related to drivers who were talking through a mobile device. Cell phones may interfere with sensitive medical devices. There are allegations that cell phone signals may cause health problems.

vi. Human interface with device

Screens and keyboards tend to be small, which may make them harder to use. Alternate input methods such as speech or handwriting recognition require training.

6.4.3 Architecture for Communication over Mobile Devices

The Mobile Device Communication Architecture encompasses the aggregate of all wireless data communication capabilities. These include:

a. Web Protocol Stack
b. Wireless Markup Language (WML)
c. Wireless Application Protocol (WAP)

a. Web Protocol Stack

A web service protocol stack is a protocol stack that is used to define, locate, implement, and make Web services to interact with each other.
A Web service protocol stack includes the following four protocols.

i. Transport Protocol

It is responsible for transporting messages between network applications and includes protocols such as HTTP(Hypertext Transfer Protocol), SMTP(Simple Mail Transfer Protocol), FTP(File Transfer Protocol), as well as the more recent Blocks Extensible Exchange Protocol (BEEP).

ii. Messaging Protocol

It is responsible for encoding messages in a common XML (Extensible Markup Language) format so that they can be understood at either end of a network connection. Currently, this area includes such protocols as XML and SOAP (Simple Object Access Protocol).

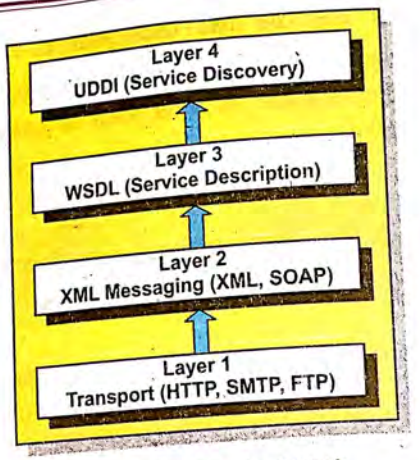


Figure 6.8 Web Protocol Stack

iii. Description Protocol

This protocol is used for describing the public interface to a specific Web service. The WSDL (Web Services Description Language) interface format is typically used for this purpose. WSDL is an XML-based language used to describe the services a business offers and to provide a way for individuals and other businesses to access those services electronically.

iv. Discovery Protocol

This protocol centralizes services into a common registry. It can publish their location and description, and makes it easy to discover what services are available on the network. Universal Description Discovery and Integration (UDDI) is intended for this purpose. UDDI (Universal Description, Discovery, and Integration) is an XML-based registry for businesses worldwide to list themselves on the Internet. Its ultimate goal is to streamline online transactions by enabling companies to find one another on the Web and make their systems interoperable for e-commerce.

b. Wireless Markup Language (WML)

Wireless Markup Language is a markup language created for devices that implement the Wireless Application Protocol (WAP), such as mobile phones. WML provides navigational support, data input, hyperlinks, text and image presentation, and forms, much like HTML (Hypertext Markup Language).

WML (Wireless Markup Language) is the first markup language standard for wireless devices. It is supported by all the major mobile phone manufacturers.

c. Wireless Application Protocol (WAP)

The Wireless Application Protocol (WAP) is an open standard protocol which provides Internet access to mobile users of wireless phones and other wireless devices such as pagers and personal digital assistants (PDAs).

In 1998 WAP Forum is formed by Nokia, Ericsson, Motorola and Unwired Planet. The basic objectives of this WAP are to bring diverse Internet content (e.g. web pages) and other data services (e.g. stock quotes) to mobile phones and other wireless terminals (e.g. PDAs, laptops). WAP allows terminals and software from different vendors to communicate with networks from different providers.

SUMMARY

- Wireless communication is a term used to describe communications between two or more devices without any physical connection.
- Wireless network is a network set up by using radio signal frequency to communicate among computers and other network devices.
- Radio signals are electromagnetic waves which are used as a medium in wireless communication.
- Radio transceiver is a wireless communication device which is used to send as well as receive data through radio signals.
- Wireless Access Point is a device that both transmits and receives data (sometimes referred to as a transceiver).
- Wi-Fi is short for "wireless fidelity. It is a popular wireless networking technology which uses radio waves to provide wireless high-speed Internet and network connections.
- WiMAX is an acronym for "Worldwide Interoperability for Microwave Access". Wimax technology is a standard based wireless technology which is used to provide Internet access and multimedia services at very high speed to the end user.
- Bluetooth is a high-speed, low-power microwave wireless link technology, designed to connect phones, laptops, PDAs and other portable equipment together.
- Infrared is similar to visible light, but with a longer wavelength. Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation.

- Cellular technology is the underlying technology for mobile telephones, personal communication system, wireless Internet and wireless web applications.
- The Global Positioning System (GPS) is a satellite-based navigation system. The GPS system consists of 24 satellites, constructed and operated by the U.S. Department of Defense.
- The Geostationary Earth orbit is located in the equatorial plane such that the period of rotation equals that of the Earth.
- Medium or Middle Earth Orbit (MEO) is a satellite system used in telecommunications. MEO satellites orbit the earth between 1,000 and 22,300 miles above the earth's surface.
- Low Earth Orbit (LEO) satellite operates at heights of between 500 and 2,000 km above the Earth's surface.
- Web Service Protocol stack is a protocol stack that is used to define, locate, implement, and make Web services to interact with each other.
- Wireless Markup Language is a markup language created for devices that implement the Wireless Application Protocol (WAP), such as mobile phones.
- The Wireless Application Protocol (WAP) is an open standard protocol which provides Internet access to mobile users of wireless phones and other wireless devices such as pagers and personal digital assistants (PDAs).

EXERCISE

Q1. Select the best choice for the following MCQs.

i. The frequency range of radio signal is between 3 KHz to _____ GHz.
A. 1 B. 2
C. 3 D. 4

ii. Which of the following is a wireless communication device used to send as well as receive data through radio signals?
A. Sender B. Transceiver
C. Receiver D. Infrared

iii. What does WAP stand for?
A. Wireless Access Place B. Wired Application Protocol
C. Wireless Access Protocol D. Wireless Access Portion

iv. _____ uses 802.11 standard, developed by the Institute of Electrical and Electronics Engineers (IEEE).
A. Wi-Fi B. Bluetooth
C. Infra-red D. WiMax

v. Which of the following is used to provide Internet access and multimedia services at very high speed to the end users?
A. Wi-Fi B. Bluetooth
C. Infra-red D. WiMax

vi. _____ signals can be used for short-range communication in a closed area using line-of-sight propagation.
A. Wi-Fi B. Bluetooth
C. Wi-Max D. Infra-red

vii. The GPS system consists of _____ satellites.
A. 20 B. 22
C. 24 D. 25

viii. GPS _____ segment facilities that track the GPS satellites, monitor their transmissions, perform analysis, and send commands and data to the constellation.
A. User B. Control
C. Space D. Air

ix. Which of the following orbits is at the distance of 22,000 miles from the surface of the Earth.?
A. Geostationary Earth Orbit B. Low Earth Orbit
C. Medium Earth Orbit D. High Earth Orbit

x. _____ is the first markup language standard for wireless devices.
A. HTML B. WAP
C. HTTP D. WML

Q2. Give short answers to the following questions.

i. What is Radio Transceiver?
ii. What is 'Hotspot'?
iii. What does IEEE stand for?
iv. What is meant by line of sight communication?
v. Differentiate between short distance and long distance wireless communication.
vi. What is Global Positioning System (GPS)?
vii. What is Wireless Markup Language?
viii. What is Wireless Application Protocol?
ix. Write short note on Web Protocol Stack?

Q3. Give detailed answers of the following questions.

i. What are the advantages and disadvantages of wireless networks?
ii. Explain different types of short distance communications technologies.
iii. Describe long distance communications technologies in detail.
iv. Explain different classifications of Satellite Systems.
v. What are the Requirements of Mobile Communication System?
vi. Give important features and limitations of Mobile Communication System.

UNIT 7

DATABASE FUNDAMENTALS

After the completion of Unit - 7, the Students will be able to:

- explain the difference between data and information.
- explain the file management system.
- define Database.
- explain Database Management System (DBMS).
- identify advantages of DBMS over the File Management System.
- identify the role of Database Administrator (DBA).
- describe the types of Database Models.
- explain the types of database languages for relational databases.
- define the basic database terminologies (Field/Attribute/Column, Record/Tuple/Row, Table/Relation, View, Data Type, Key).
- explain the steps for designing a database.
- explain with examples (Entity, attributes, relationships, keys).
- explain the cardinalities and modalities with the help of pictorial examples.
- draw Entity-Relationship (E-R) diagram for library management system, student management system, ticket booking system.
- transform the E-R diagram to the Relational schema (Transforming entities, transforming attributes, transforming relationships).
- normalize relations up to third normal form including integrity rules.

7.1 INTRODUCTION

In past, databases were found only in special research laboratories where computer scientists struggled with ways to make them efficient and useful, and published their findings in countless research papers. Today databases are a ubiquitous part of the information technology (IT) industry and business in general. We directly and indirectly use databases every day banking transactions, travel reservations, employment relationships, web site searches, purchases, and most other transactions are recorded in and served by databases.

A database is a collection of related files that are usually integrated, linked or cross-referenced to one another. The advantage of a database is that data and records contained in different files can be easily organized and retrieved using specialized database management software called database management system (DBMS).

7.1.1 Data and Information

Data

The word Data is the Latin plural of Datum which means "to give" or "something given" (The word data is usually used as a singular term). Data is a collection of facts, figures, numbers or ideas that can be organized and processed. Data may or may not be meaningful and cannot be used for decision making process

Information

When facts, figures or numbers (data) are processed and converted into meaningful form that can be used for decision making or any other useful activity, it is called Information.

Examples of data and information

1. Students' names in a class are **data** while names of students' in alphabetic order is an **information**.
2. A day's temperature, humidity, wind speed recorded are **data** while weather prediction as cold or warm is **information.**
3. A student's subject marks are **data** while his percentage of marks, grade and position are **information**.

Difference between Data and Information

	Data	Information
1	Data is raw, unorganized facts that need to be processed. Data can be something simple and seemingly random and useless until it is organized.	When data is processed, organized, structured or presented in a given context so as to make it useful, it is called Information.
2	Data is used as input in the computer.	Information is the output of computer.
3	Data alone is meaningless and valueless.	Information is useful, meaningful and valuable.
4	Data is difficult or even impossible to reproduce if lost. For examples in an Exam result all the subject marks award lists are lost or damaged, it would be very difficult to reproduce them.	Information is easier to reproduce if lost. For example, if the obtained marks of the students' are lost, these can easily be recalculated from the award lists
5	Data is an independent entity.	Information depends on data.

7.1.2 File Management System

File Management system also known as Conventional file system or simply file system is a method of storing and organizing collection of data in the form of files on the secondary storage devices. These files are accessed with the help

of certain file handling program developed in programming languages like C, BASIC and Pascal. Conventional file system is no longer used due to its demerits and limitations as mentioned below.

Limitations of File Management System

i. Data Redundancy

Independent data files include a lot of duplicated data; the same data is recorded and stored in several files. This data redundancy causes problems when data is to be updated. Hence data redundancy is more in case of file approach.

ii. Inconsistency

In this system, data is not consistent due to redundant storage. If a data item is changed all the files containing that data item need to be changed and updated properly. If all the files are not updated properly there may be high risk of inconsistency.

iii. Intensive Coding

The processing tasks like searching, editing, deletion and updating should have separate programs. It means there are no built in functions available and needs coding every time to perform these operations.

iv. Data Isolation

Data is scattered in various files and the files may be in different format. The users have to write new application program to retrieve data from these files. This is difficult, time-consuming, and costly.

v. Data Program Dependence

In file management systems, changes in the format and structure of data and records in a file require that changes be made to all of the programs that use that file. This program maintenance effort is a major burden of file management systems.

vi. Difficulty in Accessing Data

It is not easy to retrieve information using a file management system. The simplest data retrieval task from file requires extensive programming. Also this is a time consuming and a high skill activity.

vii. Integrity Problems

Integrity means reliability and accuracy of data. Data values may need to satisfy some integrity constraints. For example the balance field value of a bank account must be greater than 5000. We have to handle this through program code in file management systems.

viii. Atomicity Problem

Atomicity means that either one transaction or another should take place as a whole. It is difficult to ensure atomicity in file management system. For example while transferring an amount of Rs. 1000/- from Account A to account B, if a failure occurs during execution there could be situation like Rs. 1000/- are deducted from Account A and not credited in Account B.

ix. Poor data security

All the files are stored as text files. These files can be easily located and trapped because file management system has no centralized data security. Enforcing security constraints such as effective password protection, locking parts of file in file processing system are very difficult to program.

7.1.3 Database

Database is a shared collection of logically related data (and a description of this data i.e. metadata), designed to meet the information needs of multiple users in an organization. It usually refers to data organized and stored in a computer that can be searched and retrieved by a computer program called DBMS.

A database combines records previously stored in separate files into a shared pool of data records that provides data for many applications. The data stored in a database is independent of the application programs using it and the type of secondary storage devices on which it is stored.

7.1.4 Database Management System (DBMS)

A database management system (DBMS) is a set of programs that allow users to create, maintain and manipulate database, and store or retrieve data from those database files. Manipulation of data includes the following.

- Adding new data, for example adding details of new student.
- Deleting unwanted data, for example deleting the details of students who have completed course.
- Changing existing data, for example modifying the fee paid by the student.

The DBMS helps to create an environment in which users have better access to data. DBMS helps to give an integrated view of the organization's operations. The DBMS makes it possible to share the data in the database among multiple applications and users.

The following are few examples of the database systems, managed by DBMS.

- Customer information system
- Inventory information
- Library management
- Accounting and bookkeeping

Typical DBMS include Microsoft Access, Microsoft SQL Server, Sybase, IBM DB2, Oracle, Ingres and MySQL.

7.1.5 Advantages of DBMS over the File Management System

The DBMS is preferred over Conventional File Management System due to the following advantages:

i. Controlled Data Redundancy

In the Conventional File Management System, every user maintains its own files for handling data. The database approach combines redundant data into a single, logical structure. Every primary fact is stored at only one place in the database.

ii. Data Consistency

Minimal data redundancy leads to consistent data. By controlling data redundancy, data inconsistency is greatly reduced. If a data item appears only at one place it is easy to maintain. Any change will automatically take effect at all places wherever this data is used.

iii. Data Sharing

A database is designed as shared resource compared to Conventional File System. Authorized users are granted access to use the shared database according to their needs and rights.

iv. Enforcement of Standards

Since all access to database must be through DBMS so standards are easier to enforce. Standards may relate to the naming of data, format of data, and structure of data.

v. Security

In Conventional filing systems there is no centralized security system which restricts users according to their role in the organization. DBMS makes it easier to enforce security restrictions since database is centralized. Users are provided permissions to access data according to their rights.

vi. Reduced Program Maintenance

Many DBMS provide several tools to use in program development and maintenance. It reduces the overall time for developing and maintenance of programs.

vii. Backup and Recovery

DBMS provides facilities for backup and recovery from failures including disk crash, power failure, software errors, which may bring the database from the inconsistent state to a state prior to the failure.

viii. Program-Data Independence

The separation of data from the application programs that use the data are called data independence. In database approach data descriptions (metadata) is stored in a central location called the repository. With data independence, user can change data without changing the application programs that process the data.

ix. Support for multiple views

DBMS may allow different users to see different "views" of the database, according to the perspective each one requires. For example, the people using the payroll system may not require to see data about students and class schedules.

x. User-friendliness

Using DBMS user can easily access and manipulate data in database. DBMS provide a user friendly interface for interaction with database. In most cases, DBMSs also reduce the reliance of individual users on computer specialists to meet their data needs.

7.1.6 Role of the Database Administrator (DBA)

DBA is a person responsible for managing the overall database management and physical realization of the database system. The primary role of the DBA

is to administer, develop and implement policies and procedures necessary to ensure the security and integrity of the database. Other primary responsibilities of a DBA include:

- Implementation of Data Models
- Database design
- Performance issues
- Storage structure and access-method definition
- Granting of authorization for data access
- Routine maintenance which may include:
  - Periodically backup the database
  - Ensuring that enough free disk space is available
  - Monitoring jobs running on the database and performance

7.1.7 Database Models

A database model is a set of rules or specifications which state that how data can be stored, organized and manipulated in a database system. It provides tools for describing data, data relationships, data semantics and consistency constraints. Several models have been suggested. Few common models include:

a. Hierarchical Database Model
b. Network Database Model
c. Relational Database Model
d. Object Oriented Database Model
e. Object Relational Database Model

a. Hierarchal Database Model

In this type of model, data is organized into a tree-like structure. There is a hierarchy of parent and child segments. This structure implies that a record can have repeating information, usually in the child data segment. Each parent

can have many children but each child has only one parent. Figure 7.1 depicts a hierarchical database model.

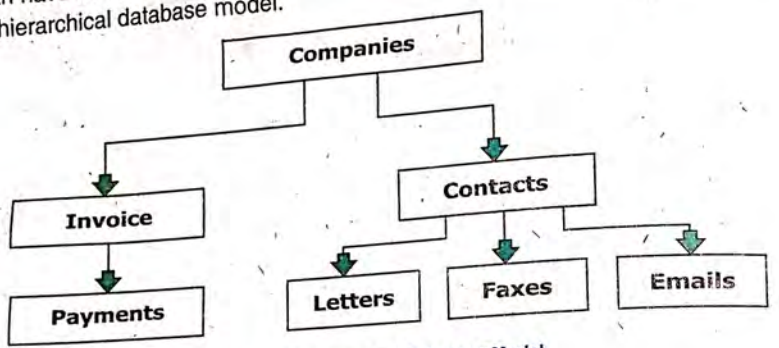


Figure 7.1 Hierarchical Database Model

b. Network Database Model

A network database is similar to a hierarchical database model except that each child can have more than one parent record. A child record is referred to as a "member" and a parent record is referred to as an "owner". The advantage of the network database is its ability to establish relationships between different branches of data records and thus offer increased access capability for the manager. Figure 7.2 shows a network database model.

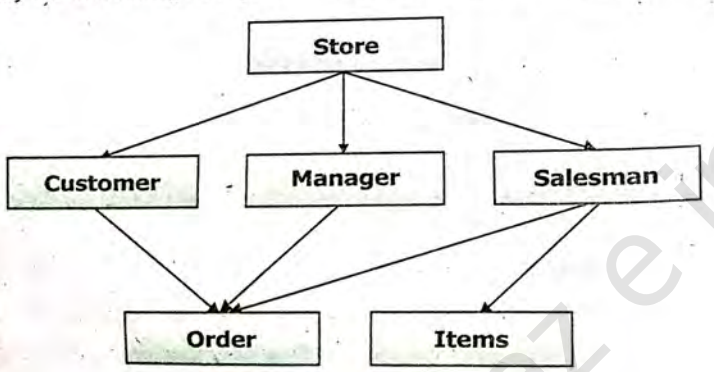


Figure 7.2 Network Database Model

c. Relational Database Model

A relation is a table with columns and rows. The Relational model uses a collection of tables/relations to represent both data and the relationship among those data. Each table has multiple columns and each column has a unique name. Information about particular entity is represented in rows (also called tuples) and columns. Figure 7.3 illustrates an example showing an Entity-Relationship (E-R) diagram that represents entities (tables) and their relationships for a sample relational model.

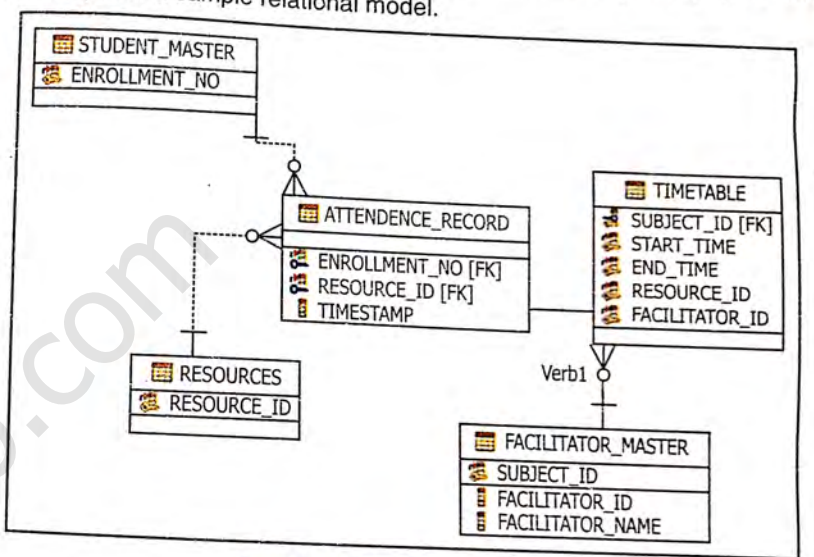


Figure 7.3 Relational Database Model

d. Object-Oriented Database Model

Object-Oriented database Model is a database model in which information is represented in the form of objects as used in object-oriented programming. Object oriented databases are different from relational databases and belong together to the broader database management system. When database capabilities are combined with object-oriented programming language capabilities, the result is an object-oriented database model.

e. Object Relational Database Model

Object relational database model add new object storage capabilities to the relational database systems at the core of modern information systems. These new facilities integrate management of traditional fielded data, complex objects such as time-series and geospatial data and diverse binary media such as audio, video, images, and applets. By encapsulating methods with data structures, an ORDB Model server can execute complex analytical and data manipulation operations to search and transform multimedia and other complex objects.

7.1.8 Database Languages for Relational Databases

To manipulate data, one approach is to interact directly with the DBMS using a special language called a query language.

Structured Query Language (SQL)

Almost all relational database management systems use SQL (Structured Query Language) for data manipulation and retrieval. SQL is the standard language for relational database systems. SQL is further divided into the following languages:

a. DDL (Data Definition Language)
b. DML (Data Manipulation Language)
c. DCL (Data Control Language)

a. Data Definition Language (DDL)

Data definition language (DDL) is a database language that defines the structure in which data are stored. These structures may include database, table, query fields and records.

b. Data Manipulation Language

A data manipulation language (DML) is a language that enables users to access or manipulate data. The types of access are:

- Retrieval of information from database
- Insertion of new data into the database
- Deletion of data from database
- Modification of data stored in the database

c. Data Control Language

Data Control Language is a database language used to control access to the data in a database. Examples of DCL are:

- Giving rights to the users
- Revoking of the already given rights

7.2 BASIC DATABASE TERMINOLOGIES

The following are some basic database terminologies.

a. Field/Attribute/Column

An attribute is a property or characteristic of an entity that is of interest to the organization. Following are some attributes:

- STUDENT: student no, name, address, phone no
- EMPLOYEE: employee no, name, address, skill

In Relational Database Model, an attribute is represented by column. Whereas the term field is usually used for a column but it is more correct to use field to specify a single item that exists at the intersection of a row and column.

b. Record/Tuple/Row

A collection of related fields treated as a single unit is called a record. For example a student's record includes a set of fields that contains Roll No, Name, Class, Date of Birth and Address.

In Relational database, a Row or a Record or Tuple represents a single occurrence of an entity.

c. Table/Relation

A table is set of values that are organized using vertical named columns and horizontal rows. A table has a specified number of columns, but may have any number of rows. Whereas in terms of relational database, a table can be considered as relation, but the two are not equivalent. For example a table may contain duplicate rows, but a true relation cannot contain duplicate rows.

d. View

A view is a dynamic and virtual table that may not exist in the database but is derived from one or more base tables. In simple words there is no stored table that represents the view instead a definition or query representing the view is stored in the database.

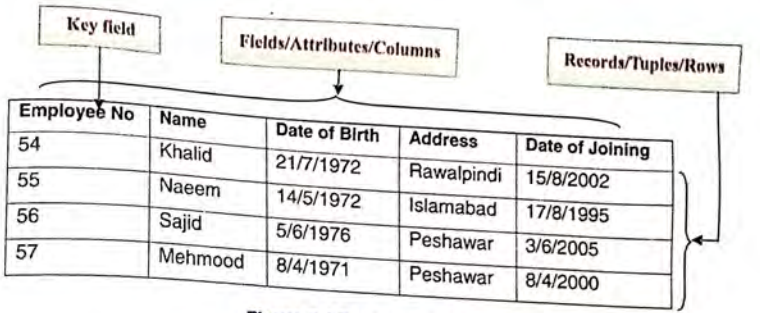
e. Data Type

Data type is the classification of a particular type of information. It is easy for human beings to distinguish among different types of data but most database systems require the user to specify the type of each data field. Integer, floating-point and character (text) are the common data types.

f. Key

In order to track and analyze data effectively, each record in a table requires an identifier that uniquely indentifies it, is called a key. The key must be completely unique to a particular record. For example student's roll number, employee number, and customer number, etc. are key fields.

Figure 7.4 shows a complete Table or Relation.



Employee No	Name	Date of Birth	Address	Date of Joining
54	Khalid	21/7/1972	Rawalpindi	15/8/2002
55	Naeem	14/5/1972	Islamabad	17/8/1995
56	Sajid	5/6/1976	Peshawar	3/6/2005
57	Mehmood	8/4/1971	Peshawar	8/4/2000

Figure 7.4 Table/Relation

7.3 PLANNING A DATABASE

Database planning is a systematic approach to the development of database that moves from concept to design and development to implementation. A well-designed database promotes consistent data entry and retrieval.

7.3.1 Steps for Designing a Database

The process of database design is divided into different steps. These are:

a. Problem Identification/definition
b. Feasibility Study
c. Requirement Analysis
d. Identifying Entities and Attributes
e. Assigning Names to Tables and Columns

a. Problem Identification/definition

One must know what the problem is before it can be solved. In this step a statement is prepared specifying the scope and objective of the problem. For example, the Admission Section Head has been getting complaints of poor service from student. This may lead an initial investigation to find whether a

new system can solve the problem. If the report suggests a new system, this leads to the next phase which is the feasibility study of the new system.

b. Feasibility Study

Feasibility Study also known as pilot study is conducted to determine whether new database system should be developed or not. Feasibility study depends on various factors which may include time needed for development, cost of development, resources needed in and after development, training of personals, and maintenance of the new system after implementation.

c. Requirement Analysis

Requirements analysis is the process of understanding the customer needs and expectations from the proposed system. Requirements are a description that how new system should behave or features to be included in it. In order to collect all these required information, a database analyst need to spend a lot of time within the business organization observing the current system, talking to the end-users and examine the overall system.

d. Identifying Entities and Attributes

After requirements identification, the next step is to identify the entities and its attributes. An entity is the main data object that is of significant interest to the organization. It is usually a person, place, thing, or event to be recorded in the database.

An Attribute is a property that describes an entity. For example if employee is an entity then, the employee's name, age, address, salary and job etc. are the attributes.

e. Assigning names to Tables and Columns

Entities are converted to tables and attributes to columns of the tables, once entities and attributes are identified. There are no standard conventions for naming tables and columns but all names should be meaningful and consistent throughout the database. Table names represent business object,

so meaningful words should be used for naming tables, for example "Customers" for customer's table. In case of attributes, meaningful names should be used wherever possible.

7.4 DATA MODELING AND ENTITY RELATIONSHIP DIAGRAM

a. Data Modeling

A data model is a logical representation of data in an organization. It is used to describe the elements of a database system and their relationships. A data model can be thought of as an entity relationship diagram that illustrates the relationships between data. Capturing all the possible relationships in a data model can be very time-intensive. It is an important step and should not be avoided. Data modelers often use multiple models to view the same data and ensure that all processes, entities, relationships and data flows have been identified.

b. ENTITY RELATIONSHIP DIAGRAM (ERD)

Entity Relationship model is expressed in terms of entities, the relationships (or associations) among those entities, and the attribute (or properties) of both the entities and their relationships in the business environment. Diagrams created by this process are called **Entity-Relationships Diagrams (ERDs).**

An entity-relationship (ER) diagram is a graphical representation of entities and their relationships to each other. It is typically used in computing for organization of data within databases or information systems. The following are a few symbols used in ERD.

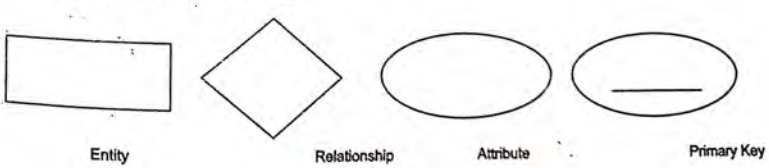


Figure 7.5 ERD symbols

7.4.1 Elements of Entity Relationship Diagram

a. Entity

An entity is a person, place, object, event or concept in user environment about which the organization wishes to maintain data. Examples of entities are as under:

- PERSON: employee, student, patient
- PLACE: city, state, country
- OBJECT: machine, building, automobile
- EVENT: sale, admission, exams
- CONCEPT: account, course, work center

Entity Instance

A single occurrence of an entity is called entity instance. For example the Instances of Entity STUDENT are as under:

RollNo: 454
Name: Ahmad Ali
Address: Peshawar
PhoneNo: 0454450454

RollNo: 343
Name: Nauman
Address: Mardan
PhoneNo: 0445666454

b. Attribute

An attribute is a property or characteristic of an entity that is of interest to the organization. Following are some attributes:

- STUDENT: student no, name, address, phone no
- EMPLOYEE: employee no, name address, skill

c. Relationship

A meaningful association among entities is called a relationship. A relationship describes how the data is shared between entities. Relationships are represented by a diamond symbol connected to the related entities.

In the original Chen notation, the relationship is placed inside a diamond, e.g. managers manage employees as shown in Figure 7.6.

Figure 7.6 Relationship

Degree of a Relationship

The number of participating entities in a relationship is known as the degree of the relationship. It has three types.

i. A **unary relationship** exists when an association is maintained within a single entity. Unary relationships are also known as a ***recursive relationship***. It is a relationship where the same entity participates more than once in different roles.

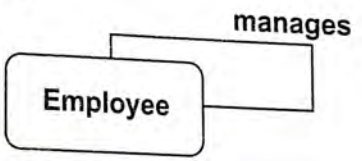


Figure7.7 Unary/Recursive relationship

In the above example employees are managed by employees.

ii. A **binary relationship** exists when two entities are associated with each other through a relationship. OR If there are two entity types involved, it is a *binary* relationship type.

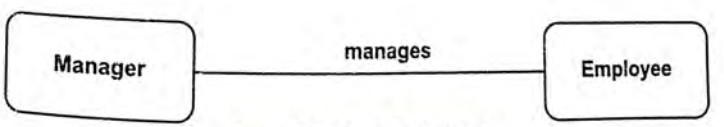


Figure7.8 Binary Relationship

Like unary relationship, in binary relationship the associations between two entity types may be described as one-to-one, one-to-many or many-to-many.

one-to-one: one instance of an entity (A) is associated with only one instance of another entity (B). For example, in a database one instance of entity type Country (A) is associated with only one instance of entity type President (B).

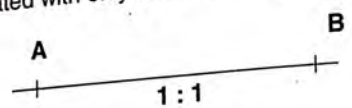


Figure7.9 one-to-one

one-to-many: one instance of an entity (A) is associated with zero, one or many instances of another entity (B), but for one instance of entity B there is only one instance of entity A. For example, for a company with all employees working in one building, the building name (A) is associated with many different employees (B), but those employees all share the same singular association with entity A.

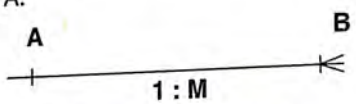


Figure7.10 one-to-many

many-to-many: one instance of an entity (A) is associated with one, zero or many instances of another entity (B), and one instance of entity B is associated with one, zero or many instances of entity A. For example, for a company in which all of its employees work on multiple projects, each instance of an employee (A) is associated with many instances of a project (B), and at the same time, each instance of a project (B) has multiple employees (A) associated with it.

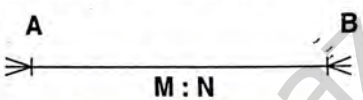


Figure7.11 many-to-many

iii. A **ternary relationship** exists when three entities are associated. OR If there are three entity types involved it is a ternary relationship type.

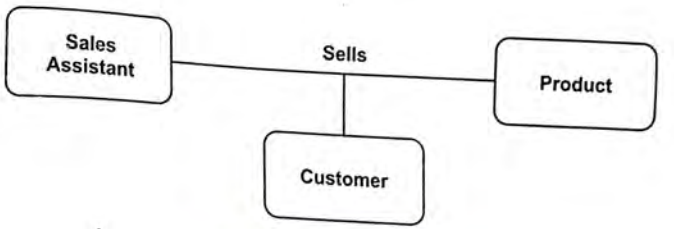


Figure 7.12 Ternary relationship

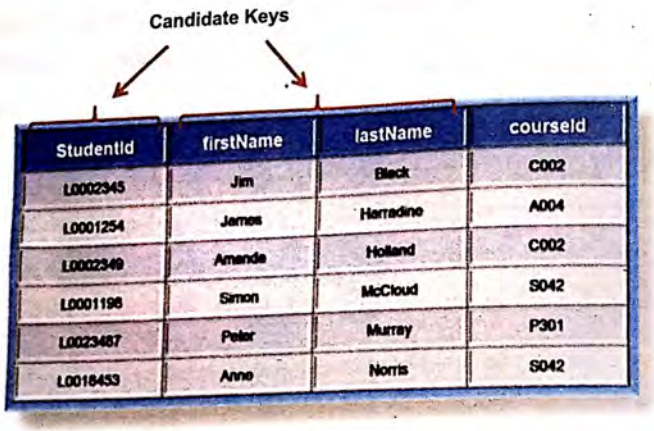
d. Keys

A key is the relational means of specifying uniqueness. A key is an important part of relational database and a vital part of the structure of a table. A Key ensures each record within a table can be uniquely identified by one field or a combination of fields within the table.

There are different types of keys.

i. Candidate Key

A Candidate key is any set of one or more columns whose combined values are unique among all occurrences. In other words a candidate key can be used to uniquely identify each record in the table. Every table must have at least one candidate key but at the same time can have several.



StudentId	firstName	lastName	courseId
L0002345	Jim	Black	C002
L0001254	James	Harradine	A004
L0002349	Amanda	Holland	C002
L0001198	Simon	McCloud	S042
L0023487	Peter	Murray	P301
L0018453	Anne	Norris	S042

Figure 7.13 Candidate keys

In the above example, student_id can be a candidate key which uniquely identifies the students in a student table. But at the same time, the combination of student's first name and last name also form a candidate key. These both can be candidate keys for student table.

A candidate key must have the following properties:

- It must contain unique values
- It must not contain null values
- It contains the minimum number of fields to ensure uniqueness
- It must uniquely identify each record in the table

ii. Primary Key

A primary key is a field, or a combination of fields used to identify particular rows in a relation. Primary key, as its name shows is the primary reference for the table and is used throughout the database to refer this table. Primary key must contain unique value and never be null.

StudentId	firstName	lastName	courseId
L0002345	Jim	Black	C002
L0001254	James	Harradine	A004
L0002349	Amanda	Holland	C002
L0001198	Simon	McCloud	S042
L0023487	Peter	Murray	P301
L0018453	Anne	Norris	S042

Figure 7.14 Primary keys

iii. Foreign Key

A foreign key is generally a primary key from one table that appears as a field in another table where the first table has relationship to the second. For example, if we have a table A with a primary key X that is linked to a table B where X is a field in B, then X would be a foreign key in B.

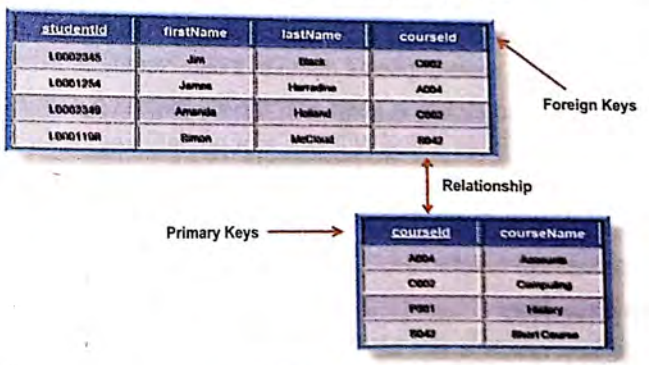


Figure 7.15 Foreign keys

In the above example, courseId is primary key in courses table, whereas it is foreign key in the student table. The two tables are linked through courseId.

iv. Composite Primary Key

In some tables a single column cannot uniquely identify entities (rows). In that case we have to use two or more columns to uniquely identify rows of the table.

When a primary key contains two or more columns or fields, it is called as composite primary key.

v. Super Key

A Super Key is a set of one or more attributes that are taken collectively and can identify all other attributes uniquely.

If we add additional attributes to a primary key, the resulting combination would still uniquely identify an instance of the entity set Such keys are called super keys A primary key is therefore a minimum super key For example, if DOB (date of birth field or attribute) is the primary key, then by adding some additional information about the day of the month key in the DOB field, this field or attribute becomes more powerful and useful Such type of key is called super key.

vi. Secondary Key

A secondary key is an attribute or combination of attributes that is not a primary key and can have duplicate data i.e. it can identify a group of records. In other words secondary key is used after the identification of the primary key. e.g. in a STUDENT table if Roll Number is a primary key, then Name of the student, address of the student, Phone number of the student and the fees paid by the student are secondary keys. Secondary keys are used to speed up searching process in databases.

vii. Alternate Key

A candidate key which is not selected as the primary key is called alternate key. For example if Roll No. and Registration No. fields are the candidate keys

and if Roll No. is selected as the primary key then Registration No. will work as the alternate key.

7.4.2 Cardinality and Modality

Cardinality refers to the maximum number of times an instance in one entity can be associated with instances in the related entity.

Modality refers to the minimum number of times an instance in one entity can be associated with an instance in the related entity.

Cardinality can be 1 or Many and the symbol is placed on the outside ends of the relationship line, closest to the entity. Modality can be 1 or 0 and the symbol is placed on the inside, next to cardinality symbol.

For a cardinality of 1 a straight line is drawn. For a cardinality of Many a foot with three toes is drawn. For modality of 1 a straight line is drawn. For a modality of 0 a circle is drawn.

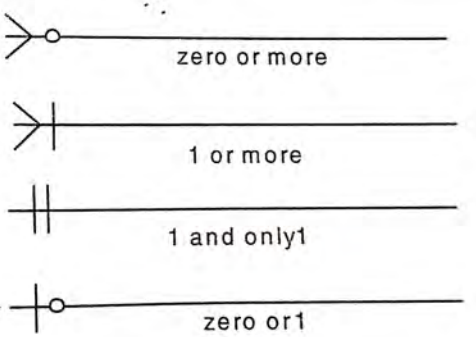


Figure 7.16

The following diagram indicates all of the possible combinations:

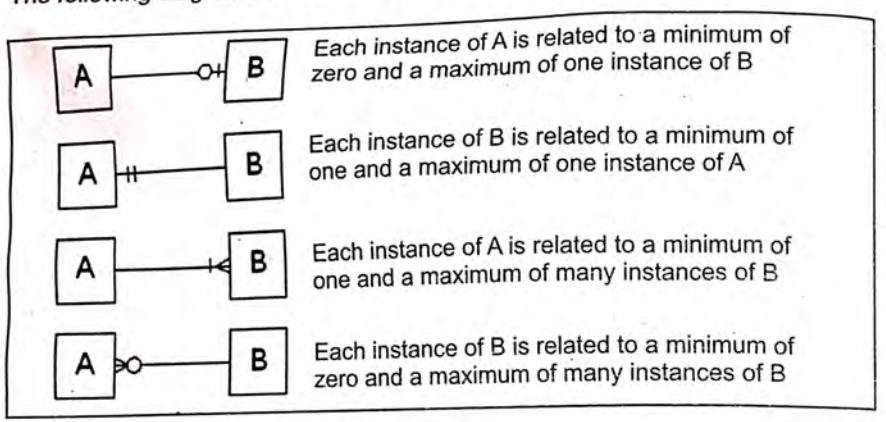


Figure 7.17

7.4.3 Sample E-R Diagrams

The following are few examples of E-R Diagrams for some systems like Library Management System, Student Management System and Ticket Booking System

E-R Diagram for Library Management System

In the library Management system shown in Figure 7.18, the following entities and attributes can be identified.

- ***Book:*** The set of all the books in the library. Each book has a Book-id, Title, Author and subject as its attributes.
- ***Member:*** The set of all the library members. The member is described by the attributes Memb_id, Name, Address and Telephone.

- ***Publisher:*** The set of all the publishers of the books. Attributes of this entity are Pub_ID, Address and Name.
- The relationship between Publisher and Book is one-to-many because a Publisher publishes many books.
- The relationship between Member and Book is also one-to-many because a Member can borrow one or more books.

Figure 7.18 E-R Diagram for Library Management System

E-R Diagram for Student Management System

In the student Management system shown in Figure 7.19, the following entities and attributes can be identified.

- ***Department***: The set of all the departments in an organization. Each department has a DepartmentName and Location as its attributes.
- ***Instructor***: The set all the instructors in a department. The instructor is described by the attributes Instructor_ID, first_name, last_name and phone.

- ***Course***: The set of all the courses offered by a department. The course is described by the attributes Course_ID, duration and course_name.
- ***Student:*** The set of all the students of the institution. Attributes of this entity are Student_ID first_name, last_name and phone.
- The relationship between Department and Course is one to many because a department offers many courses for study.
- The relationship between Department and Instructor is one to many because a department can hire many instructors to teach different courses in the institution.
- The relationship between Instructor and Course is one to many because an instructor teaches one or many courses.

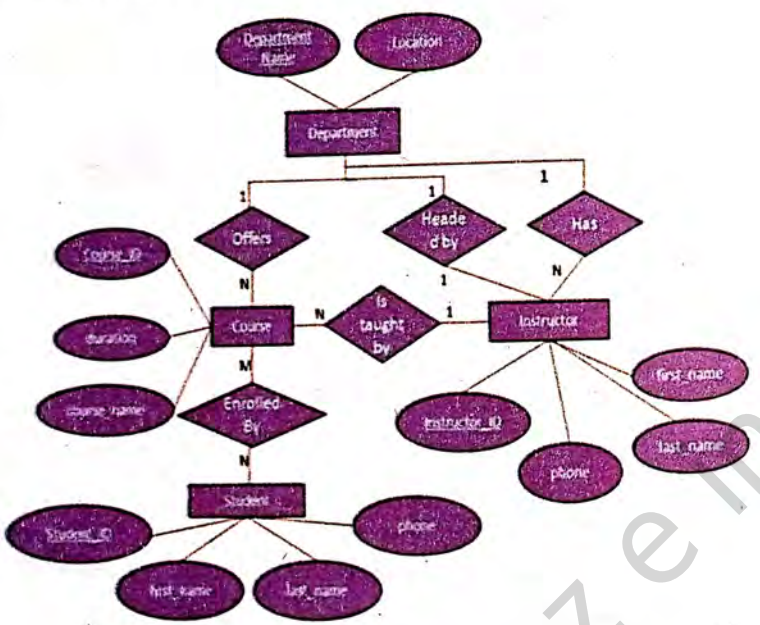


Figure 7.19 E-R Diagram for Student Management System

- The relationship between Student and Course is many-to-many because a student can be enrolled for one or more courses and a Course can be taken by one or many Students.

E-R Diagram for Ticket Booking System

In the Ticket Booking System shown in Figure 7.17, the following entities and attributes can be identified.

- ***Airline:*** The entity Airline is set of all the airlines and its attributes are Airline_Code and Airline Name.
- ***Passenger:*** The set of all the passengers who want to travel by an airplane. Each passenger has a TicketNo, Name, Address and PhoneNo as its attributes.
- ***Seat:*** The set of all the seats available for reservation to passengers. The seat is described by the attributes SeatNo, Class and Name.
- ***Flight***: The set of all the flights offered by an airline. The flight is described by the attributes FlightNo, DepartureDate, DepartureTime, ArrivalDate, ArrivalTime, From and To.
- The type of relationship between Airline and Flight is one-to-many because one airline has many flights.
- The type of relationship between Passenger and Seat is one to one because each passenger occupies a single seat for travelling in a flight.

- The type of relationship between Flight and Passenger is one to many because each flight has many passengers.
- The relationship between Flight and Seat is one to many because there may be available one or many seats available for reservation in each flight.

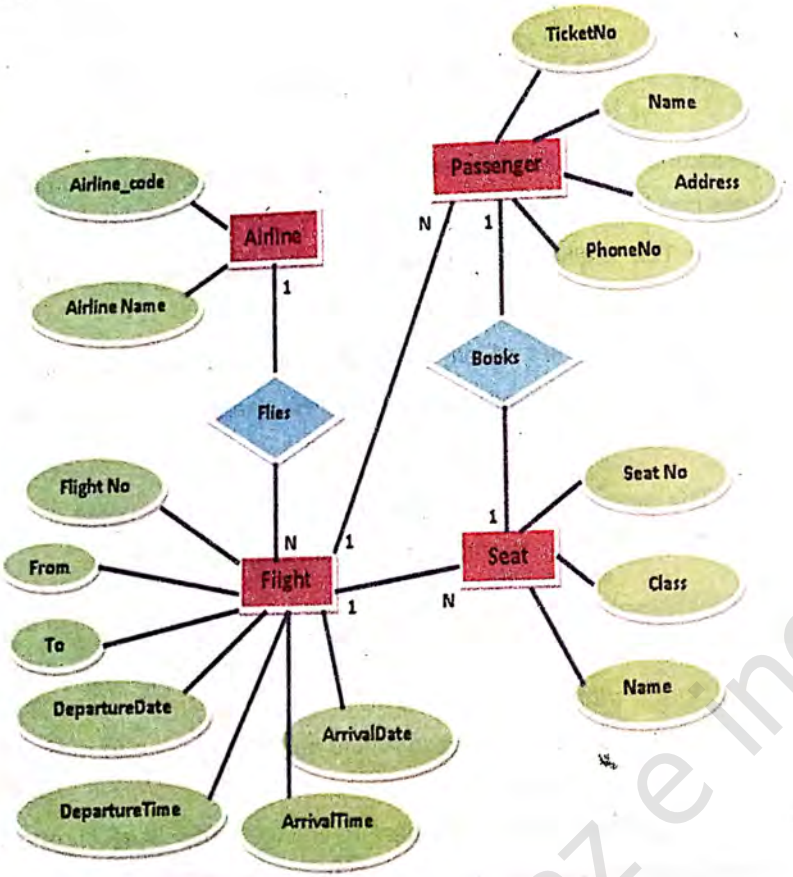


Figure 7.20 E-R Diagram for Ticket Booking System

7.5 RELATIONAL SCHEMA

A relational database schema is the tables, columns and relationships that make up a relational database. The schema describes how real world entities are modeled in the database. An ER Model is intended as description of real world entities but it represents the conceptual level of the database design and must be translated into a logical level of database design.

A relational database schema helps users to organize and understand the structure of a database. This is particularly useful when designing a new database, modifying an existing database to support more functionality, or building integration between databases.

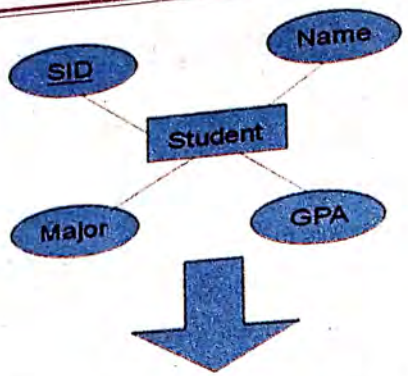
7.5.1 Transformation of E-R Model into Relational Schema

a. Transforming Entities to Relational Schema

Each entity set is replaced by a table or a relation. Each table has a name. The name used is the entity name. Each table has a number of rows and columns. Each row corresponds to an entity instance. Each column corresponds to an attribute.

b. Transforming Attributes to Relational Schema

Each attribute of the entity type is replaced by a column (field) in the table. Suppose we have an Entity Type Student that has attributes, SID, Name, Major and GPA. All the attributes of Student entity will become columns in the Student table. Figure 7.18 shows this transformation.



SID	Name	Major	GPA
1234	Ali	CS	2.8
5678	Asad	EE	3.6

Figure 7.21 Transformation of E-R Model into Relational Schema

c. Transforming Relationships to Relational Schema

Each relationship in an E-R diagram must also be represented in relational schema. The representation depends upon the nature of relationship. In some cases, a relationship is represented by making the primary key of one relation, a foreign key of another relation. In some cases, a separate relation is created to represent a relationship.

7.5.2 Normalization

Normalization is the process of organizing data in relational database in order to minimize duplication of information (data) and to safeguard the database against certain anomalies. The basic purpose of normalization is to divide large table into smaller and well formed tables/relations and remove the inconsistencies or anomalies.

Normal Form

The degree of normalization is termed as Normal Form. For example, First Normal Form (1st NF), Second Normal Form (2nd NF), Third Normal Form (3rd NF) etc.

First Normal Form

The relation is considered to be in First Normal Form (1st NF) if the intersection of each row and column contains only one value. In 1st NF we remove the repeating groups. Consider the following example.

Employee Table

Proj_no	Proj_name	Emp_no	Emp_name	Job_class	Charge_per_hour	Hours
15	Evergreen	103	Jameel Khan	Elect. Engineer	1000	23
		101	Faisal Naeem	DB Designer	900	19
		105	Bilal Ahmad	DB Designer	900	35
18	MIS	114	Zubair Ahmad	Programmer	750	12.6
		118	M. Waseem	System Analyst	800	45.3
		104	Shaukat Ali	App Designer	600	32.4

Figure 7.22

The Employee table contains repeating groups. To normalize the above table, all repeating groups must be eliminated.

Employee Table

Proj_no	Proj_name	Emp_no	Emp_name	Job_class	Charge_per_hour	Hours
15	Evergreen	103	Jameel Khan	Elect. Engineer	1000	23
15	Evergreen	101	Faisal Naeem	DB Designer	900	19
15	Evergreen	105	Bilal Ahmad	DB Designer	900	35
18	MIS	114	Zubair Ahmad	Programmer	750	12.6
18	MIS	118	M. Waseem	System Analyst	800	45.3
18	MIS	104	Shaukat Ali	App Designer	600	32.4

Figure 7.23

Attribute Proj_no is not an adequate key and does not uniquely identifies all the records. To maintain a proper primary key, the new key must be composed of a combination of Proj_no and Emp_no.

2nd Normal Form

A relation will be in 2nd NF if it is in the first normal form and all non key attributes must be fully functional dependent on the whole primary key (No partial dependencies). Consider the table 7.24

Employee Table

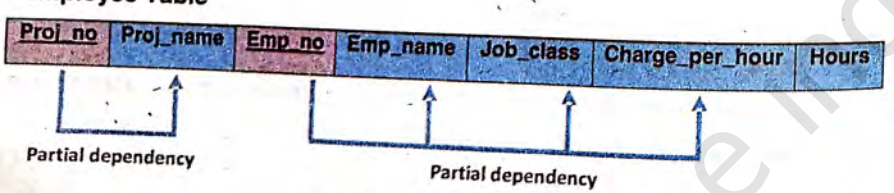


Figure 7.24

Attribute Proj_name is dependent on Proj_no, while Emp_name, Job_class and Charge_per_hour are dependent on Emp_no. Dependencies based on only part of a composite primary key are called partial dependencies.

Project Table

Figure 7.25

Employee Table

Figure 7.26

Hours Table

Figure 7.27

Because the number of hours spent on each project by each employee is dependent on both Proj_no and Emp_no, we place these hours in the Hours table hours as in Figure 7.27.

3rd Normal Form

The relation should be in the 1st and 2nd normal forms and all transitive dependencies must be removed. A transitive dependency is a dependency of one non-key attribute on another non-key attribute. Consider Table in Figure 7.28.

Employee Table

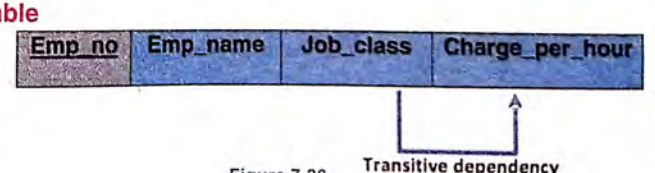


Figure 7.28

Both Job_class and Charge_per_hour are nonprime attributes and the later one is dependent on the former. So by removing transitive dependency the following new tables will be created.

Employee Table

Emp_no	Emp_name	Job_class

Figure 7.29

Job Table

Job_class	Chg_per_hour

Figure 7.30

SUMMARY

- Data is a collection of facts, figures, numbers or ideas that can be organized and processed.
- When facts, figures or numbers (data) are processed and converted into meaningful form that can be used for decision making or any other useful activity, it is called Information.
- File Management system also known as Conventional file system or simply file system is a method of storing and organizing collection of data in the form of files on the secondary storage devices.
- Database is a shared collection of logically related data (and a description of this data i.e. metadata), designed to meet the information needs of multiple users in an organization.
- A database management system (DBMS) is a set of programs that allow users to create a database, edit and update data in database files, store and retrieve data from those database files.
- A database model is a set of rules or specifications which state that how data can be stored, organized and manipulated in a database system.
- Hierarchal Database Model is a type of model in which data is organized into a tree-like structure.
- A network database is similar to a hierarchical database except that each child can have more than one parent record.
- Relational Database Model uses a collection of tables to represent both data and the relationship among those data. Each table has multiple columns and each column has a unique name.
- Object-Oriented database Model is a database model in which information is represented in the form of objects as used in object-oriented programming.
- Object relational database model add new object storage capabilities to the relational systems at the core of modern information systems.
- SQL (Structured Query Language) is the standard language for relational database systems.

- Data definition language (DDL) is a database language that defines the structure in which data are stored.
- Data manipulation language (DML) is a language that enables users to access or manipulate data.
- Data Control Language is a database language used to control access to the data in a database.
- Field/Attribute/Column is a property or characteristic of an entity that is of interest to the organization.
- Record/Tuple/Row is a collection of related fields treated as a single unit.
- Key is a unique identifier which is required to track and analyze data effectively.
- Data Modeling is a logical representation of data in an organization.
- Entity Relationship model is expressed in terms of entities, the relationships (or associations) among those entities, and the attribute (or properties) of both the entities and their relationships in the business environment.
- An entity is a person, place, object, event or concept in user environment about which the organization wishes to maintain data.
- Foreign key is generally a primary key from one table that appears as a field in another where the first table has relationship to the second.
- Secondary key is an attribute or combination of attributes that is not a primary key and can have duplicate data.
- Cardinality refers to the maximum number of times an instance in one entity can be associated with instances in the related entity.
- Modality refers to the minimum number of times an instance in one entity can be associated with an instance in the related entity.
- Relational database schema is the tables, columns and relationships that make up a relational database.
- Normalization is the process of organizing data in relational database in order to minimize duplication of information (data) and to safeguard the database against certain anomalies.

EXERCISE

Q1. Select the best choice for the following MCQs.

i. Hierarchical DBMS organizes data elements into _____.
A. Segments
B. Data compartments.
C. Data units.
D. Objects

ii. _____ is a database model in which information is represented in the form of objects.
A. Network Database Model
B. Relational Database Model
C. Object-Oriented Database Model
D. Hierarchal Database Model

iii. Who is the person who has central control over data and programs in a database system?
A. DBA
B. Designer
C. System Analyst
D. Programmer

iv. In relational terminology, an attribute is also called_____.
A. a record
B. an entity
C. a field
D. a table

v. A row in a table is also known as _____.
A. Column
B. Relation
C. Tuple
D. Field

vi. _____ is a set of rules or specifications which state that how data can be stored, organized and manipulated in a database system.
A. Database model
B. Database design
C. Database architecture
D. Database structure

vii. Which of the following database models uses a collection of tables to represent both data and the relationship among those data?
A. Network Database Model
B. Relational Database Model
C. Object-Oriented Database Model
D. Hierarchal Database Model

viii. _____ is a database language that defines the structure in which data are stored.

A. DNL
B. DCL
C. DDL
D. DML

ix. A field, or a combination of fields used to identify particular row in a relation is called_____.

A. Secondary key
B. Foreign key
C. Primary key
D. Alternate key.

x. A combination of two or more columns used to identify particular row in a relation is a _____.

A. Secondary key
B. Composite key
C. Foreign key
D. Primary key

Q2. Give short answers to the following questions.

i. Define the terms database and DBMS.

ii. Give three examples of data and information.

iii. Write three disadvantages of file management system.

iv. Give any four advantages of database system.

v. Differentiate between DDL and DML.

vi. What is data model?

vii. Differentiate between cardinality and modality.

viii. What is primary key and foreign key?

ix. What is Relation?

x. What is the role of DBA?

Q3. Give detailed answers of the following questions.

i. Explain different types of database models.

ii. What is SQL? Explain its types.

iii. Explain various steps of planning a database.

iv. What is a relation? Explain the degree of relationships with examples.

v. What is ERD? Draw an ERD for the following systems.

vi. Hospital management system

vii. Airline booking system

viii. Describe different steps of Transformation of E-R Model into Relational Schema.

ix. What is Normalization? Explain the following Normal Forms 1NF, 2NF, 3NF.

UNIT 8

DATABASE DEVELOPMENT

After the completion of Unit - 8, the Students will be able to:

- identify various relational database management systems.
- (MS Access, Open Office Base, SQL Server).
- select any suitable DBMS as an application for creating and maintaining databases.
- explain the steps involved in creating and saving a database.
- explain database toolbar, database window and Objects (Tables, Queries, Forms and Reports).
- explain different ways of creating, saving and editing a table in database.
- identify data types, create primary and foreign keys, create and edit relationship among tables, navigate through records in a table and add, modify and delete records.
- explain different ways of creating, saving and editing a form in database.
- know different form views, Use navigation buttons, add, modify and delete records.
- use form controls.
- explain different ways of creating, saving and editing a query in database.
- use the queries on database (Select, Update, Delete, Insert, Alter).
- use the report wizard to generate a report.
- use various report layouts/styles to produce reports.
- set the sort order of records that will appear on the report.
- customize reports using queries (macros and arithmetic expression).
- save, view and print the report.

8.1 INTRODUCTION

Database development is the creation, organization, management and manipulation of database systems for organizations. DBMS (Database Management System) is used to develop a database. A database management system is a set of software programs that allows users to create, edit and update data in database files, and store and retrieve data from those database files. Data in a database can be added, deleted, changed, sorted or searched using a DBMS.

8.1.1 Different Types of Relational Database Management Systems

There are three common types of relational database management systems (RDBMS).

a. Microsoft Access
b. SQL Server
c. Open Office Base

a. Microsoft Access

Microsoft Access, also known as Microsoft Office Access, is a database management system. Figure 8.1 shows MS Access 2007 main screen. An Access database is a collection of database objects i.e. tables, queries, forms, reports, macros, and modules. Users can design new objects or open existing ones to work with their databases. Unlike many database programs, an Access database can contain all of the objects that make up a database application in a single file with the .mdb file name extension. For this reason, an Access database file is sometimes called a database container.

b. SQL Server

Microsoft SQL Server is a relational database management system developed by Microsoft. Its primary function is to store and retrieve data as requested by other software applications. SQL Server offers a variety of tools for database development, maintenance and administration. It has different versions suitable from small applications for a number of users to big applications for thousands of users. It is also used to create and manage Web-based databases.

c. OpenOffice Base

OpenOffice Base is the database module of OpenOffice Suite. It is an open source application program. OpenOffice Base is a fully featured database management system. It has wizards to help new users to create database design, that is, to create tables, queries, forms and reports. It allows users to create interactive databases where they can manage data related to payroll, inventory, assets, budgets, customers, sales orders and invoices, etc.

8.1.2 MS ACCESS 2007

Microsoft Access 2007 is the common and best suited DBMS for developing and managing databases. Microsoft Access 2007 provides a powerful set of tools that help users to quickly start tracking, reporting, and sharing information. Users can rapidly create attractive and functional tracking applications by customizing one of several predefined templates, converting an existing database, or creating a new database. By using Access 2007, it is easy to adapt database applications and reports to changing business needs. The enhanced support for Windows SharePoint Services 3.0 in Access 2007 helps users to share, manage, edit, and back up data easily.

a. Opening Access

The following steps are used to open Access.

- Click the **Start** button.
- Click **All Programs** on the Start menu.
- Click **Microsoft Office** on the All Programs submenu.
- Click **Microsoft Office Access 2007** to open Access 2007 and display the Getting Started with Microsoft Office Access screen.
- This is the starting point from which user can create a new database or open an existing database.

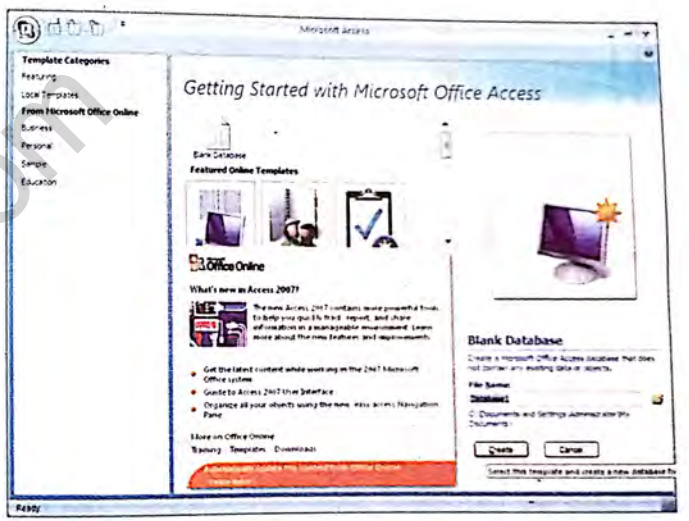


Figure 8.1 Getting Started with Microsoft Office Access

- By pressing Create button, user can create a blank database.

b. Access Window

Figure 8.2 shows important components of Access 2007 window.

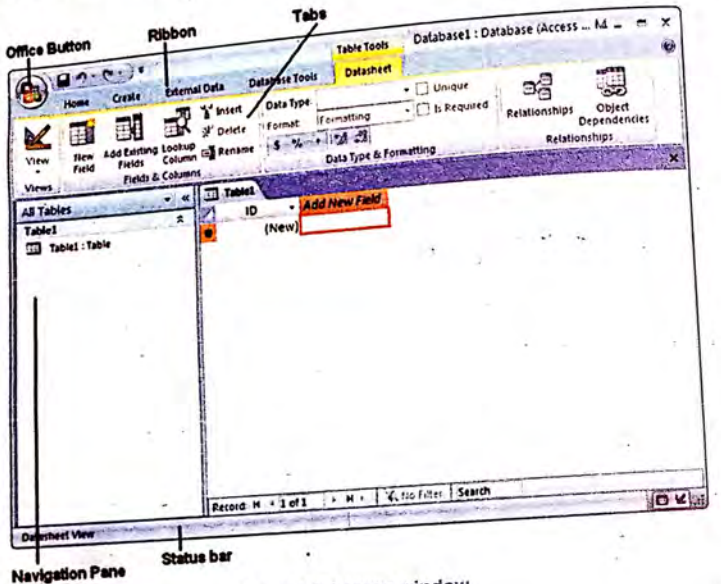


Figure 8.2 Access window

Office Button provides commands such as **Open, New, Print, Save, Manage, E-mail, Publish.**

Ribbon contains a series of command tabs; **Home, Create, External Data, Database Tools and Datasheet.** Additional tabs such as **Design** can appear depending on the context of the task chosen. Each tab contains groups of related commands.

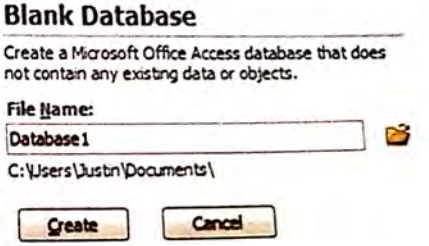
Navigation Pane displays objects such as **Tables, Queries and Forms.**

A **Status Bar** is used to display information regarding current object.

8.1.3 Creating and Saving an Access Database

The following steps are used to create and save a new database.

- First step in creating an Access database is to create a blank database file. This is done from the **Getting Started Window** when user runs the Access program. As shown in Figure 8.1.
- Click the **Blank Database icon** to bring the Blank Database side bar on the right side of the screen as shown in Figure 8.1.
- Enter a file name for database file in **File Name** bar. For example Student.
- Click the **folder** icon and browse for selecting a location for saving the database.
- Click the **Create** button to create and save the database. The database the user just created will open for work on.



8.1.4 Database Objects

The following are the main objects of Access database.

- Tables
- Queries
- Forms
- Reports

Tables: In Access 2007, data is stored in tables. A table is a set of columns and rows, with each column referred to as a field and each row of a table is referred to as a record.

Queries: Queries are used to retrieve specific data from database and to answer questions about the data. For example, a user can use a query to find the names of the employees in the database who are in grade 18.

Forms: Forms give the ability to choose the format and arrangement of fields to enter and view Data. User can use a form to enter, edit, display, modify and define data from the database.

Reports: Reports organize or summarize the data so that the user can print it or view it on the screen. Users often use reports when they want to analyze the data or present it in different styles.

8.2 WORKING WITH TABLES

A **Table** is an Access database object that is used to store information that relates to one entity. In RDBMS it is called a **Relation** and consists of **Rows** and **Columns**.

8.2.1 Creating a Table in Access

When user creates a new database in Access, the new database opens with one table named as **Table1** by default in both the **Navigation Pane**, and the **Table** tab itself. As shown in Figure 8.3

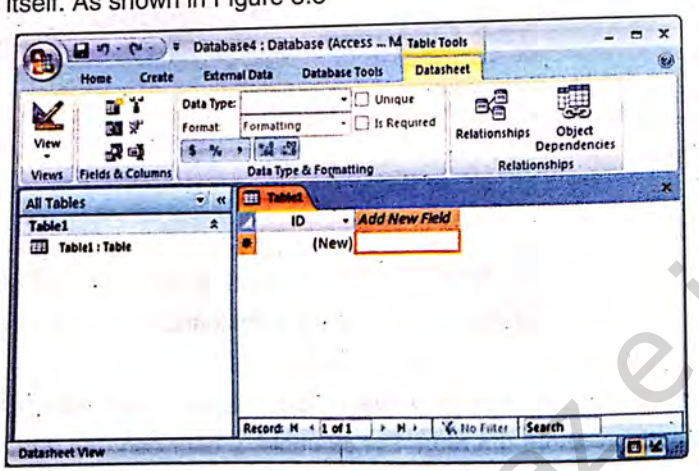


Figure 8.3 Default Table Name

a. Naming a Table

The following steps are used to give the table a unique name.

- Click on the **Office Button**.
- Select **Save** from the menu. The **Save As** dialog box will appear, as shown in Figure 8.4. Give appropriate name to the table.
- Click OK button.

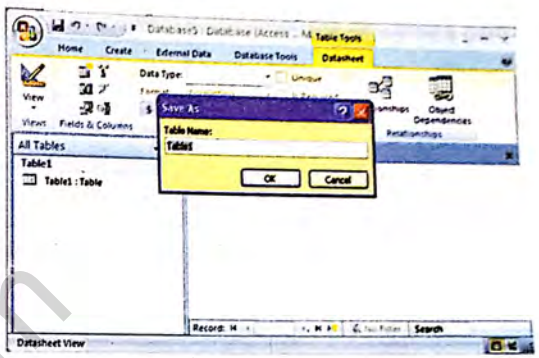


Figure 8.4 Save As Dialog Box

The new table name appears in both the **Navigation Pane** and the **Table** tab, as shown in Figure 8.5.

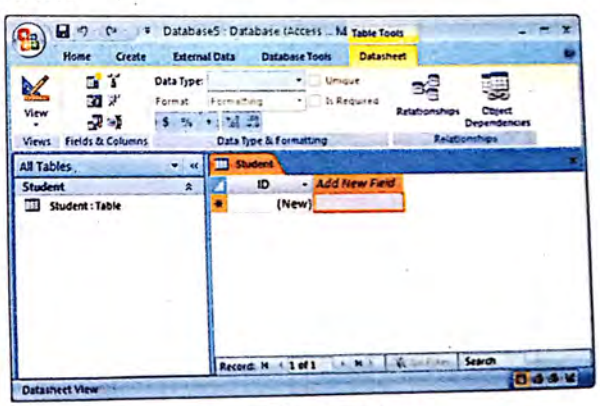


Figure 8.5 New Table Name

b. Adding Fields to a Table

Access offers two ways to add fields to a Table.

- Working in **Datasheet View**, which looks like a spreadsheet
- Working in **Design View**, where users are able to set more controls for the fields.

i. Adding Fields in Datasheet View

- By default, **Access** creates one field in each new table, the **ID** field, which can be renamed as required by the user.

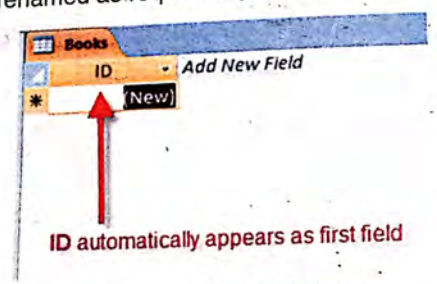


Figure 8.6 Automatic ID Field

- To add more fields to a table in **Datasheet View**, double click on the **Add New Field** header. As shown in Figure 8.7

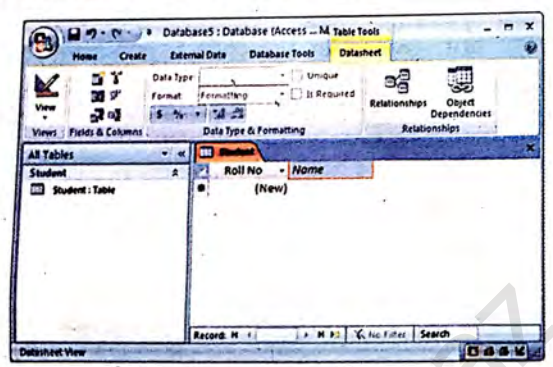


Figure 8.7 Add New Field

- The **Add New Field** text will disappear from the header. **Name the field** by typing the name directly into the header.
- Press the **tab** key on the keyboard to move to the next field.

ii. Adding Fields in Design View

In **Design View**, the field names are along the left-hand column instead of across the top like in Datasheet View, as shown in Figure 8.8.

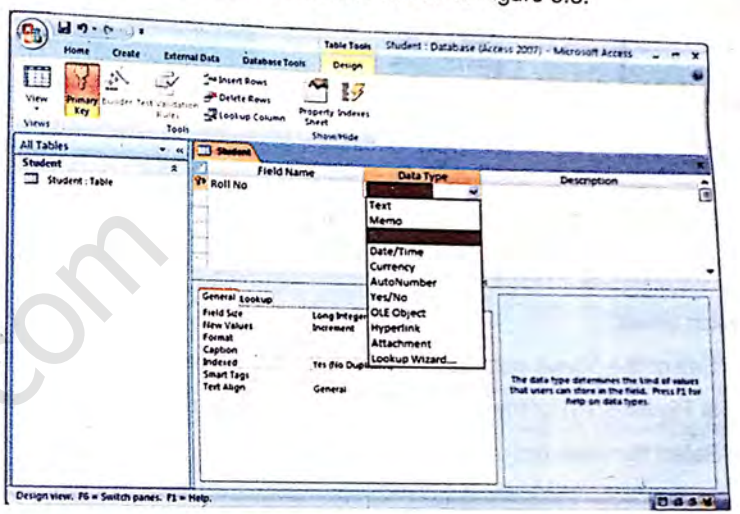


Figure 8.8 Fields in Design View

To add a new field in a table in **Design View**:

- **Click** in the cell where the user want the new field and **type the field name.**
- Press **Tab key** on the keyboard to move from one column to the other.
- Give appropriate **data type** and **description** if required. As shown in Figure 8.9.

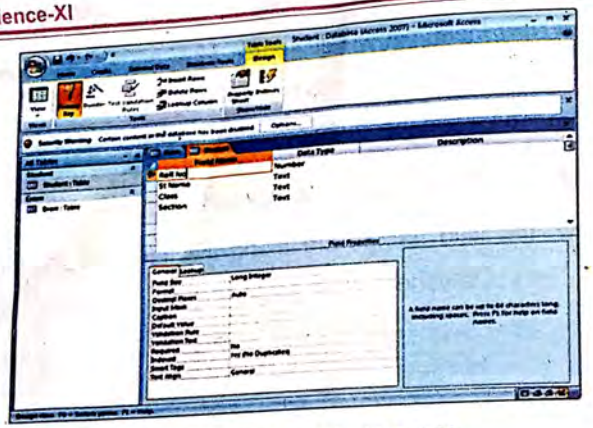


Figure 8.9 Design view of Added Field

In Design View, there are many field property options that users can set to ensure that data can only be entered in certain formats.

c. Switching Views

To switch views:

- Select the **Views** command group from either the **Home** tab (As shown in Figure 8.10) or the **Datasheet** tab on the **Ribbon**.
- Select the view option from the menu.

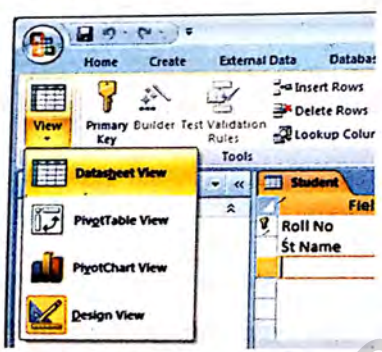


Figure 8.10 Switching Views

d. To Close a Table

There are several ways to close an active table.

- Users can **right click** on the **Table** tab and choose **Close** from the menu. OR
- A more common method is to click [X] that appears in the upper right hand corner of the active database object window.

e. To Open a Table

To open a table:

- **Right click** the Table name of the table to open in the **Navigation Pane**. Then, choose **Open** from the menu. OR
- **Double click** the table name in the **Navigation Pane**. The selected table will open in the active database object window.

f. Adding More Tables to the Database

By default, Access starts out with one table. To add more tables to the database:

- Click on the **Create** tab on the **Ribbon**, as shown in Figure 8.11
- Select **Table** from the **Tables command group**. A new table will open in the active database object window.

Figure 8.11 Create New Table

- Figure 8.12 shows Exam table created in Student database.

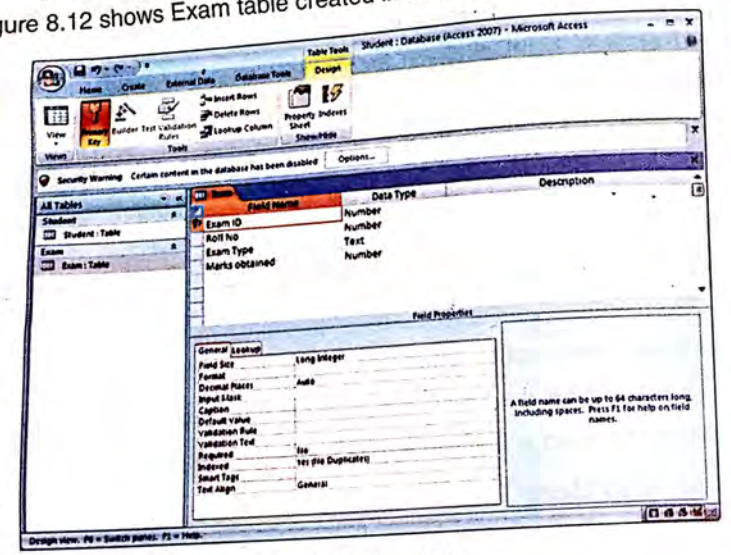


Figure 8.12 Exam Table

8.2.2 Data Types in MS-Access 2007

There are nine types of field data types which are used in Access 2007.

1. Text: Access assigns Text as the default data type to all fields. The maximum size of text field is 255 characters. All types of characters i.e. alphabets, numbers and special characters are allowed in text data type.

2. Memo: Memo data type allows as many as 63999 characters to fields. Users use them to provide descriptive text comments. Access displays the contents of Memo fields in a Datasheet view. A memo field cannot be a Primary key field.

3. Number: Number data type is assigned to numeric fields. Various numeric data subtypes are available in the **Field Properties** pane of Table Design

window. Users specify how to display the number by setting its **Format** property to one of the formats.

4. AutoNumber: An AutoNumber field is a numeric (Long Integer) value that Access automatically fills in for each new record that a user enters to a table. Access can increment the AutoNumber field by 1 for each new record or fill in the field with a randomly generated number, depending on the **New Values** property setting, that a user select.

5. Yes/No: Logical fields in Access use 1 for Yes (True) and 0 for No (False). Users use the Format property to display Yes/No fields as Yes or No.

6. Currency: Currency is a special fixed format Number with decimal places designed to store currency value.

7. Date/Time: Date and time are stored in a special fixed format. User controls how Access displays dates by selecting one of the Date/Time Format properties.

8. OLE Object: It is used for OLE (Object Linking and Embedding) objects (such as Microsoft Word documents, Microsoft Excel spreadsheets, pictures, sounds, or other binary data) that were created in other programs using the OLE protocol.

9. Hyperlink: It is used for hyperlinks. A hyperlink can be a path of another document or a Web address.

Field Properties

Properties can be specified in the **Field Properties box** which are displayed in the bottom left hand corner of the Table Window. Figure 8.13 shows the properties for a field with data type **Number**.

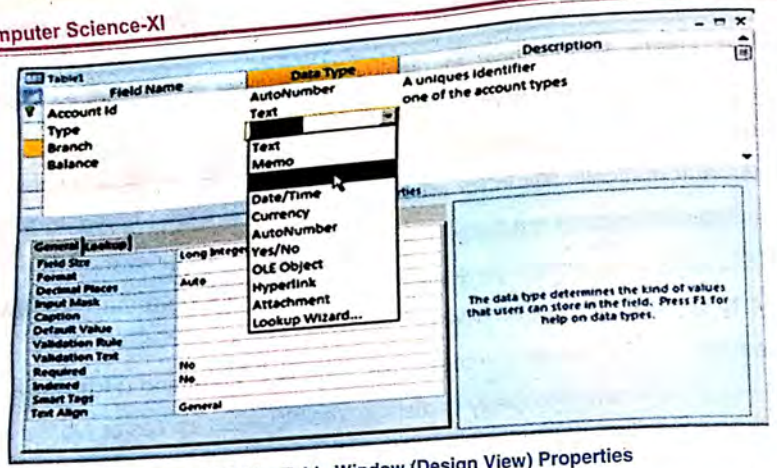


Figure 8.13 The Table Window (Design View) Properties

Field properties determine how data will be entered, stored and displayed.

- **Format** determines how the data is formatted for display — a number of options are provided together with the ability to specify custom formats for some data types.
- **Decimal Places** applies to *Number* or *Currency* fields and determines the number of digits after the decimal point.
- **Input Mask** defines a pattern to which input data must conform.
- **Caption** determines the label used with the field on forms and reports, and what appears at the top of a column in queries (the default is the *Field Name*).
- **Default Value** determines a default value for a field when new records are created.
- **Validation Rule** can be used to specify a condition or conditions that data must satisfy.
- **Validation Text** is displayed on the *Message Box* when data entered violates the *Validation Rule*.
- **Required** means that the field must be filled with valid non-null data before a record can be inserted (or updated).

- **Indexed** determines whether an index is built for the table to search and sort the data.

8.2.3 Creating Primary Key and Foreign Key in the Tables

a. Primary key

Primary key is a unique field in a table. After defining all the field names and their data types in Design View, create a primary key for the table as shown in Figure 8.14.

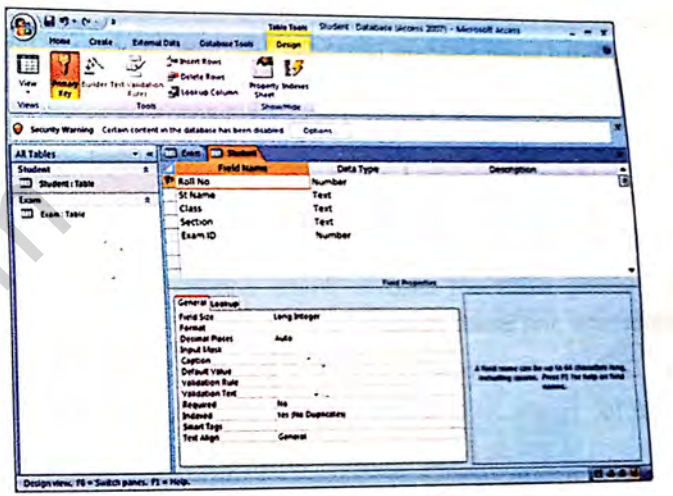


Figure 8.14 Creating primary key for STUDENT table

The following steps are used to create a primary key.

- Select the field name **Roll No** by clicking the selection box on the left side of the field name.
- Click the primary key icon on the **Tools group** of **Design tab**. OR
- **Right click** on the field name and select **Primary Key** option from the menu.

b. Foreign Key

Foreign key is a key which is used as primary key in one table and secondary key in the other. It is used to create relationship between entities. In our project of Student Database, we will take **Roll No** field the foreign key when we create relationship between the **Student table** and the **Exam table**.

8.2.4 Creating and Editing Relationships between Tables

Relationships are links that associate a field in one table with a field in another. For example, in our **Student Database,** we have created two tables, **Student table** for storing students' basic information and the **Exam table** for storing their examination data for different examinations.

Relationships also allow creating queries, forms and reports to display information from several tables.

a. Creating Relationship

The following steps are used to create one-to-many relationship between **Student** table and **Exam** Table.

- Click the **Relationship** icon in **Database Tools** as shown in Figure 8.15.

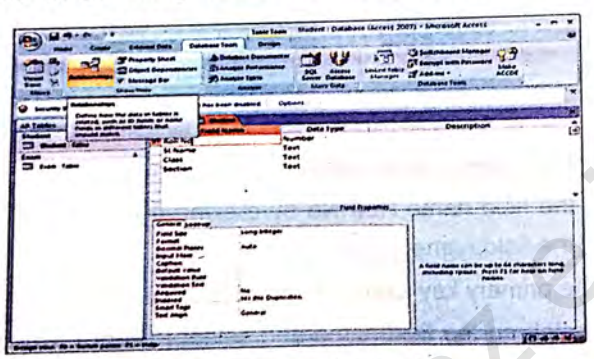


Figure 8.15 Creating Relationship

- Click the **Student table** and click the **Add button** shown in Figure 8.16.
- Click the **Exam table** and click the **Add button**.
- Click the **Close** button to close the dialog box.

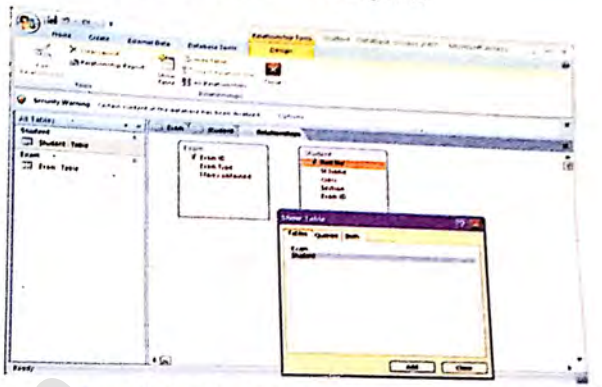


Figure 8.16 Adding tables for Creating Relationship

- Move the mouse pointer to the primary key **Roll No** in **Student table** and drag it to the foreign key **Roll No** in the **Exam table**. **Edit Relationship dialog box** will appear when mouse button is released, as shown in Figure 8.17.

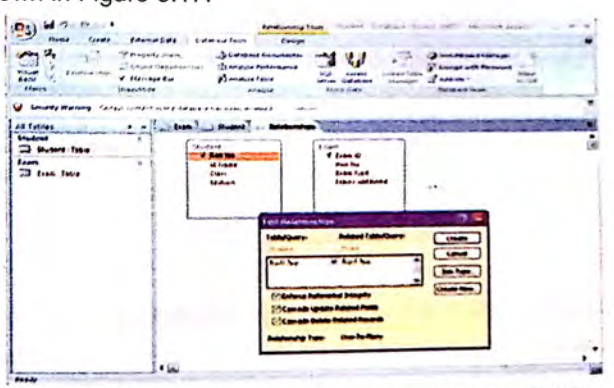


Figure 8.17 Edit Relationship dialog box for creating relationship

- Check the Enforce Referential Integrity, Cascade Update Related Fields and Cascade Delete Related Records check boxes.
- Click the Create button to create the relationship (one-to-many) between tables, as shown in Figure 8.18.

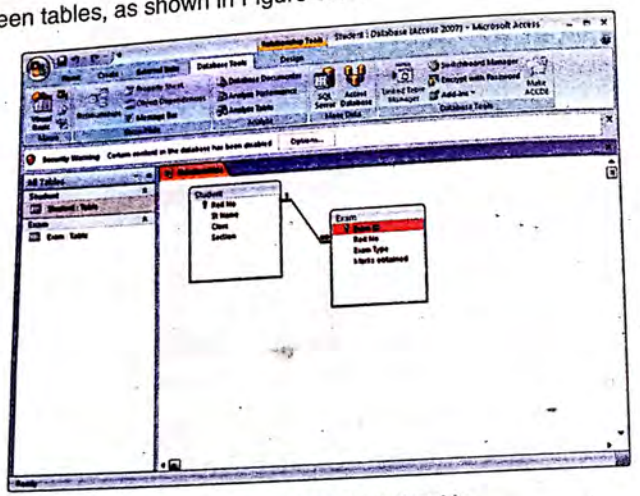


Figure 8.18 One-to-many relationship

Joining line from one table to the other shows the type of relationship from one table to the other. For example "1" to "Infinity sign" indicates the one-to-many relationship.

b. Editing Relationship

The following steps are used to edit relationship between tables.

- Click Relationship in the Database Tools tab.
- Click the join line that connects the fields.
- **Right-click** on the line and select **Edit Relationship** option, as shown in Figure 8.19.
- Recreate the relationship by using the procedure described earlier.

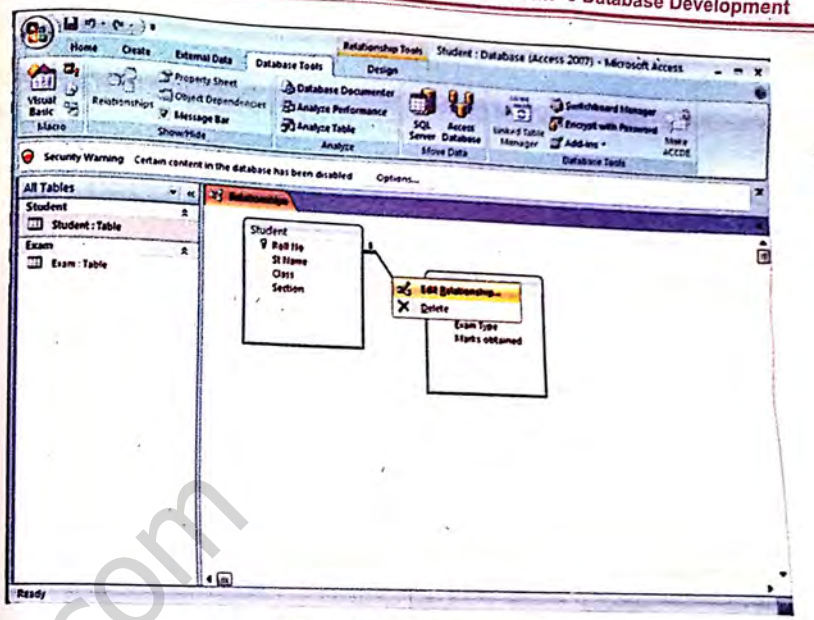


Figure 8.19 Edit Relationship

8.2.5 Using Navigation buttons in a Table

Navigation buttons are used to navigate records in a table. These buttons lie at the bottom left corner, as shown in Figure 8.20. When users click at any field of a record, they can see the record number and the total number of records in the table. The button to the left of the record number will move to the previous or the first record and the button to the right will move to the next or the last record in the table. The last button on the right side will allow entering a new record. Users can also enter a new record by clicking the **New** icon in the **Records** group on the **Home** tab.

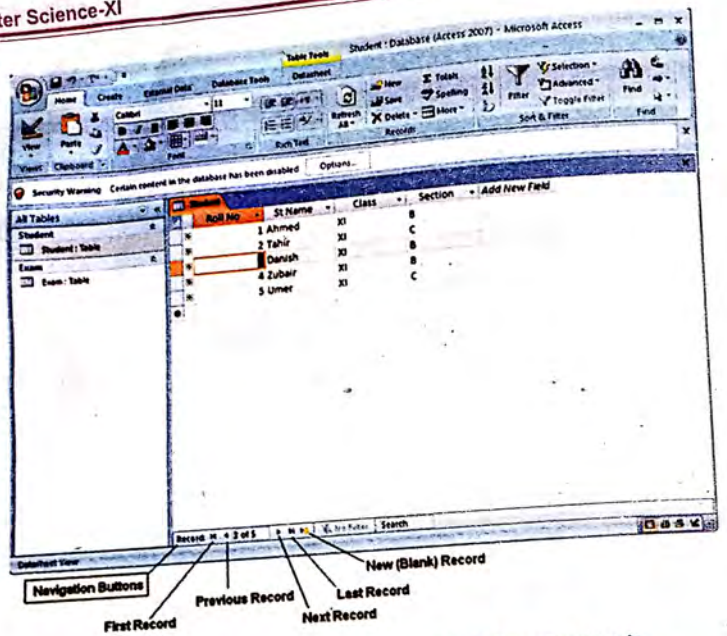


Figure 8.20 Using Navigation buttons to navigate through records

8.2.6 Adding, Modifying and Deleting Records

a. Adding Records in a Table

The following steps are used to add new records in a table.

- Right click on the table in the **Navigation Pane** in which to add new record and select **Open** option or double click it.
- Click the **New button** in the **Records group** in **Home tab** or click the new record button in the navigation bar at the bottom left of the screen. This will move the pointer to the first blank row after the last record.
- Enter the data for the new record.

b. Adding Records in a Related Table

The following steps are used to add records in related table. For example **Exam table** which is related to the **Student table** in **Student database**.

- Open the **Student table** by double clicking it in the Navigation Pane.
- Click the "+" symbol at the left end of the first row in **Student table**.
- Add records in the related **Exam table** as shown in Figure 8.21.

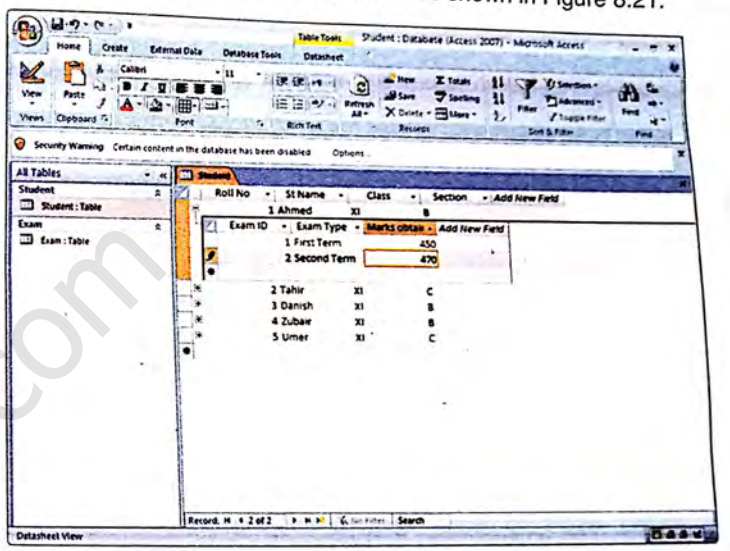


Figure 8.21 Adding record in a related table

When User clicks the "+" symbol it changes to "-" symbol and if click it again, will return to the primary table and the "-" symbol will change to "+" symbol again.

c. Modifying Records in a Table

The following steps are used to modify any information in a record.

- Click the field containing the data to change.

- Change the record as required.

d. Deleting Records from a Table

The following steps are used to delete records from a table.

- Select the record to be deleted by clicking its row selector box which is on the left end of the row.
- Press the **Delete** key or choose Delete from the **Records** option on the **Home** tab
- Click the **Yes** button to proceed with the deletion in the dialog box that appears.

8.3 WORKING WITH FORMS

A **Form** in Access is a database object used to display, edit and enter data from a data source such as a query or table. It also may contain controls that provide the user with needed functionality or enhancements.

A **Form** generally serves three purposes:

- It allows users to perform data entry. Data can be inserted, updated, or deleted from a table using a Form object.
- It allows users to enter custom information, and based on that information a task is performed. For example, a system may want to ask for parameters before running a report.
- It allows users a method of navigating through the system. For example, one may create a form where a user can select a report to run.

User can also add certain control components to a **Form**, like buttons, combo box, list box, drop down menus and sub-forms.

8.3.1 Creating Access Form

Access 2007 has several automatic tools for creating forms. These tools are located in the **Forms** group on the **Create** tab in the **Ribbon**.

The Access 2007 forms tools include:

- The **Form** command makes a basic form, showing a single record at a time.
- The **Split Form** command creates a form showing one record on top, and includes the datasheet view of entire source table on the bottom.
- The **Multiple Items** command creates a form that shows all the records at once, which looks very similar to the source table in datasheet view.
- The **Form Wizard** is hidden under the **More Forms** command. It takes users through the process of creating more customized forms.

a. To Create a Form using the Form Command

The basic **Form** command is the one that allows the person entering data to see just one record at a time. It also includes all the fields in the source table and the user can modify the layout of the basic form to hide fields or add controls.

The following steps are used to create a form using this command.

- Highlight the table to use as a source table.
- With the source table highlighted, select the **Form** command from the **Forms** command group in the **Create** tab on the **Ribbon**.
- The new form is created and opens in the object pane. Figure 8.22 shows a form created for Student table.

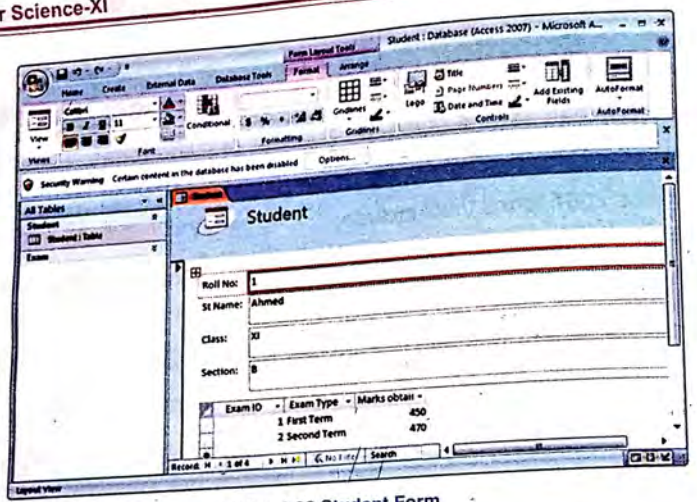


Figure 8.22 Student Form

The newly created form has the same name as the source table by default. User can give the form a new name while saving the form.

b. To Navigate through Form

Users can navigate the records using **Navigation Buttons** located at the bottom left of the form. Record navigation works the same way for forms as it does for tables.

c. To Add a Record using a Form

The following steps are used to add a record to the database using a form.

- Navigate to a new record, either by using the **New Record** navigation button, or the **New** command in the **Records** group on the **Ribbon**.
- Add the new data.
- **Save** the record.

d. To Edit Records using a Form

The following steps are used to edit/change a record using a form.

- **Open** the form to edit.
- Navigate to the required record to edit.
- **Click** in the particular field and make the changes.
- **Save** the record.

e. To Delete Record using a Form

The following steps are used to delete a record using a form.

- **Open** the form.
- Navigate to the required record to delete.
- Select the **Delete Record** option in the **Forms group**.
- Click **Yes** button to confirm deletion.
- **Save** the database.

8.3.2 Using Form Controls

A control in Access 2007 is an object on a form that passes information between the user and the form. Common control types include labels, boxes and buttons. Adding a control to a form is common task and most forms in Access contain many controls. The following steps will show how to add controls to a form in Access 2007.

- Start Access 2007 and open a database file that already has a form created. Look in the **Navigation Pane** for the form where to add a control and **Right-click** on **Form** icon to bring up the menu.
- Select **Design View** from the menu and select the **Design tab**. Look in the **Controls group** for the control to add and click on that control. Notice how the mouse cursor in Access changes to show a crosshair and an icon representing that control.
- Move the crosshair of the mouse cursor to the location on the form where to create that control and press the left button of mouse. The control will appear on the form.

- **Customize** the properties of the control just added. Move the cursor over the control and click on the right mouse button to bring up its context menu. Select **Properties** to display the **Properties screen** for that control.
- Use a text box as an example. Select the **Data** tab of the **Properties screen** of a text box. The first item on this panel is the **control source** that specifies the data that will appear in the text box.

a. Creating Command Buttons

Another way to make a form more user-friendly is by adding **command buttons** to the form. Command buttons are a quick way for form user to take a specific action. These command buttons are grouped into the following categories of actions, including:

- **Record Navigation** command buttons allow users move among the records in the database.
- **Record Operation** command buttons let users do a task like save or print a record.
- **Form Operation** command buttons give the ability to quickly open or close a form, print the current form, and other actions.
- **Report Operation** command buttons offer the user a quick way to do a task such as preview or mail a report.

To Add a Command Button to a Form

The following steps are used to add a command button to a form.

1. Click the **Button** command in the **Controls** group on the **Ribbon**, as shown in Figure 8.23.

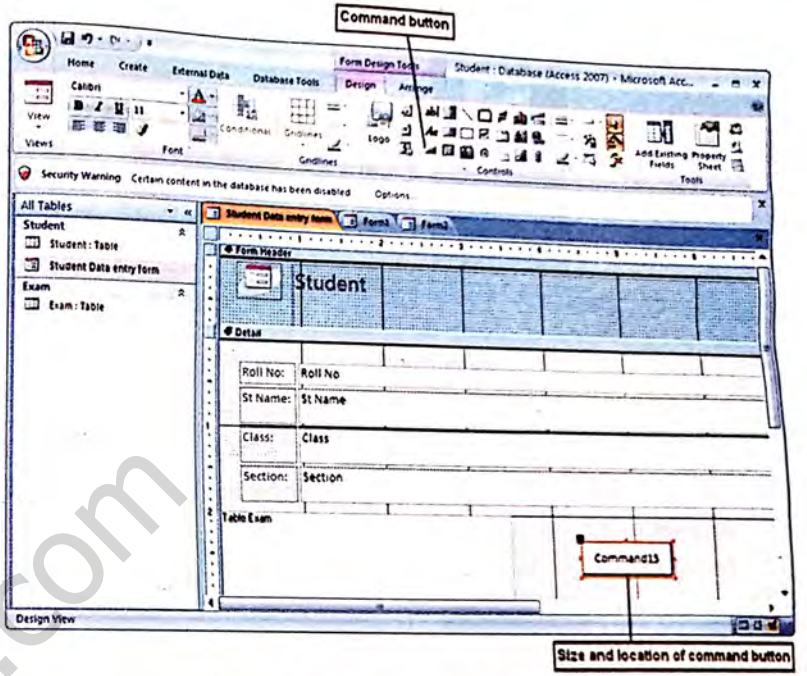


Figure 8.23 Button Command in Controls Group

2. Move the mouse pointer to the required location and click to add button. The **Command Button Wizard** opens, as shown in Figure 8.24.
   - Select the type of command from the **Categories** list. (For example **Record Navigation**)
   - Select the specific action the command button to perform from the **Actions** list. (For example **Find Next**)
   - Click **Next**.

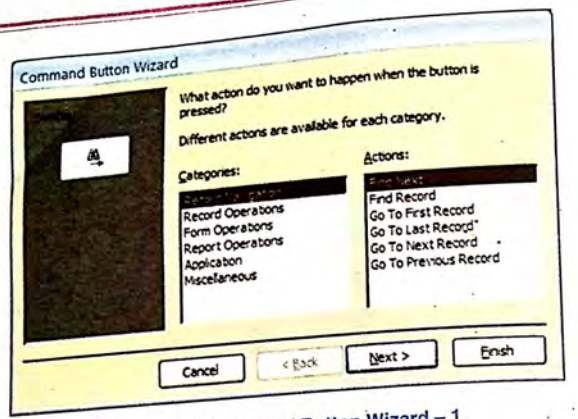


Figure 8.24 Command Button Wizard – 1

3. In the next step, as shown in Figure 8.25.
   - ➢ If user wants text to appear on the button, enter it in the **Text** box.
   - ➢ If user wants a picture to appear on the button, select one using the **Browse** button.
   - ➢ Click **Next**.

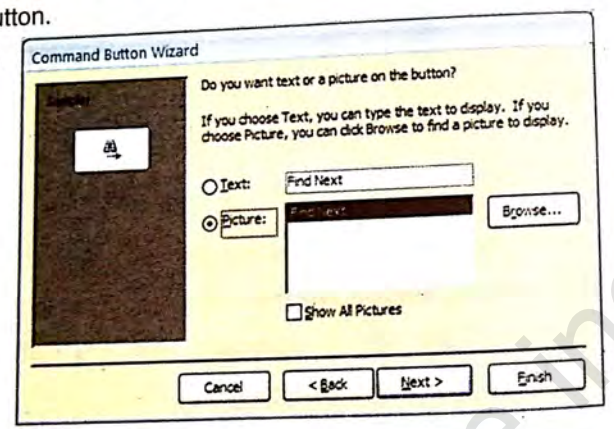


Figure 8.25 Command Button Wizard – 2

4. In this step, as shown in Figure 8.26.
   - ➢ Give the button a meaningful name.

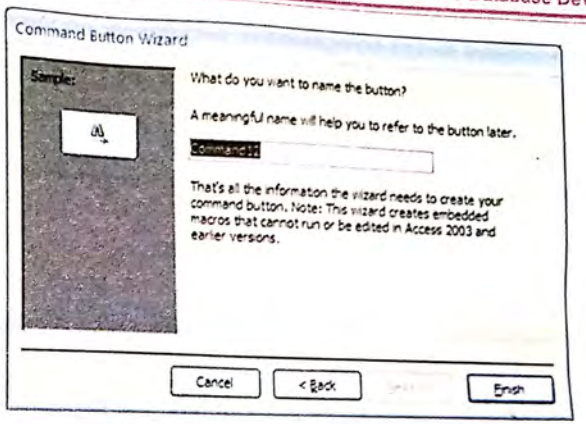


Figure 8.26 Command Button Wizard – 3

   - ➢ Access will give your button a default name. Renaming it with a more useful name will help you later.

5. Click **Finish**, the command button appears as shown in Figure 8.27.

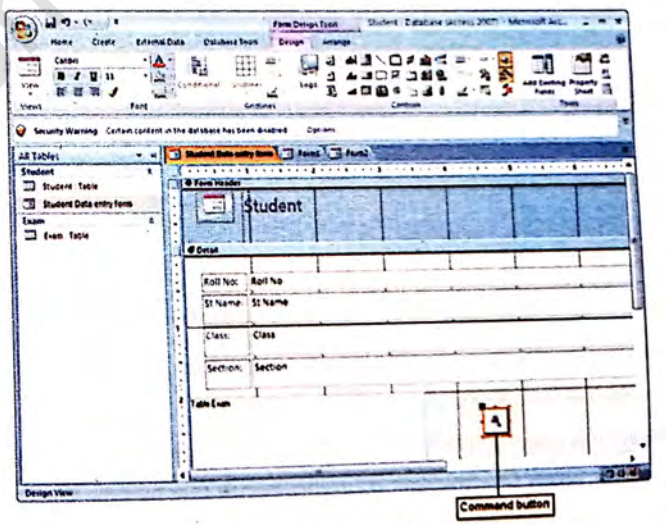


Figure 8.27 Command button

The command button should be operational and appear on the form in Form View.

b. Adding a Logo

Access automatically puts a form icon, like the one shown in Figure 8.28, in the header area of every form that you create.

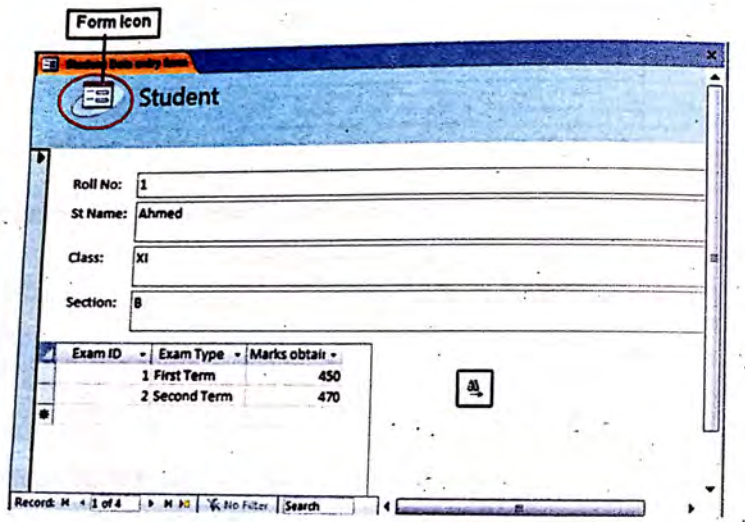


Figure 8.28 Form Icon

One way to customize the look of forms is to remove that icon and replace it with a logo. This is very easy to do using the **Logo** command.

The following steps are used to replace the form icon with a logo of choice.

- Delete the form icon.
- Select the **Logo** command from the **Controls** group on the Ribbon.
- Use the **Insert Picture** dialog box to locate the picture file to use as the logo. Then, click **Ok**. The new logo should appear.

User can move and re-size the logo, as well. Moving and re-sizing objects on a form is covered later in this lesson.

c. Applying a Style with AutoFormat

Another simple way to dramatically change the way the form looks is to apply a style with the **AutoFormat command**. User can modify the color for each part of the form, but Microsoft Access has already combined colors in several attractive styles. These styles are available under the **AutoFormat command**. To apply a pre-set format to the form:

- Click on the **AutoFormat** command on the **Format** Ribbon, as shown in Figure 8.29
- Select the desired format. The changes will appear when the mouse button is released.

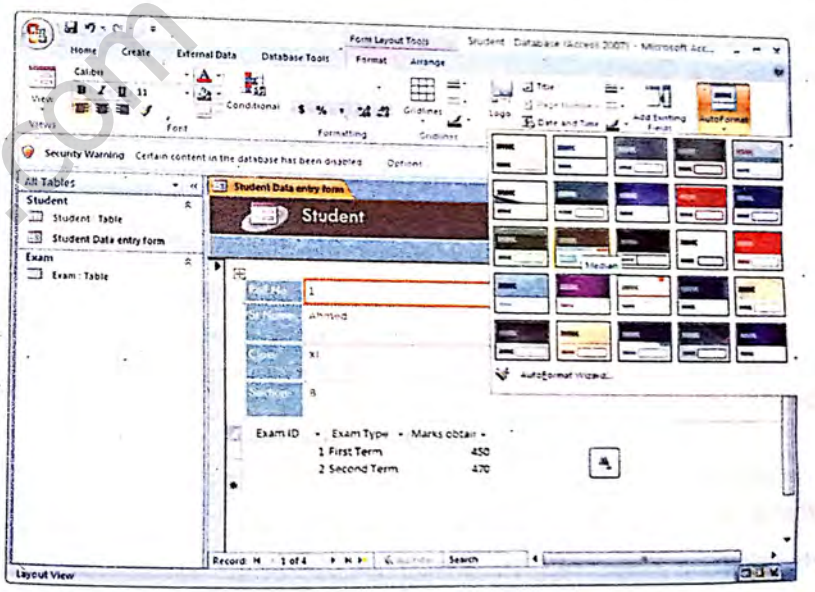


Figure 8.29 AutoFormat Options

8.4 WORKING WITH QUERIES

Queries are a way of **searching** for and **compiling** data from one or more tables. Running a query is like asking a detailed **question** of the database. When users build a query in Access, they are **defining specific search conditions** to find exactly the data they want.

Queries are far more powerful than the simple searches or filters user might use to find data within a table. This is because queries can draw their information from **multiple** tables based on a set of search conditions they define. A well-designed query can give information that users might not be able to find out just by examining the data in tables.

The real power of an Access 2007 database is its ability to pull data for quick analysis, which is what happens when a user runs a query. Access will display results in a table that can be analyzed and manipulated further.

Planning a Query

There are three questions users need to answer when they are planning a query:

- **What do you want the results to look like?** Identify every field or bit of information that user wants to include in the results.
- **Where is the information stored in the database?** List which tables (and/or queries) hold the information that user wants to see.
- **What conditions do you want the data to meet?** This helps to determine how to set the criteria so that Access can search the records properly.

Example: In Student database, a query might be:
What is the list of students with their marks, studying in Class XI and Section B?

Planning:
Let us use the three-question process to plan this query.

- **What fields do we want to see in the results?**
  Roll No, Student Name, Class, Section, Marks
- **In which tables is the information stored?**
  Student table - to get the Students' roll numbers, names, classes and sections
  Exam table - to get students' marks
- **What is the condition we want the data to meet?**
  We want to look for the marks of students where the section is B.

8.4.1 Creating the Query

Once users have planned out their query, they can build and run it using Access query tools.

a. To Build a Query using the Query Design Command

The following steps are used to build and run a query using the **Query Design** command.

- Select the **Query Design** command from the **Create** tab on the Ribbon. **Show Table** dialog box appears.
- Use the **Show Table** dialog box to select which tables (and/or queries) to include in the query. According to our query and plan, we will select both the tables.
- Click **Close** button.

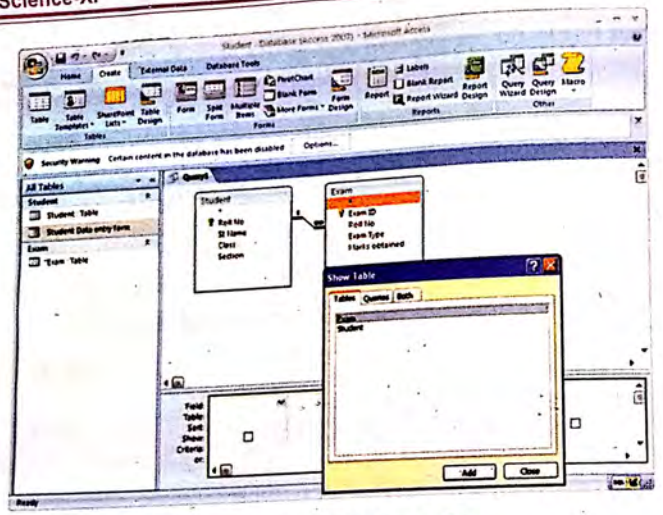


Figure 8.30 Show Table Dialog Box

- Drag and drop the fields to see in the results to the bottom portion of the query design screen. As shown in Figure 8.31.

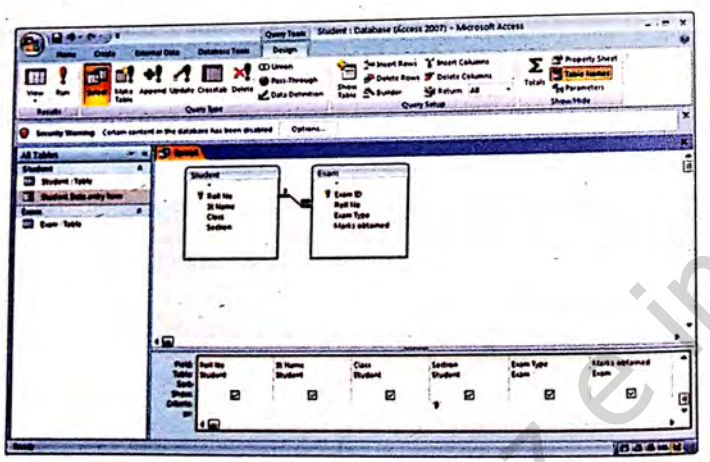


Figure 8.31 Add Fields to Query Design Screen

- Enter the condition in the **Criteria** row for the condition field. For our query, we will type **"B"** in the cell labeled **Criteria** for the **Section** field.
- Once the condition is set, click **Run!** in the **Results group** on the Ribbon.
- View the results to determine if they match the desired results. As shown in Figure 8.32.

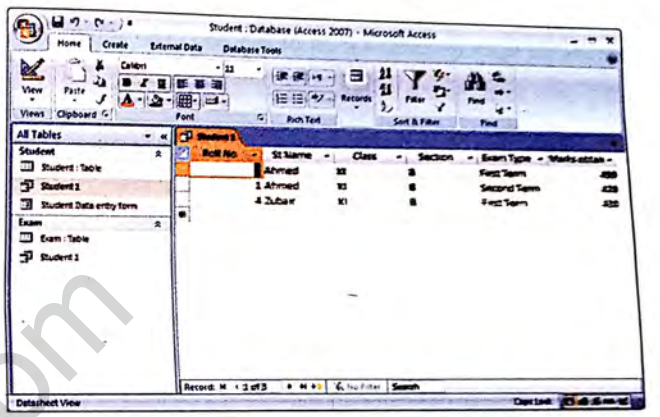


Figure 8.32 Students Query Results

b. Saving the Query

The following steps are used to save the query for later use.

- Right click on the query tab.
- When the **Save As** dialog box opens, give query a meaningful name.
- Click **OK**.
- The query will now be listed in the object list on the left side of the Access window.

8.4.2 Types of Queries in Access

The following are some common types of queries in Access.

- Select
- Update
- Delete

a. Select Query

A select query is a type of database object that shows information in Datasheet view. A query can get its data from one or more tables, from existing queries, or from a combination of the two. The tables or queries from which a query gets its data are referred to as its record-source.

Basic steps to create a select query:

User can create a select query by using the **Query Wizard** or by working in **Design view**. Some design elements are not available when users use the wizard, but user can add these elements later by using Design view. Although the two methods are somewhat different from each other, the basic steps are essentially the same.

- Choose the tables or queries that to use as sources of data.
- Specify the fields that user wants to include from the data sources.
- Optionally, specify criteria to limit the records that the query returns.
- After user has created a select query, it can be run to see the results.

b. Update Query

An Update Query is an action query (SQL statement) that changes a set of records according to criteria (search conditions) user specify. It is a very powerful feature and a fundamental part of relational databases since the user can modify a huge number of records at one time. Understanding and using Update Queries improves the performance of applications (versus doing the same changes manually or in code), and makes them easier to maintain.

Figure 8.33 Update Query Option

Update Queries let users modify the values of a field or fields in a table. You can specify the records to modify by applying a filter (WHERE clause) and linking the table to other tables and queries.

The updated value can be:

- The same value for all records.
- A value from another field in that table (updates the field based on a field's value in its own record).
- A value from a field in a linked table.
- An expression based on values in the table or linked tables (multiple fields can be used to calculate the new value).
- A function value which can include field values as its parameters
- User defined function that may or may not include field values as parameters.

Example: In Students' database let us create an update query to change the Section of all students to "G".

- Create a new query using the **Student** table. Include the fields that are going to be used to update the records.
- Select **Update** from **Query Type**, as shown in Figure 8.34.
- Type "G" for **Section** field in **Update To** row, as shown in Figure 8.34.

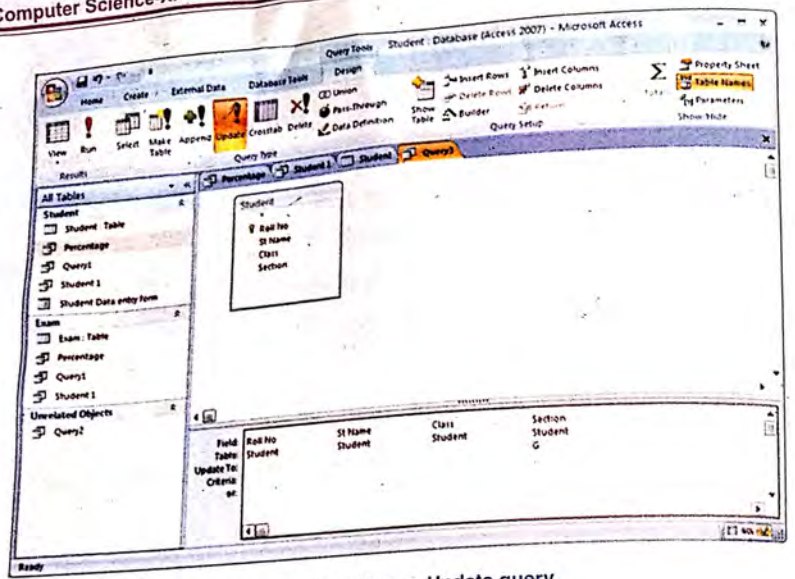


Figure 8.34 Creating an Update query

- Run the query, using the **Run button**  to update the data in **Student table** that meets the criteria that is applied. The warning dialog box indicates the number of records that will be updated, click **Yes** to accept.

Remember that the update query will permanently update records from the specified table(s), Therefore it is very important that the user has backed up the table(s) or database before running this object.

- Check the Update Query Results by running the Student table as shown in Figure 8.35.

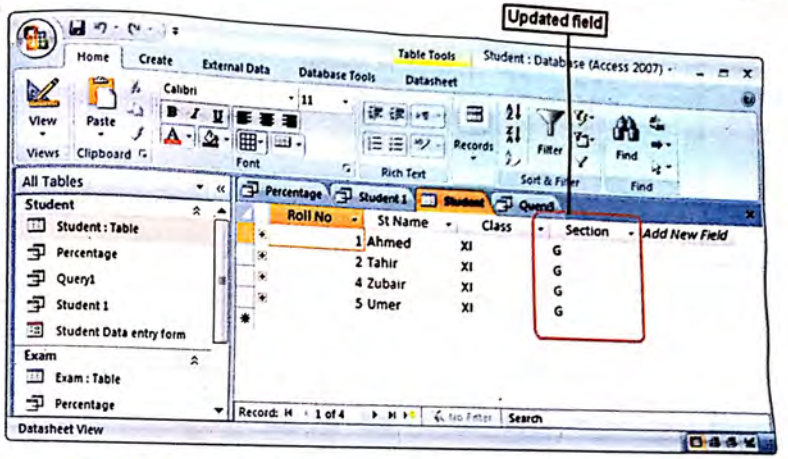


Figure 8.35 Student table after updating Section field through update query

c. Delete Query

Delete query is used to delete records from a single database table or multiple tables. Delete query removes records from tables permanently. As with the other types of action queries, the delete query works with a group of records that meet specified criteria that user apply. User can use the delete query to remove all records or only records that meet the defined criteria.

Example: In Students database let us create a Delete query to remove the records of students of Section "B" in Student table.

- Create a new query using the **Student** table. Include those fields that are going to be used to delete the records.
- In the query design view, click on the drop-down arrow to the right of the **Query Type** button and choose **Delete Query.**
- Type "B" for **Section** field in **Criteria** row, as shown in Figure 8.36.

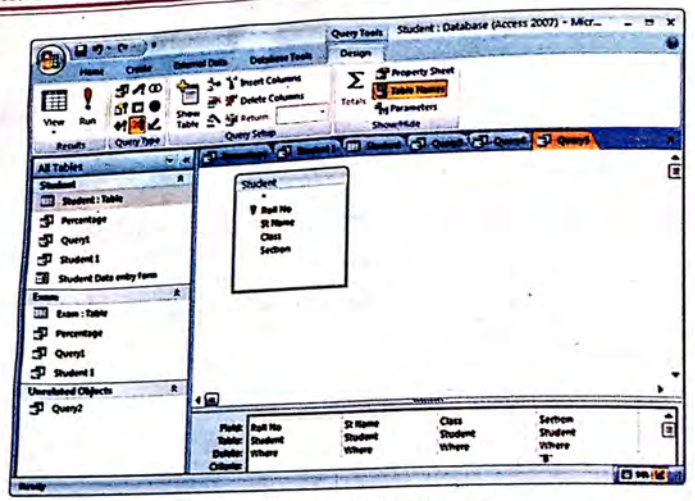


Figure 8.36 Creating a Delete query

- Run the query, using the **Run button** to delete the data in **Student table** that meets the criteria that is applied. The warning dialog box indicates the number of records that will be deleted, click **Yes** to accept.

Remember that the query will permanently delete records from the specified table(s), Therefore it is very important that the user has backed up the table(s) or database before running this object.

- Check the Delete Query Results by running the Student table.
- Close the query, saving if required

8.5 GENERATING REPORTS

A **report** is an Access object. It is used to display data in an organized manner so that users can print it. A **report** is an effective way to present data using an attractive layout.

Access offers tools that allow users to create and format a report. The **Report Wizard** takes users through the steps of creating a report. The **Report command**, however, is much easier to use, and all of the formatting options are still available in Layout View once the report is created. With these tools, user can create a report based on a table or a query.

8.5.1 Using the Report Wizard to generate a Report

The following steps are used to generate a report using Report Wizard.

- Select the **Create** tab on the **Ribbon**. Then click **Report Wizard** from the **Reports group** to open the pop up window. As shown in Figure 8.37.

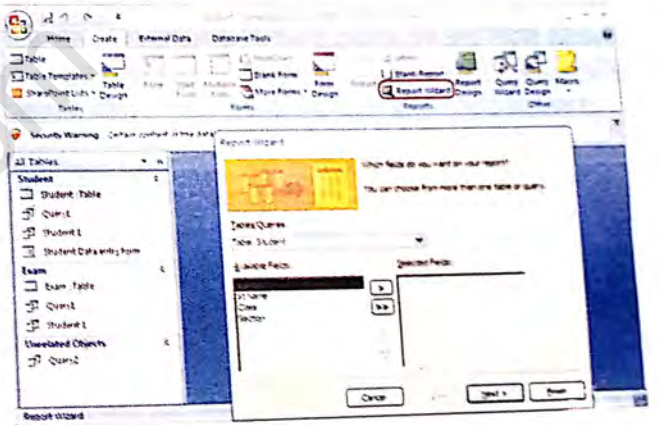


Figure 8.37 Report Wizard

- Select data for Report from **Tables/Queries** drop down menu and then select the required **Fields**. Click **Next**.
- Next step is for **Grouping Levels,** where user can add grouping levels if required. We do not need it for this particular example. Click **Next**.

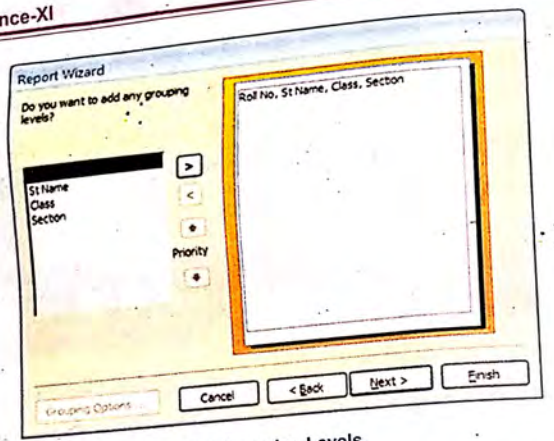


Figure 8.38 Grouping Levels

- This step of the Report Wizard is used to select the **Sort Order** for the report. For example we might want to display records in **Ascending** order of **Roll No** field as shown in Figure 8.39. Click **Next**

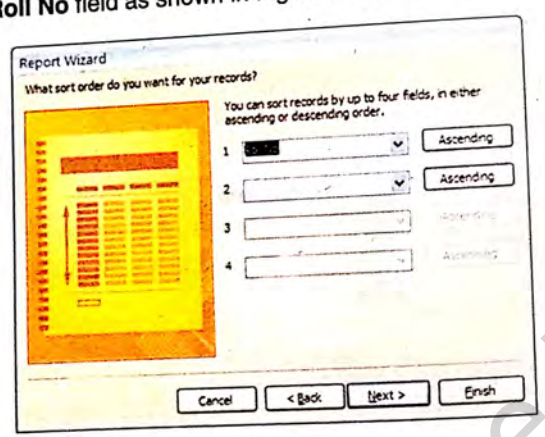


Figure 8.39 Sort Order

- Here user selects the **Lay Out** of the report. There are various lay out options, but in our case we will keep to the default setting. Click **Next**.

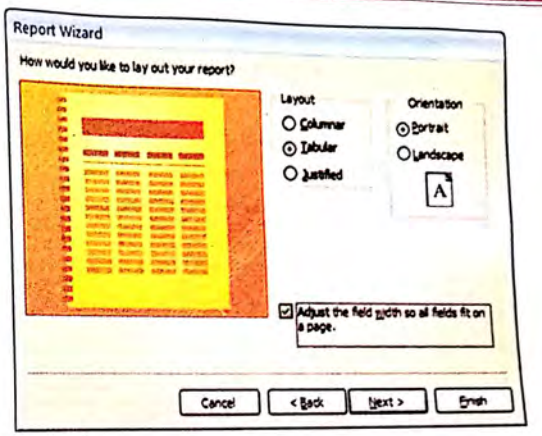


Figure 8.40 Lay out

- Select the **Style** for the report. As shown in Figure 8.41. Click **Next**.

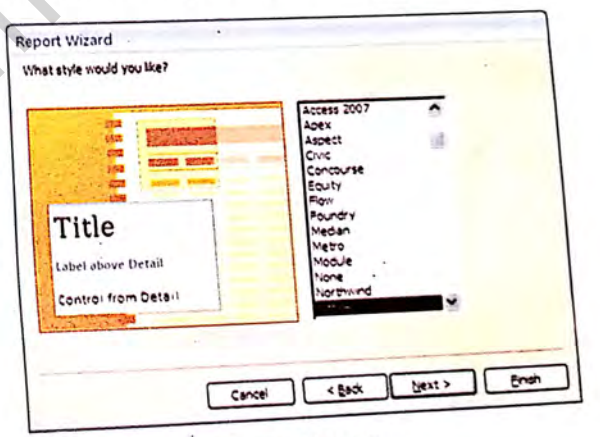


Figure 8.41 Lay out

- Give **Title** to the report (like Student) and then click **Finish**, as shown in Figure 8.42.

Figure 8.42 Title for Report

- The Access Report will now be previewed on the screen, and should look something like shown in Figure 8.43.

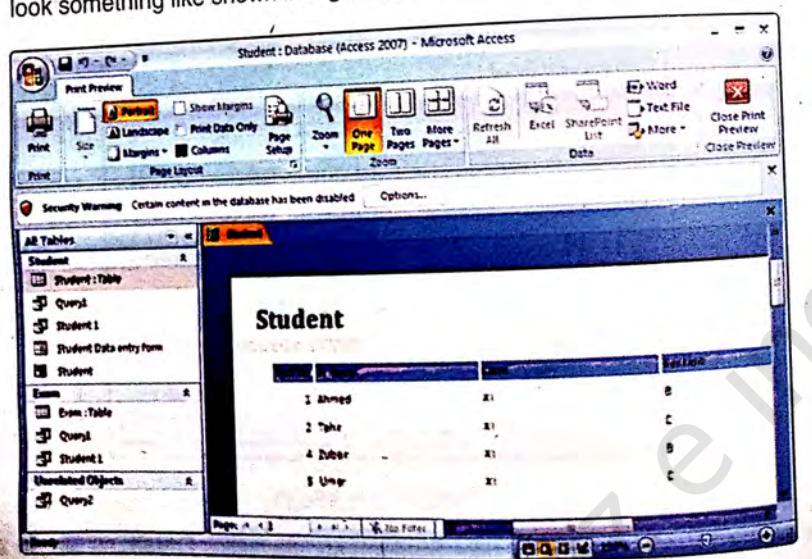


Figure 8.43 Student Report preview

8.5.2 Saving and Printing a Report

a. Saving a Report

The following steps are used to **Save** the report.

- Right click on the report tab.
- Choose **Save** from the list that appears.
- When the **Save as** dialog box opens, give the report a suitable name.
- Click **OK.**

b. Printing a Report

Click on the **Print** command in the Print group, as shown in Figure 8.44.

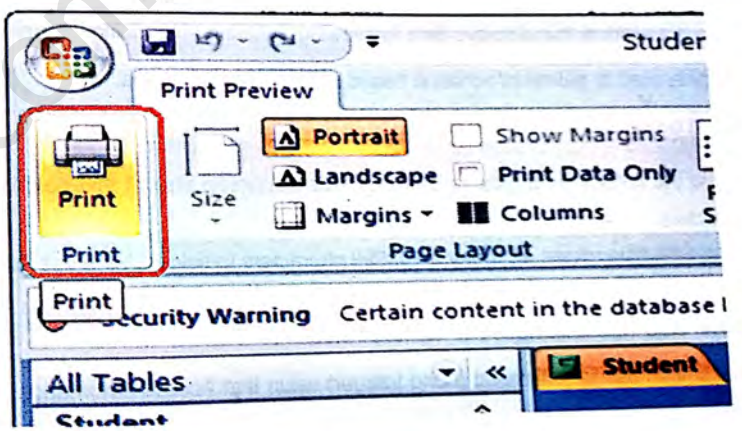


Figure 8.44 Printing Report

SUMMARY

- Database development is the creation, organization, management and manipulation of database systems for organizations.
- Microsoft Access is a database management system.
- Microsoft SQL Server is a relational database management system used to store and retrieve data as requested by other software applications.
- OpenOffice Base is the database module of OpenOffice. It is a fully featured database management system.
- A table is a set of columns and rows, with each column referred to as a field and each row of a table is referred to as a record.
- Form is a window that displays data for viewing, entering and editing information.
- Query is used to gather information based on one or more criteria.
- Report is used for printing information from database.
- Text is the default data type to all fields. The maximum size of text field is 255 characters.
- Memo data type allows as many as 63999 characters to fields. Users use them to provide descriptive comments.
- Number data type is assigned to numeric fields.
- AutoNumber field is a numeric (Long Integer) value that Access automatically fills in for each new record that is added to a table.
- Yes/No is logical data type which uses 1 for Yes (True) and 0 for No (False).
- Date/Time data type is used to assign special fixed format for date/time data.

- OLE Object is used for OLE (Object Linking and Embedding) objects (such as Microsoft Word documents, Microsoft Excel spreadsheets, pictures, sounds, or other binary data) that were created in other programs using the OLE protocol.
- Hyperlink data type is used for hyperlinks. A hyperlink can be a path of a document or a Web address.
- Select Query is a type of database object that shows information in Datasheet view. A query can get its data from one or more tables, from existing queries, or from a combination of both.
- Update Query is an action query (SQL statement) that changes a set of records according to criteria user specify.
- Delete Query is used to delete records from a single database table or multiple tables.

EXERCISE

Q1. Select the best choice for the following MCQs.

i. Which of the following is used to store data in a database?
A. Table B. Form
C. Query D. Report

ii. _____ is a window that displays data for viewing, entering and editing information.
A. Table B. Form
C. Query D. Report

iii. Which of the following is logical data type?
A. Text B. Memo
C. Autonumber D. Yes/No

iv. _____ is an open source application program.
A. MS Access B. OpenOffice Base
C. SQL Server D. MS Word

v. What is the maximum size of text field data type?
A. 253 B. 254
C. 255 D. 256

vi. _____ Key is a unique key field in a table.
A. Secondary B. Foreign
C. Composite D. Primary

vii. Which key is used to create one-to-many relationship between tables?
A. Secondary B. Foreign
C. Composite D. Primary

viii. _____is used to display data in an organized manner so that users can print it.
A. Table B. Form
C. Query D. Report

Q2. Give short answers of the following questions.

i. Name different types of database management systems.
ii. What is OpenOffice Base?
iii. How forms are useful in database?
iv. Name common Access database objects.
v. How primary key is assigned in a table?
vi. What is a report?
vii. How relationship can be edited in Access.
viii. Name different navigation buttons in a form.

Q3. Give detailed answers of the following questions.

i. Explain the following database objects.
a) Tables b) Forms
c) Queries d) Reports

ii. Explain different data types used in Access.
iii. Describe two ways of creating a table in Access.
iv. Explain the process of creating forms in Access.
v. Write the steps for creating relationships between tables.
vi. Explain different types of queries used in Access.
vii. How can one-to-many relationship can be created between two tables? Give example.
viii. What is a query? How query is created using wizard option in Access 2007?

ANSWERS TO MCQs

Unit 1 OVERVIEW OF COMPUTER SYSTEM

Q.1 Multiple Choice Questions.

i	ii	iii	iv	v	vi	vii	viii	ix	x
B	C	C	C	D	B	A	A	D	C

xi	xii	xiii	xiv	xv
B	B	C	A	D

Unit 2 COMPUTER MEMORY

Q.1 Multiple Choice Questions.

i	ii	iii	iv	v	vi	vii	viii	ix	x
B	C	C	A	D	A	C	B	B	C

Unit 3 CENTRAL PROCESSING UNIT

Q.1 Multiple Choice Questions.

i	ii	iii	iv	v	vi	vii	viii	ix	x
A	B	C	B	C	A	A	C	A	B

xi	xii	xiii	xiv	xv
B	B	A	A	D

Unit 4 INSIDE SYSTEM UNIT

Q.1 Multiple Choice Questions.

i	ii	iii	iv	v	vi	vii	viii	ix	x
B	D	D	A	D	C	B	A	C	C

Unit 5 NETWORK COMMUNICATION AND PROTOCOLS

Q.1 Multiple Choice Questions.

i	ii	iii	iv	v	vi	vii	viii	ix	x
B	C	A	D	B	C	D	B	A	C

xi	xii	xiii	xiv	xv
D	D	C	D	C

Unit 6 WIRELESS COMMUNICATIONS

Q.1 Multiple Choice Questions.

i	ii	iii	iv	v	vi	vii	viii	ix	x
A	B	B	A	D	D	C	B	A	D

Unit 7 DATABASE FUNDAMENTALS

Q.1 Multiple Choice Questions.

i	ii	iii	iv	v	vi	vii	viii	ix	x
A	C	A	C	C	A	B	C	C	B

Unit 8 DATABASE DEVELOPMENT

Q.1 Multiple Choice Questions.

i	ii	iii	iv	v	vi	vii	viii
A	B	D	B	C	D	D	D

GLOSSARY

A

Abacus
The abacus, which emerged about 5,000 years ago in Asia and is still in use today, may be considered the first computer.

Accelerated Graphics Port (AGP)
The Accelerated Graphics Port (AGP) is a high-speed point-to-point channel (pathway), primarily used for 3D computer graphics.

Accumulator
Accumulator is a general purpose register and is used by CPU for performing arithmetic and logic operations and to hold the result of those operations.

Address bus
Address bus carries addresses not data.

Application layer
Application layer serves as the user interface for users and application processes to access network services.

Application software
Application software are computer software, designed to help the user to perform singular or multiple related specific tasks.

Asynchronous transmission
In asynchronous transmission, data is transmitted one byte at a 'time'.

B

Base Register
The Base Register can perform arithmetic and data movement and it has some special addressing abilities.

Basic Input Output System (BIOS)
Basic Input Output System (BIOS) also known as the System BIOS or simply BIOS is the firmware built into the computer system.

Bit
Bit or binary digit is the basic unit of information in computing. A bit is the smallest amount of memory a computer can recognize. A bit can hold only one of two values, either '0' or '1'.

Bluetooth
Bluetooth is a high-speed, low-power microwave wireless link technology, designed to connect phones, laptops, PDAs and other portable equipment together.

Blu-ray disk
Blu-ray is an optical disk format designed to display high definition video and store large amounts of data.

Bus
Computer Bus is an electrical pathway or channel though which the processor communicates with internal and external device attached to the computer.

Bus topology
In the bus topology, each node (computer, server, peripheral) attaches to a common cable.

Byte
Byte is a unit of storage that is eight bits long. A byte is the unit most computers use to represent a character such as an alphabet, a number, or a special symbol.

C

Cache memory
Cache (pronounced as cash) memory is extremely fast Static RAM (SRAM) that is built into a computer's central processing unit (CPU), or located next to it on a separate chip.

Cardinality
Cardinality refers to the maximum number of times an instance in one entity can be associated with instances in the related entity.

Cellular technology
Cellular technology is the underlying technology for mobile telephones, personal communication system, wireless Internet and wireless web applications.

Chip
Chip or microchip is a small piece of semi-conducting material (usually silicon).

Circuit switching network
Circuit switching is a scheme in which the network sets up a dedicated point-to-point connection between nodes and terminals before the communication starts, just like the nodes were already connected.

Client
Client is a network device that participates in a client/server relationship by requesting a service from a server.

Communication media
Communication media are the links that provide paths for communication devices.

Communication Standards
Communication Standards provide guidelines (also called rules or protocols) to manufacturers, vendors, government agencies, and other service providers to ensure the kind of interconnectivity of networks for communication.

Compact disk (CD)
A compact disk (CD) is a plastic-fabricated, circular medium for recording, storing, and playing back audio, video, and computer data.

Complex Instruction Set Computer (CISC)
Complex Instruction Set Computer (CISC) is processor architecture. The

Glossary

instructions which the processor could execute were built into the chip. CISC have a large amount of different and complex instructions.

Computer
A Computer is an electronic device that accepts input data with the help of input devices, stores it until needed, processes it and then displays the output as a result with the help of output devices.

Computer case
A computer case also known as computer chassis, cabinet, box, tower, enclosure, housing, system unit or simply case is the enclosure that contains most of the components of computer system.

Computing Device
The term "Computing Device" is used for all such machines that can perform calculations.

Control bus
The control bus is used by the CPU to direct and monitor the actions of the other functional areas of the computer.

Cooling system
Cooling system is used to maintain proper temperature inside the system unit.

Counter register
The Counter register acts as a counter for repeating or looping instructions.

CPU (Central Processing Unit)
CPU is the main hardware of every computer system. It consists of two parts i.e. the Control unit (CU) and Arithmetic Logic Unit (ALU).

D

Data
Data is a collection of facts and figures that can be organized and processed.

Data bus
Data bus is the bidirectional bus. It can communicate in two ways, but in one direction at a time.

Data Control Language (DCL)
Data Control Language is a database language used to control access to the data in a database.

Data definition language (DDL)
Data definition language (DDL) is a database language that defines the structure in which data are stored.

Data link layer
Data link layer provides reliable transmission of data across a physical link.

Data manipulation language (DML)
Data manipulation language (DML) is a language that enables users to access or manipulate data.

Data Modeling
Data Modeling is a logical representation of data in an

organization.

Data Register
Data Register has a special role in multiply and divide operations. It works like a buffer and holds anything that is copied from the memory ready for the processor to use it.

Data type
Data type is the classification of a particular type of information.

Database
Database is a shared collection of logically related data (and a description of this data i.e. metadata), designed to meet the information needs of multiple users in an organization.

Database management system (DBMS)
A database management system (DBMS) is a set of programs that allow users to create a database, edit and update data in database files, store and retrieve data from those database files.

Database model
A database model is a set of rules or specifications which state that how data can be stored, organized and manipulated in a database system.

DDR SDRAM
DDR SDRAM (Double Data rate SDRAM) is twice the bandwidth of a single data rate (SDR) SDRAM.

Delete Query
Delete Query is used to delete records from a single database table or multiple tables.

Device driver
A device driver is a program that controls a particular type of device that is attached to the computer.

DIMM
DIMM (Dual in-line memory module) is the upgraded form of SIMM.

Direct access storage
Direct access, also called Random access is a storage system where the data is stored and read directly from storage devices.

Disk controller
Disk controller is the circuit which enables the CPU to communicate with disk drives.

E

Entity
An entity is a person, place, object, event or concept in user environment about which the organization wishes to maintain data.

Entity Relationship model
Entity Relationship model is expressed in terms of entities, the relationships (or associations) among those entities, and the attribute (or

properties) of both the entities and their relationships in the business environment.

F

Field/Attribute/Column
Field/Attribute/Column is a property or characteristic of an entity that is of interest to the organization.

File Management system
File Management system also known as Conventional file system or simply file system is a method of storing and organizing collection of data in the form of files on the secondary storage devices.

Fire wire
Fire wire is a high speed port which is used to connect video devices such as video Cameras, Camcorders, to the computer system.

Firmware
Firmware is a term often used for the fixed, small programs that control various electronic devices.

Foreign key
Foreign key is generally a primary key from one table that appears as a field in another where the first table has relationship to the second.

Form
Form is a window that displays data for viewing, entering and editing information.

Full-duplex mode
In Full-duplex mode, both stations can send and receive the data simultaneously.

G

Gateway
A gateway is a hardware device or a computer running software that allows communication between networks with dissimilar network protocols or architectures.

General purpose registers
General purpose registers are used to store data as well as addresses.

General-purpose applications software
General-purpose applications software are programs that perform common information processing jobs for end users.

Geostationary Earth Orbit (GEO)
Geostationary Earth Orbit (GEO) is a satellite system used in wireless telecommunications.

Global Positioning System (GPS)
The Global Positioning System (GPS) is a satellite-based navigation system. The GPS system consists of 24 satellites, constructed and operated by the U.S. Department of Defense.

Guided media
Guided media are the physical links in

which signals are confined along a narrow path,

H

Half-duplex mode
In half-duplex mode, each station can transmit and receive data, but not at the same time.

Hard disk drive (HDD)
A hard disk drive (HDD) is a non-volatile, random access storage device for digital data. It contains rotating platters on a motor-driven spindle within a protective enclosure.

Hardware
Computer hardware refers to the physical parts or components of a computer such as monitor, keyboard, Computer data storage, hard disk, mouse, CPU, memory, motherboard and chips.

Hierarchal Database Model
Hierarchal Database Model is a type of model in which data is organized into a tree-like structure. There is a hierarchy of parent and child segments.

I

Information
When facts, figures or data are processed and converted into meaningful form that can be used for decision making or any other useful activity, it is called Information.

Infrared
Infrared is similar to visible light, but with a longer wavelength. Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation.

Input devices
Input devices are the external hardware components that are used to enter or accept data and instructions into computer memory for processing.

Input Operation
Input Operation is the process of capturing or accepting data or information, by using input devices. Input can take a variety of forms, from commands we enter by the keyboard to data from another computer or device.

Instruction
An instruction (or instruction code) is a group of bits that tells the computer to perform a specific operation.

Instruction cycle
Instruction cycle (sometimes called fetch-and-execute cycle, fetch-decode-execute cycle, or FDX) is the basic operation cycle of a computer.

Instruction format
An instruction format defines the layout of the bits of an instruction. An instruction format must include an Op-

code (Operation-Code) and zero or more Operands.

Instruction register

Instruction register is a part of Control Unit, which stores the instructions currently being executed.

Internet Protocol address (IP address)

An Internet Protocol address (IP address) is a number that is used to identify a device, for example a computer, a printer, on the network.

K

Key

Key is a unique identifier which is required to track and analyze data effectively.

L

LAN (Local Area Network)

LAN (Local Area Network) is a network that connects computers and devices in a limited geographical area like home, school, and office building, etc.

Language processor

Language processor or translator is a type of system software that translates a source program (other than machine language) into object program (Machine language).

Licensed or Proprietary Software

Licensed or Proprietary Software is a computer software that is licensed, giving the right to use the software under certain conditions, but restricted from other uses, such as modification, further distribution and re-building under exclusive legal right of the copyright holder.

Line of Sight communication

Line of Sight communication is a type of wireless data transfer that requires "visual contact" with the two devices/antennas.

Low Earth Orbit (LEO)

Low Earth Orbit (LEO) satellite operates at heights of between 500 and 2,000 km above the Earth's surface.

M

Magnetic core memory

Magnetic core memory was the most widely used form of digital computer memory based on a very simple idea. A core, a ring of magnetic material, stores one bit by the direction of its magnetization. A magnetic core is a ring of ferrite material.

Magnetic Storage

Magnetic storage refers to the storage of data on a magnetized medium.

Magnetic Tape

Magnetic Tape is a sequential access storage device used for data collection, backup and archiving.

Mainframe computers

Mainframe computers are the second powerful and expensive computers than supercomputers. Mainframes are used mainly by large organizations for critical applications, typically bulk data processing such as census, industry and consumer statistics, enterprise resource planning, and financial transaction processing.

MAN (Metropolitan Area Network)

A metropolitan area network is a computer network that usually spans a city or in a large metropolitan area.

Medium

Medium is the physical path that message uses to travel from source to destination.

Middle Earth Orbit (MEO)

Medium or Middle Earth Orbit (MEO) is a satellite system used in telecommunications. MEO satellites orbit the earth between 1,000 and 22,300 miles above the earth's surface.

Memory

Computer memory is a semiconductor hardware device used to store data or programs for use in computers either on permanent or temporary basis.

Memory Address Register

Memory Address Register holds the memory address, the memory address from which data will be provided to the CPU or will have the address to which data will be sent and then stored.

Memory Buffer Register

Memory Buffer Register holds the contents of the memory which are to be moved from memory to other components or from components to the memory.

Memory slot

A computer memory slot is a socket or opening in computer main board in which the main memory is installed.

Memory Word

A Memory Word is a unit that a computer processor is designed to handle efficiently.

Mesh topology

In a mesh network topology, each of the network node, computer and other devices, are interconnected with one another.

Message

Message is the data or information that is to be communicated.

Micro wave transmission

Micro wave is a wireless transmission technology that travels at high frequency than radio waves and provide throughput as a wireless network media.

Glossary

Microcomputers
Microcomputers are more commonly known as personal computers (PCs). The microcomputer is generally the smallest and least expensive of the computer family.

Mobile Computing
Mobile Computing is a technology that allows transmission of data, voice and video via a computer or any other wireless enabled device without having to be connected to a fixed physical link.

Modality
Modality refers to the minimum number of times an instance in one entity can be associated with an instance in the related entity.

Motherboard
Motherboard or main board is the main circuit board in computer system that hold main component of the system unit.

N

Network
A network is a collection of independent computers or nodes that communicate with each other on a shared network medium.

Network database model
A network database model is similar to a hierarchical database except that each child can have more than one parent record.

Network interface card (NIC)
A network interface card also known as network interface controller, network adapter and LAN adapter is computer hardware component that connect a computer to a computer network.

Network layer
Network layer allows the data called packets or datagram to go from one physical network to another.

Network Topology
Network Topology refers to the physical layout and connectivity of computers in a network.

Non-volatile memory
Non-volatile memory is a permanent memory that can retain the stored information even when not powered.

Normalization
Normalization is the process of organizing data in relational database in order to minimize duplication of information (data) and to safeguard the database against certain anomalies.

O

Object relational database model
Object relational database model add new object storage capabilities to the relational database systems at the core of modern information systems.

Glossary

Object-Oriented database Model
Object-Oriented database Model is a database model in which information is represented in the form of objects as used in object-oriented programming.

Open Source Software
Open Source Software is computer software of which source code is also available to the user.

Operating system
Operating system is a set of programs that manages and coordinates the hardware of a computer and provides services to application software, programmers and users of computer.

Optical disk
Optical disk is a flat, usually circular disc which encodes binary data in the form of pits.

OSI model
OSI model defines a networking framework for implementing protocols in seven different layers.

Output devices
Output devices are used to display results of processing to the user.

Output Operation
Output Operation is the result, which comes from the transformation process or it is the outcome of the process.

P

Packet switching network
Packet switching is a network communication method in which the data get transmitted in blocks, regardless of type and content, called packets based on the destination address in each packet.

Parallel port
A parallel port is a parallel communication physical interface.

Peer-to-Peer network
In peer-to-peer networking there are no dedicated servers or hierarchy among the computers.

Peripheral Component Interconnect (PCI) port
The Peripheral Component Interconnect (PCI) is a computer bus (an electric pathway) for attaching hardware device in a computer.

Physical layer
Physical layer is concerned with the transmission and reception of the unstructured raw bit stream over a physical medium.

Plotters
Plotters are hardcopy output devices. They are mainly used by architects, engineers, and others who need to generate high-precision graphical output of large sizes on papers.

Port
A port is a piece of equipment to which a plug or cable is connected.

Power supply
A power supply unit is the component

that supplies power to the other components of a computer system.

Presentation layer
Presentation layer converts incoming and outgoing data from one presentation format to another (for example, from a text stream into a popup window with the newly arrived text).

Primary or Main memory
Primary or Main memory holds instructions and data when a program is executing.

Printers
Printers are output devices which are used to produce output on physical media such as paper.

Processing Operation
Processing Operation is the transformation process to convert the input into output.

Productivity software
The productivity software is a type of application software that are used to produce documents, presentations, databases, charts and graphs etc.

Program Counter Register
Program Counter is also known as Instruction Pointer, it is a processor register that holds either the address of the instruction being executed or the address of the next instruction to be executed.

Protocol
A protocol is a set of rules that governs data communications.

Q

Query
Query is used to gather information based on one or more criteria.

R

Radio signals
Radio signals are electromagnetic waves which are used as a medium in wireless communication.

Radio transceiver
Radio transceiver is a wireless communication device which is used to send as well as receive data through radio signals.

Radio wave transmission
Radio wave wireless transmission distributes radio signals through the air over long distances such as between cities, regions, and countries, and short distances such as within an office or home.

Random Access Memory (RAM)
Random Access Memory (RAM) is the common type of computer memory. It is the Read and Write (R/W) memory of a computer.

Receiver
Receiver is the device which receives

transmitted message.

Record/Tuple/Row
Record/Tuple/Row is a collection of related fields treated as a single unit.

Reduced Instruction Set Computer (RISC)
Reduced Instruction Set Computer (RISC) is a microprocessor that is designed to perform a smaller number of types of computer instructions.

Registers
Registers are small memory units. There are a large number of registers inside the processor.

Relational Database Model
Relational Database Model uses a collection of tables to represent both data and the relationship among those data. Each table has multiple columns and each column has a unique name.

Relational database schema
Relational database schema is the tables, columns and relationships that make up a relational database.

Report
Report is used for printing information from database.

Ribbon cable
A ribbon cable also known as multi-wire planar cable is a cable with many conducting wires running parallel to each other on the same plat plane.

Ring topology
In a ring topology, every node is logically connected to two other nodes, forming a ring. Traffic flows through the entire ring until it reaches its destination.

ROM (Read only memory)
ROM (Read only memory) is non volatile memory, i.e., the information stored in it, is not lost even if the power supply goes off.

Router
Router is a device that forwards data packets across different networks.

S

SATA (Serial Advanced Technology Attachment)
SATA (Serial Advanced Technology Attachment) is a new technology cable for connecting storage drives to computer.

Scanner
Scanner is an input device. It is an electronic device that scans printed or handwritten text documents, images, or a particular object to convert them into a digital file format.

SDRAM
SDRAM (Single Data rate RAM) is a high speed semiconductor memory.

Secondary key
Secondary key is an attribute or combination of attributes that is not a

primary key and can have duplicate data. In other worlds secondary key is used after the identification of the primary key.

Secondary memory

Secondary memory (also called auxiliary memory) holds data and programs that may not currently in use and provides long-term storage.

Select Query

Select Query is a type of database object that shows information in datasheet view.

Sender

Sender or Transmitter is a device that sends the message.

Sequential access storage

Sequential access is a storage system where the data is stored and read in a fixed or linear order.

Serial port

A serial port is a serial communication physical interface through which information transfers in or out one bit at a time.

Server

Server is a powerful computer that provides centralized administration of the network and serves up the resources that are available on the network, such as printers and files.

Session layer

Session layer sets up, coordinates, and terminates conversations, exchanges, and dialogues between the applications running on different stations.

Shareware

Shareware is also called trail-ware and refers to licensed software that is delivered to the user without payment for trial uses with limited functionality and for a specific period after which it expires.

SIMM

A SIMM or single in-line memory module is type of old RAM.

Simplex mode

In Simplex mode, the communication takes place in only one direction.

Slot

It is an opening or socket in a computer main board where a circuit board or expansion card can be inserted to add new functionalities to the computer.

Software

Computer software is a step by step set of instructions that directs the computer what to do and how to do. It turns the data into information - that makes a computer useful.

Sound card

Sound card also known as an audio card is an internal expansion card that facilitates the input and output of audio

signals to and from a computer.

Special purpose application software

The software that is designed to perform a specific task is known as special purpose application software.

Special Purpose Registers

Special Purpose Registers are used to hold the state of a program. They include program counter, instruction register, memory address register and memory buffer registers.

SQL (Structured Query Language)

SQL (Structured Query Language) is the standard language for relational database systems.

Star topology

In a star topology all the nodes (server, workstations, peripherals, etc.) on the network are connected directly to a centralized connectivity device called a hub, switch, or router.

Storage Operation

Storage Operation is the process of storing the data, information and instructions, so that the user can retain and retrieve it whenever required.

Subnet Mask

Subnet Mask indicates the network portion of an IP address.

Supercomputers

Supercomputers are the most powerful and the most expensive computers designed or scientific, engineering, and business applications. These computers can process billions to trillions of instructions per second.

Switch or Hub

A network switch or hub is a device that connects network nodes to a central location.

Synchronous transmission

In synchronous transmission, large volumes of information can be transmitted block-by-block or word-by-word simultaneously.

System software

System software are set of programs that operate and control the computer system.

System Unit

The System Unit is core of a computer system. Usually it is a rectangular box with many electronic components that make the entire system.

T

Table

A table is a set of columns and rows, with each column referred to as a field and each row of a table is referred to as a record.

TCP/IP

TCP/IP is an industry standard suite of protocols designed for local and wide area networks.

Transistor
By 1948, the invention of the transistor greatly changed the computer's development.

Transport layer
Transport layer handles the transparent transport of data segments between network devices.

U

Unguided media
Unguided media also called Wireless media transports signals without using any physical conductor between the two devices communicating.

Update Query
Update Query is an action query (SQL statement) that changes a set of records according to criteria that user specify.

USB (Universal Serial Bus)
USB (Universal Serial Bus) is a serial port which provides a fast serial transmission between devices and computers.

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

V

Video card
A video card also known as video adapter, graphics accelerator card, display card or graphics card is an expansion card whose function is to generate output images to a display unit.

Volatile memory
Volatile memory is computer memory that requires power (electricity) to maintain the stored information.

VPN (Virtual Private Network
A virtual private network (VPN) is a network that uses a public telecommunication infrastructure to provide remote offices or individual users with secure access to their organization's network.

W

WAN (Wide Area Network)
WAN (Wide Area Network) covers large distance for communication between computers.

Web Service Protocol stack
Web Service Protocol stack is a protocol stack (a stack of computer networking protocols) that is used to define, locate, implement, and make Web services interact with each other.

Wi-Fi
Wi-Fi is short for "wireless fidelity. It is a popular wireless networking technology which uses radio waves to provide wireless high-speed Internet and network connections.

WiMAX
WiMAX is an acronym for "Worldwide Interoperability for Microwave Access". Wimax technology is a standard based wireless technology which is used to provide Internet access and multimedia services at very high speed to the end user.

Wireless Access Point
Wireless Access Point is a device that both transmits and receives data (sometimes referred to as a transceiver).

Wireless Application Protocol (WAP)
The Wireless Application Protocol (WAP) is an open standard protocol which provides Internet access to mobile users of wireless phones and other wireless devices such as pagers and personal digital assistants (PDAs).

Wireless communication
Wireless communication is a term used to describe communications between two or more devices without any physical connection.

Wireless Markup Language
Wireless Markup Language is a markup language created for devices that implement the Wireless Application Protocol (WAP), such as mobile phones.

Wireless network
Wireless network is a network set up by using radio signal frequency to communicate among computers and other network devices.

INDEX

A

Address Bus 80,99
Alternate Key 230
Application Software 13
Arithmetic and Logic Unit (ALU) 73
Assembler 15
Asynchronous Transmission 129
Attribute 219, 224

B

Bit 42
Bluetooth 187
Blu-Ray Disk (BD) 62
Bus Topology 149
Business Software 17
Byte 43

C

Cache Memory 47, 75
Cardinality 231
CD (Compact Disk) 61
Cellular Communication 189
Chip memory 44
Chip Memory 63
Circuit Switching 165
CISC (Complex Instruction Set Computer) 88
Client 139
client/server Architecture 139
Coaxial Cable (Coax) 131
Communication Media 130
Compiler 15
Computer 2
Computer Bus 108
Computer case 97
Computing Devices 2
Control Bus 81,109
Control Unit (CU) 73
CPU (Central Processing Unit) 20
CRT Monitors 28

D

Data 208
Data Bus 109
Data communication standards 152
Data Modeling 223
Data Processing Instructions 83
Data Transfer Instructions 82
Database 211
Database Models 215
Database Objects 253
DBA 214
DBMS 212
Desktop Computers 8
Device Driver 14
Digital Cameras 24
Direct Access Storage 55
Disk Controller 107
Double Data Rate Synchronous Random Access Memory (DDR SDRAM) 116
Dual In-line Memory Module (DIMM) 115
DVD (Digital Versatile Disk) 62
Dynamic RAM 51

E

Educational software 17
EEPROM 53
Entertainment software 17
Entity 224
ENTITY RELATIONSHIP DIAGRAM (ERD) 223
EPROM 53
Expansion Slots 103

F

Field 219
Fire wire Port 111
Firmware 19
Flash Memory 64
Foreign Key 229,264
Forms 254
Freeware 19
Full-Duplex mode 127

G

Gateway 137
General Purpose Registers 76
Geostationary Earth Orbit (GEO) 192
Global Positioning System (GPS) 190
Guided Communication Media 130

H

Half-Duplex mode 127
Handheld Computers 9
Hard disk 58
Hardware 11

I

Impact Printers 29
Information 208
Infrared 135
Input devices 20
Input Operation 6
Instruction 79
Instruction Cycle 86
Instruction Format 84
Internal Buses 75
Internal processor memory 47
Interpreter 15
IP Addressing 166

J

Joystick 23

K

Key 220
Keyboard 21

L

L1 cache 48
L2 cache 48
L3 cache 48
LAN (Local Area Network) 142
Language Processor 15
Laptop Computers 8
LCD Monitors 28
Licensed software 18
Light Pen 23
Line of Sight Communication 184
Low Earth Orbit (LEO) 193

M

Magnetic cards 25
Magnetic Disk 56
Magnetic Ink Character Recognition (MICR) 26
Magnetic memory 45
Magnetic Stripe Card 26
Magnetic Tape 55
MAIN MEMORY 44
Mainframe Computers 9
MAN (Metropolitan Area Network) 143
Medium 125
Medium Earth Orbit (MEO) 192
Memory 20
Memory Cards 65
Memory Chip 114
Memory Slots 107
Memory Units 42
Memory Word 43
Mesh Topology 150
Message 125
Micro waves 133
Microcomputers 7
Microphone 24
Mobile Computers 10

Modality 231
MONITORS 27
Motherboard 100
Mouse 22

N

network 123
Network Interface Card (NIC) 114
Non-impact printers 30
Non-Volatile memory 46
Normalization 238
Notebook Computers 8

O

Op-Code 84
Open Source Software 18
Operand 85
Operating System 14
Optical disk 60
Optical Fiber Cable 132
OSI Model 152
OSI MODEL LAYERS 153
Output devices 20
Output Operation 7

P

Packet Switching 165
Parallel Ports 110
Peer-to-Peer Network Architecture 141
PLOTTERS 31
Pointing Devices 21
Ports 102
Primary key 263
Primary Key 263
Primary memory 44
PRINTERS 28
Processing Operation 6
Productivity software 16
Program Control Instructions 84
PROM 53
Proprietary Software 18
Protocol 126
PS/2 Port 110

Q

Queries 247
Query 280

R

Radio Signals 183
Radio Transceiver 183
Radio waves 133
RAM (Random Access Memory) 50
Receiver 126
Record 219
Registers 49, 74
Relation 217
RELATIONAL SCHEMA 237
Relationship 223, 264
Reports 254
Ribbon Cable 105
Ring Topology 148
RISC (Reduced Instruction Set Computer) 88
ROM (Read Only Memory) 52
Router 137

S

Scanner 24
Secondary Key 230
SECONDARY STORAGE 53
Sender 125
Sequential Access Storage 54
Serial Ports 109
Server 139
Shareware 18
Simplex mode 126
Single In-line Memory Module (SIMM) 115
Smart card 26
Software 13
Sound Card 112
Speakers 32
Special Purpose Registers 78
Star Topology 146
Static RAM (SRAM) 51
Storage Operation 7
Subnet Masks 170
Super Computers 10
Super Key 230
Switch 136
Synchronous Dynamic Random Access Memory (SDRAM) 116
Synchronous Transmission 128
System Bus 80
System Software 13
System unit 97

T

TCP/IP 158
TCP/IP Applications 162
TCP/IP Architecture 159
TCP/IP PORTS 161
Touch Screen 23
Touchpad 23
Trackball 22
Tuple 219
Twisted Pair Cable 130

U

Unguided Communication Media 133
USB Port 111
Utility Software 14

V

Volatile memory 46
VPN (Virtual Private Network) 145

W

WAN (Wide Area Networks) 144
Web Protocol Stack 199
Wi-Fi 185
WiMAX 187
Wireless Access Point 183
Wireless Network 179

Z

Zip disk 57

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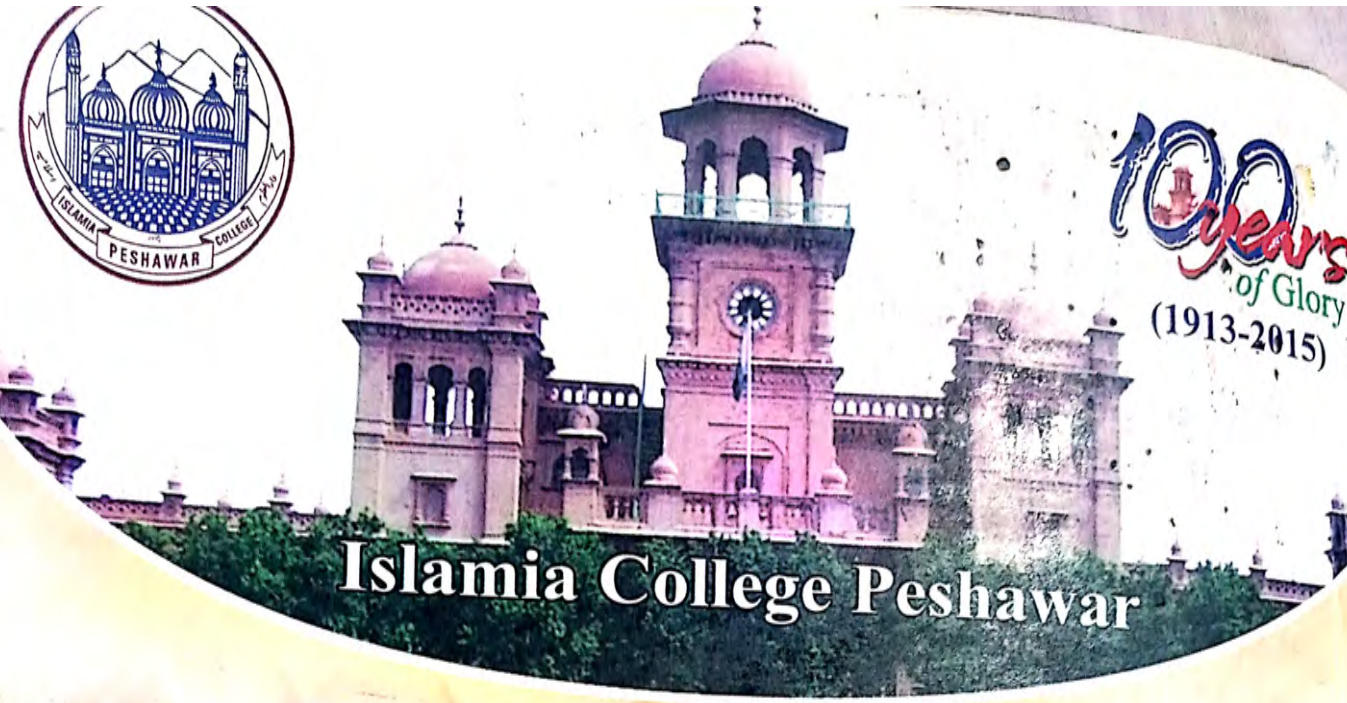
Keeping in view his experience and expertise in the subject, this book will prove to be an asset both for the students and the teachers.

مومن تو آپس میں بھائی بھائی ہیں۔
پس اپنے دو بھائیوں میں صلح کرادیا کرو
اور اللہ تعالیٰ سے ڈرتے رہو۔
تاکہ تم پر رحم کی جائے۔

(سورۃ الحجرات:10)

رشوت لینے والا اور دینے والا
دونوں جہنمی ہیں۔

(حدیث نبوی صلی اللہ علیہ وسلم)



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