Based on National Curriculum of Pakistan 2022-23

Model Textbook of

Computer Science

Grade

9

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A Model Textbook of Computer Science for Grade 9

based on National Curriculum of Pakistan (NCP) 2022-23

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Preface

This Model Textbook for Computer Science Grade 9 has been developed by NBF according to the National Curriculum of Pakistan 2022-2023. The aim of this textbook is to enhance learning abilities through inculcation of logical thinking in learners, and to develop higher order thinking processes by systematically building the foundation of learning from the previous grades. A key emphasis of the present textbook is creating real life linkage of the concepts and methods introduced. This approach was devised with the intent of enabling students to solve daily life problems as they grow up in the learning curve and also to fully grasp the conceptual basis that will be built in subsequent grades.

After amalgamation of the efforts of experts and experienced authors, this book was reviewed and finalized after extensive reviews by professional educationists. Efforts were made to make the contents student friendly and to develop the concepts in interesting ways.

The National Book Foundation is always striving for improvement in the quality of its textbooks. The present textbook features an improved design, better illustration and interesting activities relating to real life to make it attractive for young learners. However, there is always room for improvement, the suggestions and feedback of students, teachers and the community are most welcome for further enriching the subsequent editions of this textbook.

May Allah guide and help us (Ameen).

Murad Ali Mohmand
Managing Director

UTILITY OR PRACTICAL APPLICATIONS OF THE SUBJECT

The Grade 9 Computer Science textbook, based on the NCC Curriculum 2022-23, provides a practical and engaging introduction to computing for students. It covers key topics such as **computer systems, algorithms, programming, data analysis, applications and** ***impacts*** **of computing** with a focus on hands-on applications that prepare students for the digital world.

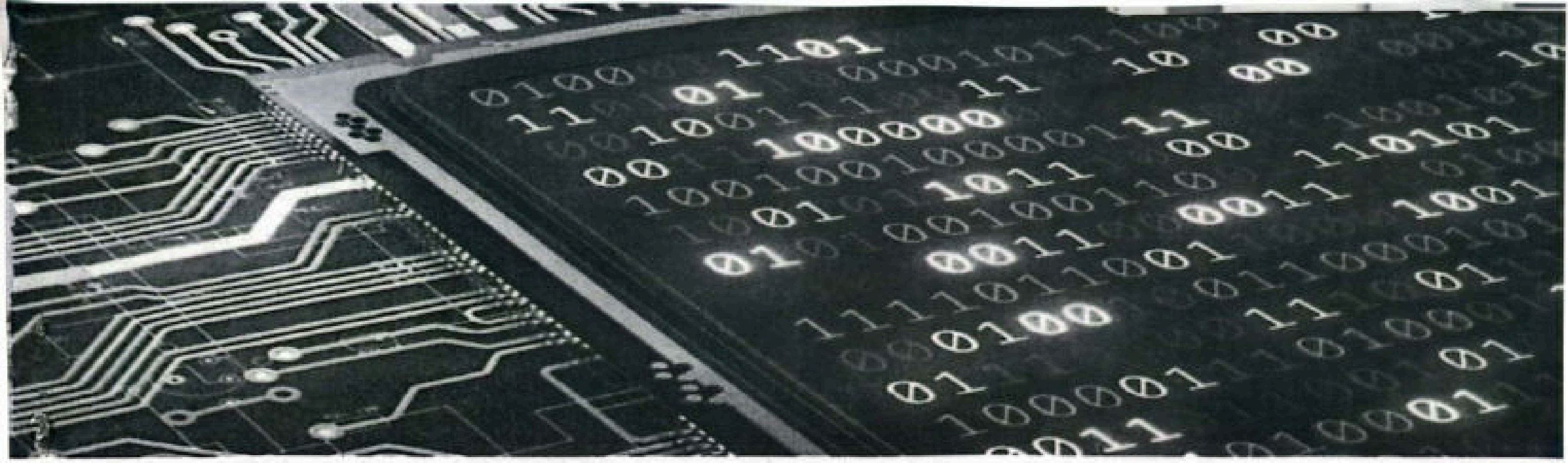
One of the core focuses of the book is on the **basic components of a computer system.** Students are introduced to hardware and software, which sets the stage for understanding how computers work. This knowledge is fundamental in all fields of computing, enabling students to grasp how technology integrates into various industries.

The textbook places a strong emphasis on **algorithm development and programming,** which are crucial skills in the modern workforce. By covering popular programming languages like **HTML, CSS,** and **JavaScript**, students gain hands-on experience in web development. This knowledge is immediately applicable in real-world projects, such as designing websites and developing interactive applications, making the learning both engaging and relevant. Learning these programming languages also provides a gateway to more advanced coding concepts and helps students build logical thinking and problem-solving skills.

The book also covers **data and analysis**, which is critical in an era where data-driven decision-making has become the backbone of businesses. Understanding how to collect, process, and analyze data allows students to appreciate its significance across various industries. Moreover, it introduces them to the basics of data management and security, which are increasingly important in safeguarding information in the digital world.

A notable section on the **applications and impacts of computing** provides students with a broad understanding of how computers influence different sectors of society. Whether it's through artificial intelligence, cybersecurity, or automation, this section connects theoretical knowledge with real-world applications, allowing students to see how computing can solve everyday challenges and improve efficiency across various domains.

Lastly, the inclusion of **entrepreneurship in computing** fosters a forward-thinking mindset, encouraging students to explore how their technical skills can be transformed into innovative products and services.



Contents

Unit 1: Computer Systems

Unit 2: Computational Thinking & Algorithms

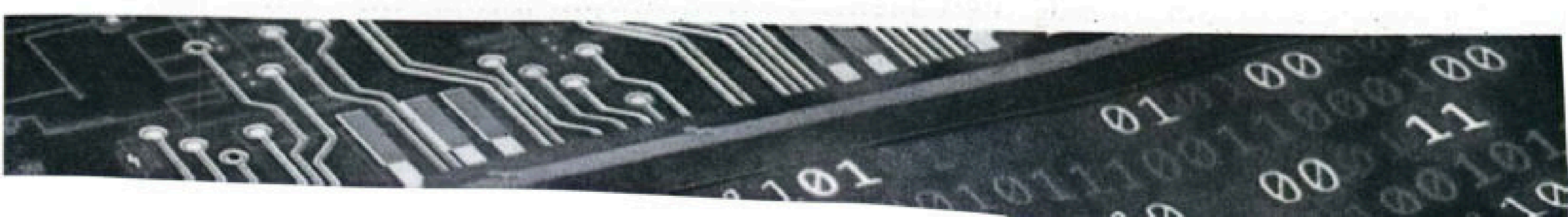
Unit 3: Programing Fundamentals

Unit 4: Data and Analysis

Unit 5: Applications of Computer Science

Unit 6: Impacts of Computing

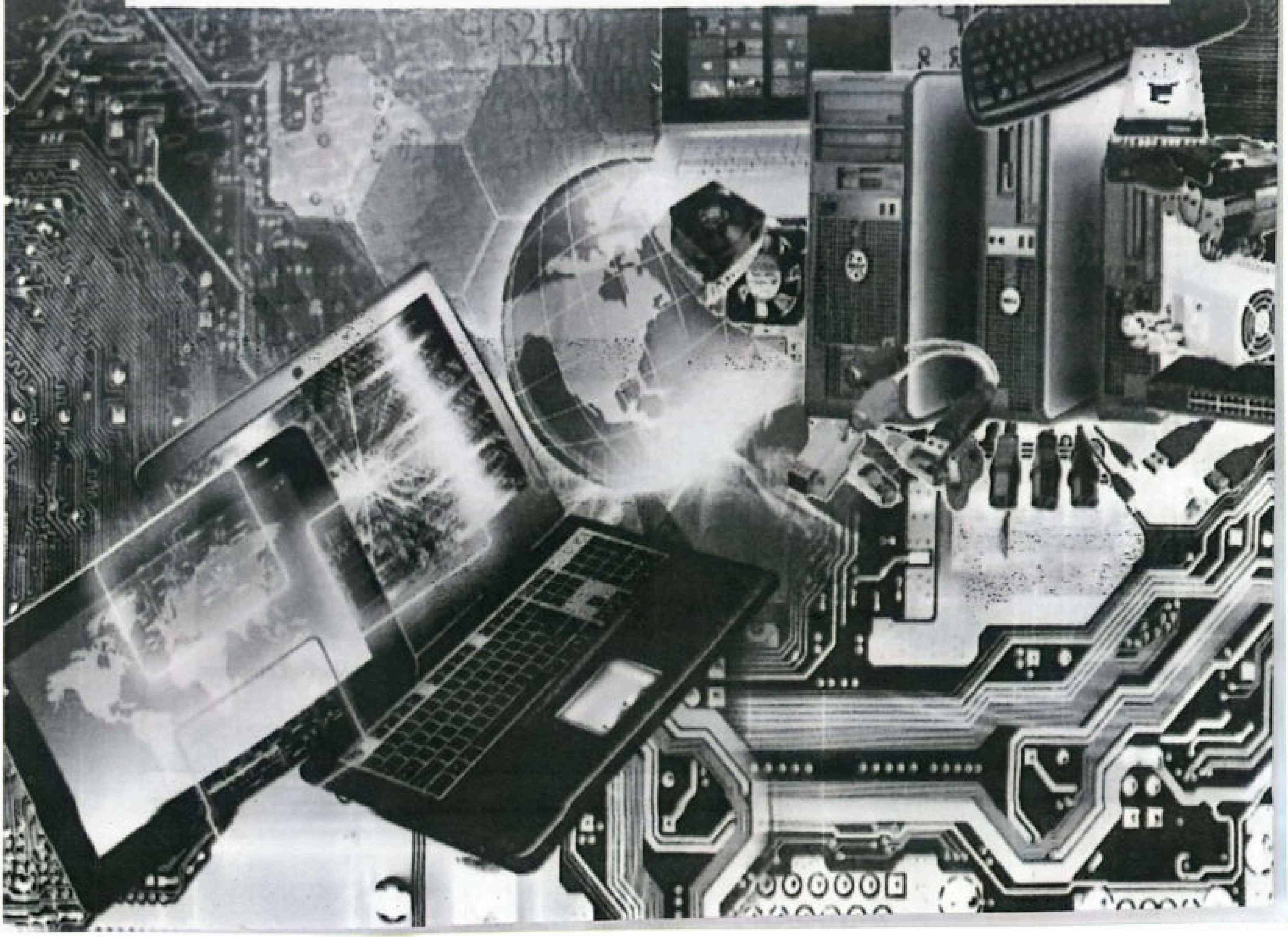
Unit 7: Entrepreneurship



COMPUTER SYSTEMS

After completing this lesson, you will be able to:

- define and describe types of systems (artificial, natural), computer hardware components such as computer architecture (CPU, microprocessors, etc.)
- identify and explain system software, application software, lowlevel and high-level programming languages, and their uses.
- identify and analyze data communication, computer networks, networking devices, basic networking systems and understand how data is transmitted and key concepts such as protocols, speeds, etc.



Introduction

A computer system is a fundamental and important part of modern life. It has revolutionized the way we work, communicate, learn, and entertain ourselves. A computer system is not just a single device but a sophisticated combination of hardware and software components that work together to process information, solve problems, and execute a multitude of tasks.

Understanding computer systems is very important in today's digital age, whether you are a casual user or a professional in the field of computing. It empowers us to utilize the capacities of computers for diverse purposes, from business and scientific research to creative activities and entertainment.

1.1 Brief History of Computer Systems and Generations of Computers

A computer is a programmable electronic device that performs arithmetic and logical operations automatically using a set of instructions provided by the user. When we study the aspects of computing and computers, it is important to know about the history of computers.

1.1.1 Early Computing Devices

Humans used sticks, leaves, stones and bones as counting tools before computers were invented. More computing devices were produced as technology advanced and the human intelligence improved over time. A few early-age computing devices are discussed as follows (Fig 1.1.)

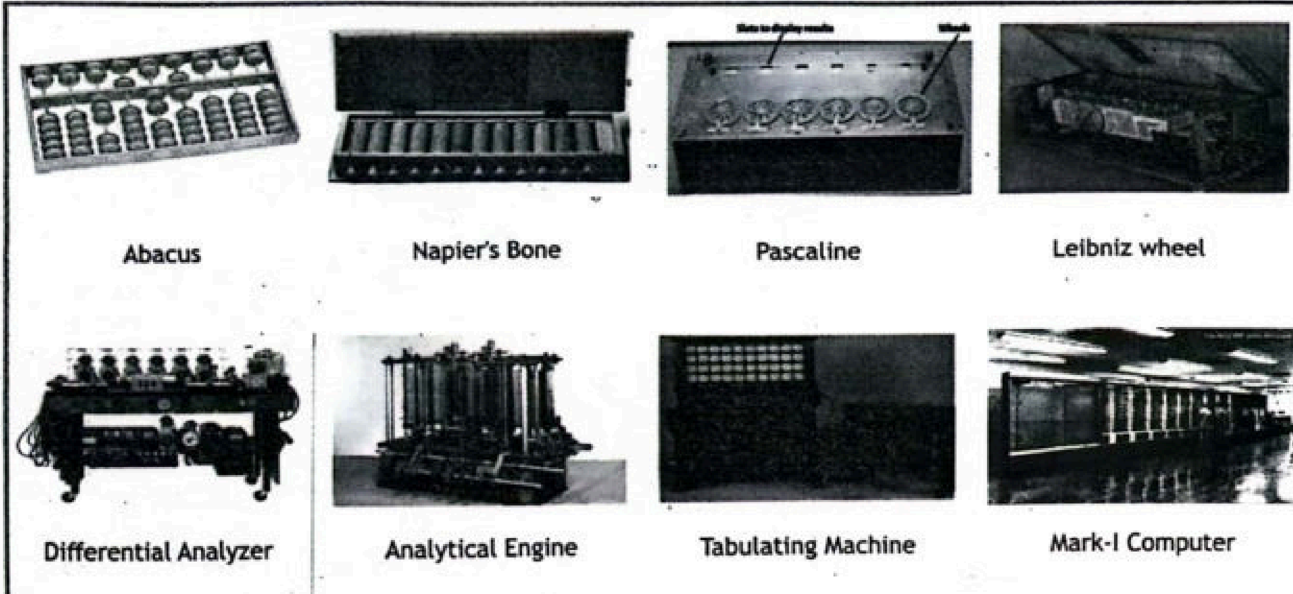


Fig.1.1: Early Computing Devices

Abacus: An ancient tool with beads on rods for arithmetic, used across cultures for centuries.

Napier's Bones: Invented by John Napier, this device used numbered strips (bones) to simplify multiplication and division and introduced the decimal point system.

Pascaline: Blaise Pascal's mechanical calculator (1642), used gears and wheels in a wooden box to perform basic arithmetic automatically.

Stepped Reckoner: Wilhelm Leibniz's digital mechanical calculator (1673) with grooved wheels for advanced calculations.

Difference Engine: Charles Babbage's steam-powered machine (1820s) for solving numerical problems mechanically.

Analytical Engine: Babbage's improved design (1830s), capable of general-purpose computation, data storage, and use of punch cards for input.

Tabulating Machine: Invented by Herman Hollerith (1890), this punch card-based mechanical calculator could compute statistics and store data, laying the foundation for IBM.

Mark I: Howard Aiken's electromechanical computer (1944), capable of adding three 8-digit numbers per second, using electric switches and printing outputs on punch cards or a typewriter.

1.1.2 Computer Generations

History of computers is a chain that runs from the ancient abacus and the analytical engine of the nineteenth century, through the modern quantum computers of present age. It is generally divided into five generations. Each generation of computers is characterized by major technological developments of that time.

First Generation (1940-1956)

The first generation of computers relied on vacuum tubes as their core technology. These large glass components formed the basis of electronic circuits. A vacuum tube is shown in Fig.1.2.

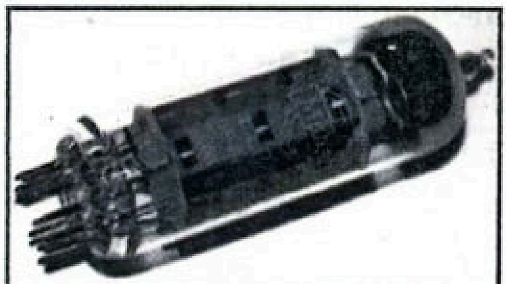


Fig.1.2 Vacuum Tube

Characteristics:

- These computers were slow and unreliable, consuming vast amounts of power.
- They were large in size, expensive to manufacture, and prone to overheating.
- Programming was done using machine language, which was challenging and limited.
- Input was provided through punched cards, and output was generated via printouts.

Examples: ENIAC, UNIVAC I, IBM 604, and Mark I.

Second Generation (1956-1963)

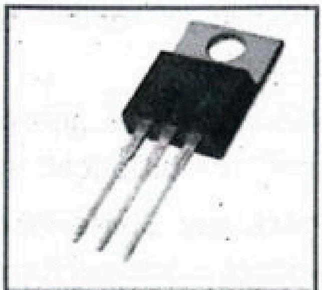


Fig.1.3 Transistor

The second generation marked the replacement of vacuum tubes with transistors, which revolutionized computing. A Transistor is shown in Fig.1.3.

Characteristics:
- These computers were smaller, faster, and more reliable compared to the first generation computers.
- They were more cost-effective, offering increased processing speed and memory capacity.
- Programming advanced to assembly languages and high-level languages such as FORTRAN (Formula Translation) and COBOL (Common Business Oriented Language).
- Input and output methods included punched cards, magnetic tapes, and disks.

Examples: UNIVAC II, IBM 7030, and CDC 1604.

Third Generation (1963-1971)

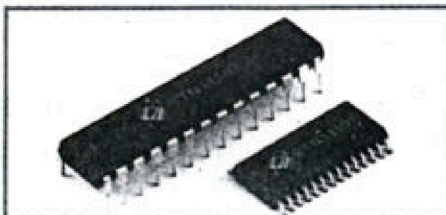


Fig.1.4 IC Chips

Integrated circuits (Ics), which combined multiple transistors on a single chip, defined the third generation of computers. An IC chip is shown in Fig.1.4.

Characteristics:
- In this generation, computers became significantly smaller, faster, and efficient.
- They were highly reliable and introduced keyboards and monitors.
- These systems were capable of running multiple applications simultaneously, improving functionality.

Examples: IBM System/360 and CDC 6600.

Fourth Generation (1971-Present)

DO YOU KNOW?
Intel invented the world's first microprocessor, the Intel 4004 in November, 1971

The fourth generation saw the development of microprocessors, which integrated entire processing units onto a single chip using LSI (Large-Scale Integration) and VLSI (Very-Large-Scale Integration) technologies. A Microprocessor is shown in Fig.1.5.

Fig.1.5 Microprocessor

Characteristics:
- These computers offered exceptional speed, compact size, and vast storage capacities.
- Advanced graphical user interfaces (GUIs) and multimedia capabilities became standard.
- They supported modern programming languages such as C++, Java, and Python.

Teacher's Guide
- Encourage students to explore additional resources, such as books, websites, and educational videos, to deepen their understanding of computing history and systems.
- Stay updated on emerging trends and advancements in computing to inspire ongoing curiosity and learning among students.

- Portable devices, including laptops and smartphones, became widespread and accessible.

Examples: Intel Pentium series, IBM ThinkPad, Apple MacBook Pro, and Dell Inspiron.

Fifth Generation (Present and Beyond)

The fifth generation focuses on artificial intelligence (AI) and natural language processing (NLP).

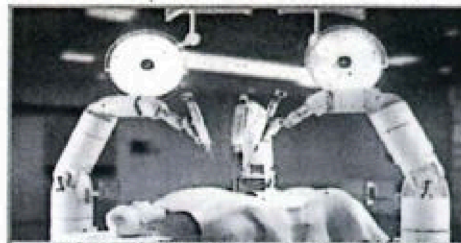


Fig.1.6 Robot in medical field

Characteristics:

- Computers in this generation are capable of learning, reasoning, and solving problems autonomously.
- Advanced parallel processing allows these systems to handle complex tasks efficiently.
- Voice recognition and gesture controls have become common.
- Expert systems and ROBOTS are used in specialized fields like medicine and engineering. (Fig.1.6)

1.2 Understanding Systems and their Types

What is a System?

A **system** is a collection of interconnected components working together to achieve specific goals. It processes inputs to produce desired outputs. Systems exist in both natural and artificial domains, and understanding them allows better design, management, and optimization across various fields like engineering, biology, and management.

1.2.1 Natural and Artificial Systems

Natural Systems

Natural systems occur organically in nature, characterized by self-regulation, adaptability, and stability. They consist of interconnected elements that work harmoniously without human intervention. Some Natural system are shown in Fig.1.7.

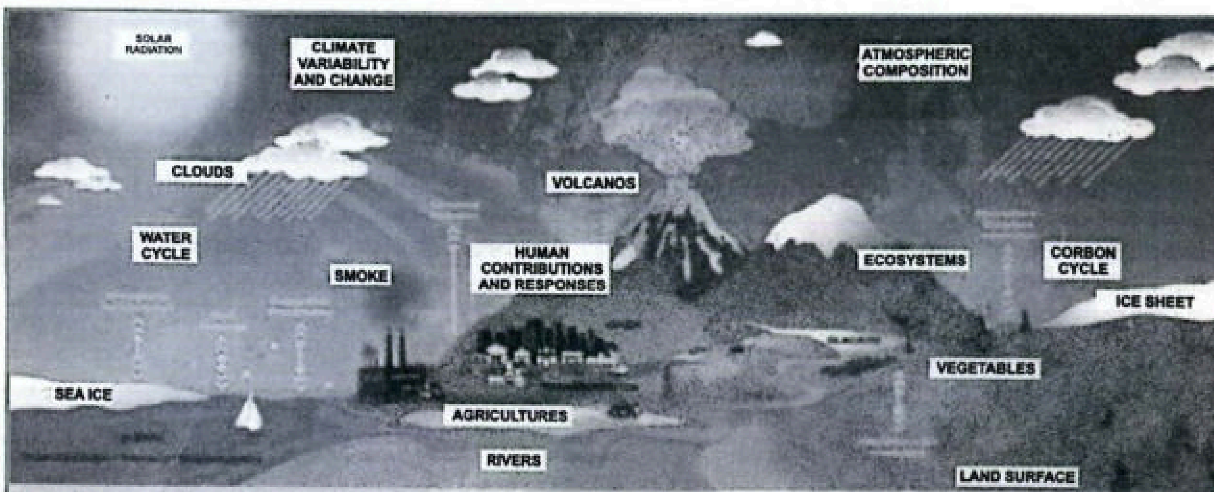


Fig.1.7 Natural Systems

Natural systems include ecosystems (forests, grasslands, aquatic), weather patterns, geological systems (mountains), the solar system, and biological systems (human body), showcasing interconnected processes and adaptations.

Artificial Systems

Artificial systems are human-designed and built to fulfill specific needs or solve problems. They are intentionally created and often require maintenance to remain functional.

Artificial systems include communication networks (e.g., telephone, internet, satellites), information systems (e.g., databases, software), transportation systems (e.g., cars, planes, trains), energy systems (e.g., power plants), manufacturing systems (e.g., robotics), and healthcare systems (e.g., medical devices). Some artificial systems are shown in Fig.1.8.

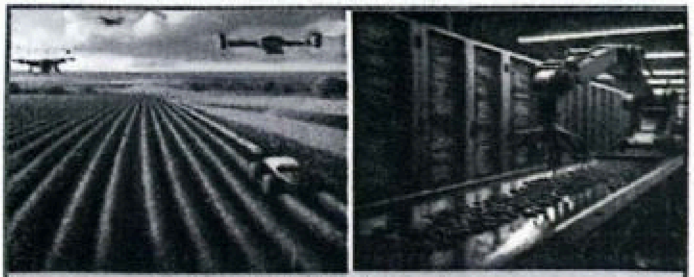


Fig. 1.8 Artificial Systems

Difference between Natural and Artificial systems

	Natural Systems	Artificial Systems
1	Systems occurring naturally without human input.	Systems designed and built by humans.
2	Highly intricate and interdependent.	Structured, simpler compared to natural systems.
3	Natural energy sources (e.g., sunlight, water flow).	Artificial energy like electricity or fuel.
4	Can adapt and evolve autonomously.	Requires human updates or redesign to adapt.
5	Usually sustainable and long-lasting.	Dependent on maintenance and resource vailability.
6	Performs roles vital to life and ecology.	Designed for specific human purposes.
7	Governed by natural laws (e.g., physics, biology).	Operates under predefined human-set rules.
8	Evolves through natural selection over time.	Can be modified or innovated rapidly by humans.
9	Examples include Forests, rivers, weather, human body, etc.	Examples include Computers, vehicles, factories, power grids, etc.

Teacher's Guide

- Explore the characteristics and behaviors of natural systems like ecosystems and weather patterns.
- Discuss the design, purpose, and functionality of artificial systems such as communication networks, transportation systems, and healthcare systems.

1.3 Core Components of a Computer System

A computer system comprises of several core components that work together to perform various tasks. The essential components of a computer system include Input devices, Output devices, System unit (motherboard, memory, CPU, power supply, etc.), and data storage devices.

1.3.1 Input Devices

Input devices are the means by which users provide data and instructions to the computer, facilitating interaction between humans and the computer. Some important input devices are shown in Fig.1.9.

POINT TO PONDER:
Why the keys on keyboard are not arranged in alphabetical order?

Important Input Devices:

- **Keyboard:** The most commonly used device for entering text, numbers, and symbols into the system. It is essential for tasks such as document creation, programming, and data entry.
- **Mouse:** A hand-held device used to control the pointer on the screen. It facilitates selecting, dragging, and opening files, as well as graphic design tasks.
- **Microphone:** Converts sound into digital signals, allowing audio input for applications like voice commands, video calls, and sound recording.
- **Scanner:** Captures images, text, or documents and converts them into a digital format for editing, viewing, or sharing. Widely used in offices and graphic design.
- **Barcode Reader:** Scans barcodes on products to extract information such as price, product details, or inventory data, commonly used in retail and logistics.
- **Digital Camera:** Captures high-quality photographs and videos, which can be uploaded to the computer for editing, sharing, or inclusion in digital projects.
- **Touch Screen:** Combines input and output functionalities by allowing users to interact directly with the display through touch gestures. It is commonly used in smartphones, tablets, and kiosks.

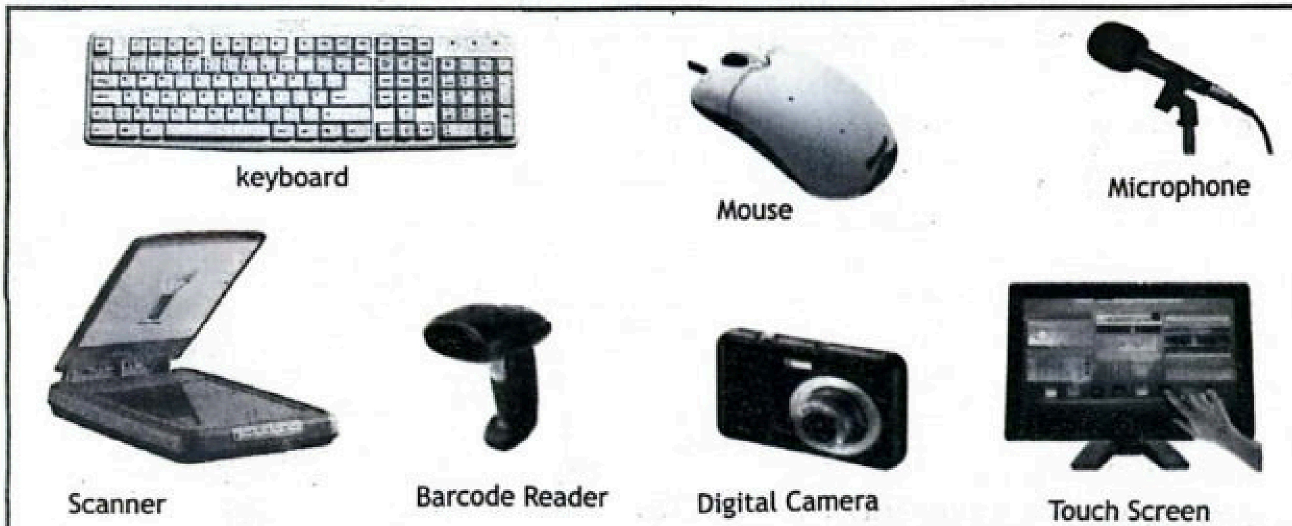


Fig. 1.9 Input Devices

1.3.2 System Unit

The system unit is the central hub of the computer, housing its components, such as the motherboard, processor, and drives. All input and output devices connect to the system unit.

Motherboard

Motherboard is the main circuit board of the system, containing the microprocessor, memory, and slots for connecting other components. It serves as the backbone of the computer, ensuring communication between all parts. A motherboard is shown in Fig.1.10.

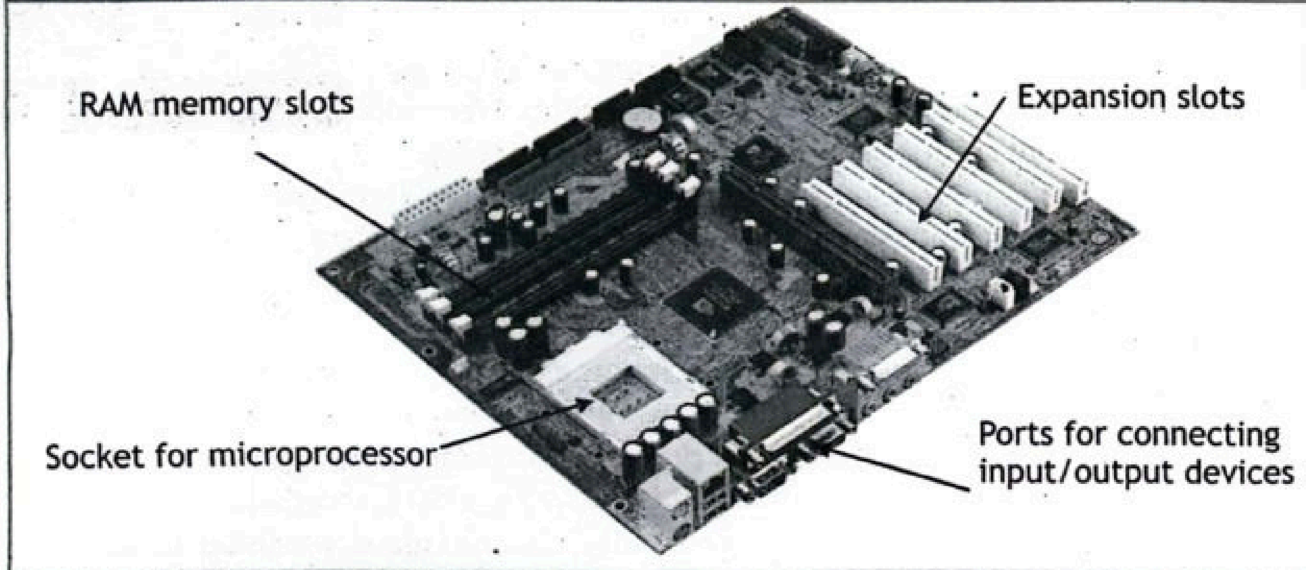


Fig.1.10 Motherboard

Microprocessor

A microprocessor (also known as the CPU, Central Processing Unit) is the "brain" of the computer that executes instructions and performs calculations. A microprocessor (a) with its main components (b) is shown in Fig.1.11.

- Arithmetic Logic Unit (ALU): Handles mathematical operations and logical comparisons.
- Control Unit (CU): Manages and directs all system activities, including the execution of instructions.
- Registers: Temporary storage spaces within the CPU used during processing to hold data and instructions temporarily.

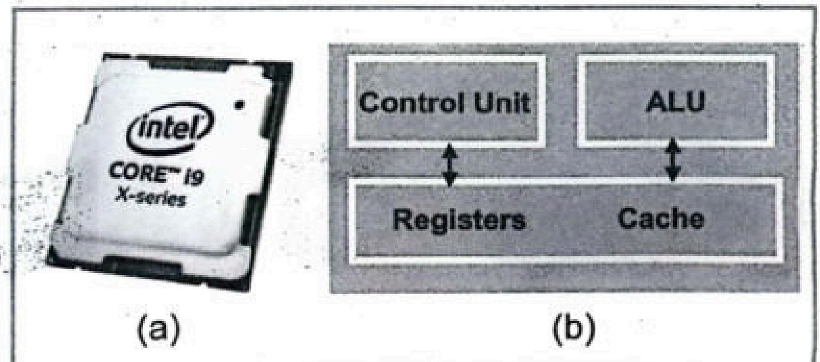


Fig.1.11 (a) Microprocessor (b) Microprocessor components

1.3.3 Storage Devices

Storage devices hold data and programs, either for long-term retention or temporary access. These devices range from internal fixed drives to portable external devices, as shown in Fig.1.12.

Examples of Storage Devices:

- **Hard Disk:** A magnetic storage device with a capacity ranging from hundreds of gigabytes to several terabytes. It serves as the primary storage medium for operating systems, applications, and data.
- **SSD(Solid State Drive):** SSD (Solid State Drive) is a modern data storage device that uses ICs to store information, unlike traditional Hard Disks that rely on spinning disks and mechanical components. SSDs are known for their speed, durability, and energy efficiency.
- **CD (Compact Disk):** An optical storage medium with a capacity of 700 MB, used for data sharing and archiving.
- **DVD (Digital Versatile Disk):** Similar to CDs but with a larger storage capacity of up to 16 GB, suitable for multimedia content.
- **Memory Card:** Small, portable storage devices used in mobile phones, cameras, and laptops, with capacities ranging from a few GB to several hundred GB.
- **USB Flash Drive:** A compact and portable storage device connected via USB ports, offering storage capacities up to 1 TB(Tera byte) and high-speed data transfer.

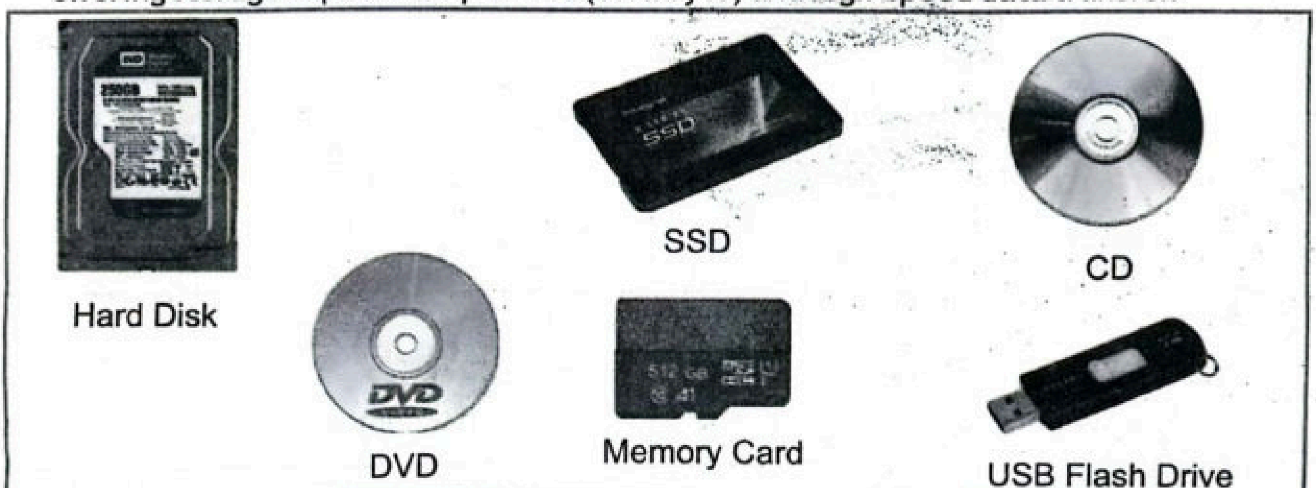


Fig. 1.12 Storage Devices

1.3.4 Output Devices

Output devices are used to provide the results of processed data in various formats, including visual, printed, and audio. Output devices are shown in Fig.1.13.

Common Output Devices:

- **Monitor:** Displays information visually on a screen. Modern LCD/LED monitors are slim, energy-efficient, and provide high-quality images compared to older models.

- **Printer:** Produces hard copies of documents and images.

  Impact Printers: Use mechanical action to transfer ink onto paper (e.g., dot matrix *printers*).

  Non-Impact Printers: Include inkjet and laser printers, offering faster and higher-quality outputs.

FOR YOUR INFORMATION:
The first high-speed printer was developed in 1953 by Remington Rand (an early American business machines manufacturer) for use on UNIVAC computer.

- **Plotter:** Used for printing large-scale graphics, such as engineering designs, maps, and banners, on large sheets.
- **Speakers:** Convert digital audio signals into sound, enhancing multimedia experiences like music playback, video editing, and gaming.

Fig. 1.13 Output Devices

1.3.5 Ports, Expansion Slots and Expansion Cards

These components enable the connection and enhancement of the computer's capabilities.

Ports: Interfaces for connecting peripheral devices such as USB drives, external hard disks, printers, and HDMI cables. Common ports include USB, HDMI, Ethernet, and audio jacks, as shown in Fig.1.14.

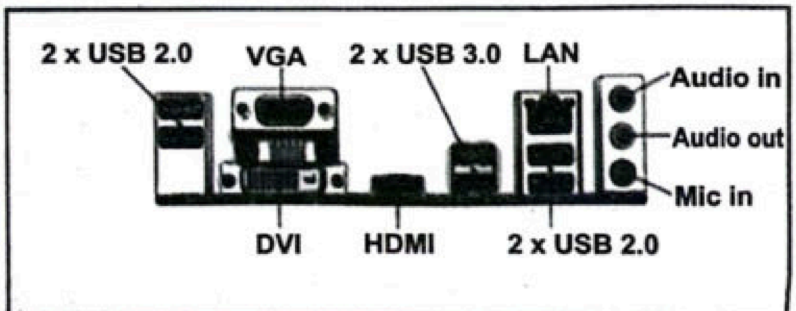


Fig.1.14 Ports on motherboard

Expansion Slots: These are sockets on the motherboard where additional hardware can be installed to expand system functionality. Some common expansion slots are shown in Fig.1.15.

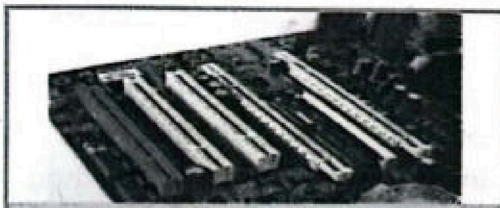


Fig. 1.15 Expansion Slots

Expansion Cards: These are circuit boards inserted into expansion slots, such as sound cards, graphics cards, and network cards. While many are integrated into modern motherboards, add-on cards are still used for specialized tasks. Fig.1.16. shows a network card.

Fig. 1.16 Expansion Cards

1.4 Von Neumann Architecture

Von Neumann Architecture is an essential concept in computer science that explains how a computer's hardware and software work together to process information. It was first published by John Von Neumann in 1945. His architecture is based on the stored-program computer concept, where instructions and program data are stored in the same memory. This design is still used in most computers produced today.

Modern Von Neumann architecture design consists of a CPU(Central Processing Unit) that contain a Control Unit, Arithmetic and Logic Unit (ALU), Memory Unit and Registers. Its also contain busses and Input/Output controllers, as shown in Fig. 1.17.

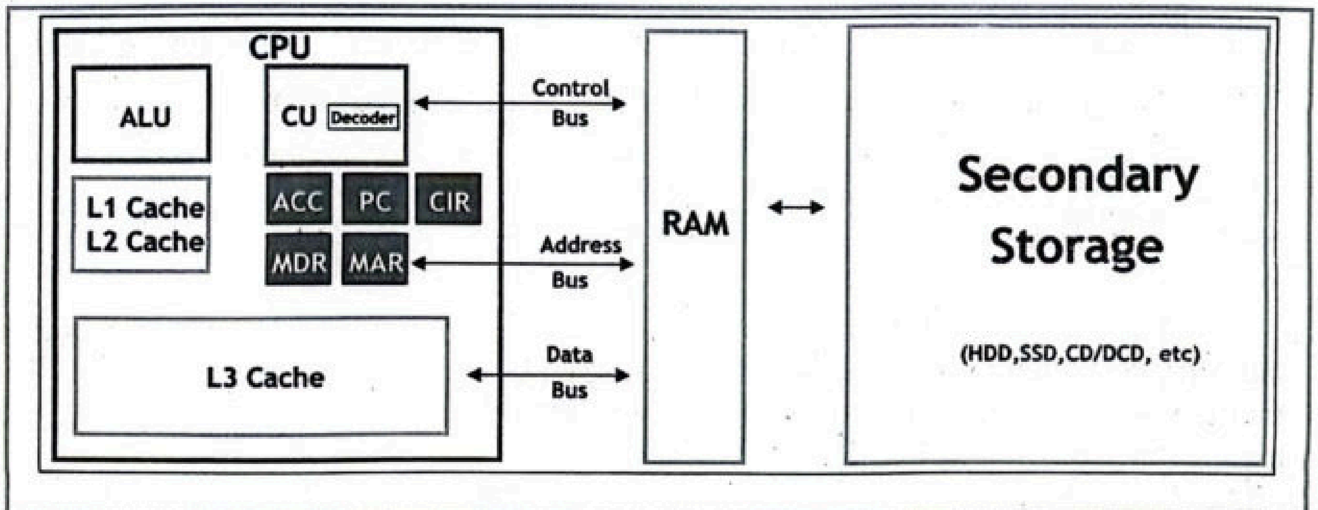


Fig.1.17 Von Neumann architecture

Central Processing Unit (CPU)

The Central Processing Unit (CPU) is the main electronic circuit responsible for executing the instructions of a computer program. The CPU contains the CU, ALU, Cache memory and registers.

- Control Unit (CU)

The control unit controls the operation of the computer's ALU, memory and input/output devices, telling them how to respond to the program instructions interpreted from the memory unit. The control unit also decodes the instructions i.e. converts them to meaningful form for the CPU and provides the timing and control signals required by other computer components. A control unit is shown in 1.18.

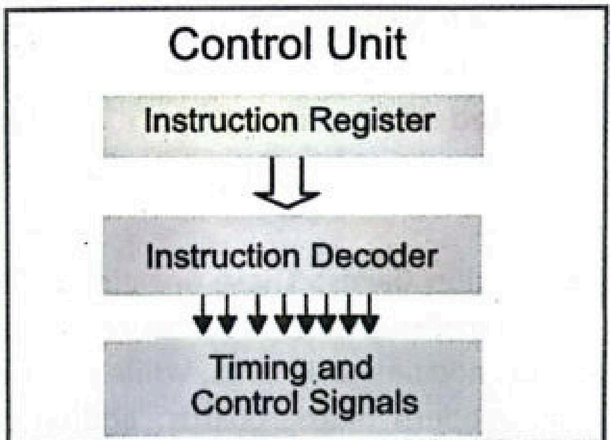


Fig.1.18 Control Unit

- Arithmetic and Logic Unit (ALU)

The ALU allows arithmetical (add, subtract etc.) and logical (AND, OR, NOT etc.) operations to be carried out.

- Registers

Registers are high speed storage areas in the CPU. All data must be stored in a register before it can be processed. Some common register are:

MAR	Memory Address Register	Holds the memory location of data that needs to be accessed
MDR	Memory Data Register	Holds data that is being transferred to or from memory
AC	Accumulator	Where intermediate arithmetic and logic results are stored
PC	Program Counter	Contains the memory address of the next instruction to be executed
CIR	Current Instruction Register	Contains the current instruction during processing

Memory Unit

In Von Neumann architecture the memory unit consists of RAM (Random Access Memory) and Cache memory, sometimes referred to as primary or main memory. This memory is fast and also directly accessible by the CPU. Memory unit is shown in Fig.1.19.

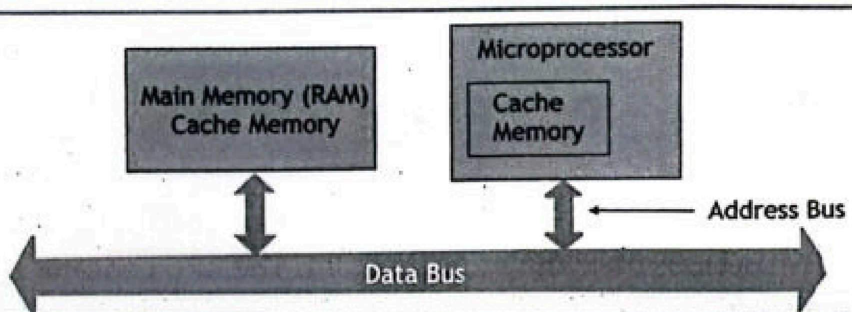


Fig.1.19 Cache Memory

Buses

Buses are the pathways or lines by which data is transmitted from one part of a computer to another, connecting all major internal components to the CPU and memory.

A standard CPU system bus is comprised of a control bus, data bus and address bus.

Address Bus	**Carries the addresses of data (but not the data) between the processor and memory**
Data Bus	Carries data between the processor, the memory unit and the input/output devices
Control Bus	Carries control signals or commands from the CPU in order to control and coordinate all the activities within the computer

Input/Output (I/O) Controller

This component manages the flow of data between the CPU and external devices like hard drives, USB devices, and network interfaces.

1.5 Data Transmission within a computer system

Data transmission in a computer system refers to how data moves between components like the CPU, memory, storage, and input/output devices. This process ensures the system works efficiently to complete tasks. Here is how it works:

Bus System:

The computer uses a bus system to transfer data. A **data bus** carries the actual data, an **address bus** specifies where the data should go, and a **control bus** manages signals for actions like read and write. System buses are shown in Fig.1.20.

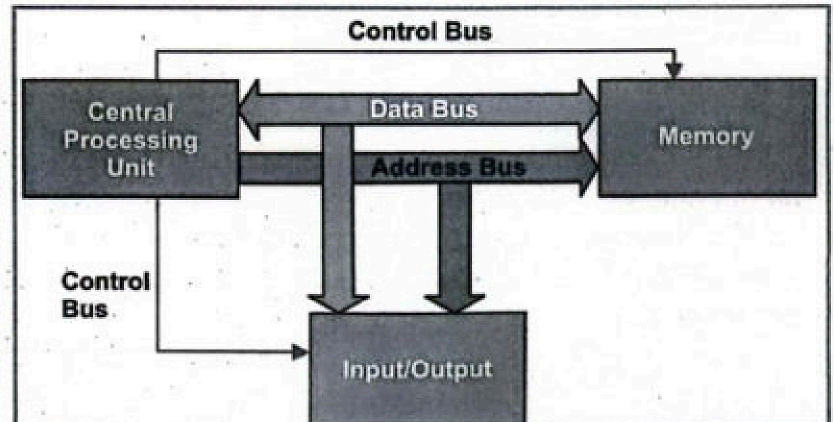


Fig.1.20 System Buses

Registers:

These are small, fast storage units inside the CPU that hold frequently used data. They exchange data with main memory via buses for quick processing.

Teacher's Guide

- Organize interactive demonstrations and hands-on activities to help students understand the functionality of computer components.
- Develop assessments that evaluate students' comprehension of core concepts, including quizzes, projects, and presentations.
- Provide opportunities for practical tasks and demonstrations to assess students' ability to apply their knowledge.

Memory Levels: Computers store data in a hierarchy:

- **Cache** is the fastest but smallest memory.
- **RAM** is larger but slower.
- **Storage devices** (like SSDs and HDDs) are the largest and slowest.

Instruction Cycle: Programs follow the **fetch-decode-execute** process:

- Fetch the instruction from memory.
- Decode to understand it.
- Execute the operation.

Pipelining:

The CPU processes multiple instructions simultaneously by breaking them into stages, improving speed and efficiency.

Data Paths:

Inside the CPU, pathways connect components like the Arithmetic Logic Unit (ALU) and Control Unit to execute instructions effectively.

Interrupts and I/O:

Devices like the keyboard or display send interrupts to pause the CPU's current task and handle important events.

1.6 Computer Memory

In computing, memory refers to the physical devices used to store programs (sequence of instructions) or data on a temporary or permanent basis for use in a computer or other digital/computing devices. Memory in a digital computer contains the main part of operating system and all the application programs and related data that is being used.

1.6.1 Memory Terminology

The following are some important memory terms.

Bit: The smallest unit of memory, representing a binary digit (0 or 1). Each memory cell stores one bit, with two states: ON (1) and OFF (0).

Byte: A group of 8 bits forms one byte, which is the smallest unit of data a computer can process. One byte stores one character (like 'A' or "*"). Memory is typically measured in bytes, with higher units being shown in Table 1.1.

MEMORY UNIT	EQUIVALENT TO	
1 Byte	8 Bits	
1 Kilobyte (KB)	2^{10} Bytes	= 1024 Bytes
1 Megabyte (MB)	2^{20} Bytes	= 1024 KB
1 Gigabyte (GB)	2^{30} Bytes	= 1024 MB
1 Terabyte (TB)	2^{40} Bytes	= 1024 GB
1 Petabyte (PB)	2^{50} Bytes	= 1024 TB
1 Exabyte	2^{60} Bytes	= 1024 PB

Table 1.1 Memory Units

Memory Word: The smallest unit of data a computer can process in a single operation. The size of a memory word (called word size) can range from 16 to 64 bits, depending on the computer's architecture.

Word Size: Word size refers to the number of bits a CPU can process in one instruction. For example, a 32-bit CPU processes data in 32-bit chunks, while a 64-bit CPU can handle 64-bit chunks. A larger word size improves the computer's ability to handle more complex operations and larger memory spaces.

1.6.2 Memory Built-up and Retention power

All types of computer memories, as for as their built-up (construction) or manufacturing is concerned, are divided into Chip memory, Magnetic memory and Optical memory. And as far as their retention power is concerned these memories are divided into Volatile memory and Non-Volatile memory.

Types based on Memory Built-Up

Computer memory can be categorized based on its construction and how it retains data. These classifications help define where and how data is stored, as well as how quickly it can be accessed.

- **Chip Memory**

Chip memory is built using semiconductor technology and is widely used in modern electronic devices due to its speed and compact size. Examples of chip memory include RAM (used for temporarily holding data during operations), ROM (used for storing system boot instructions), and Flash memory (found in USB drives and SSDs). Chip memory is widely used in smartphones, gaming consoles, and computers.

- **Magnetic Memory**

Magnetic memory stores data on magnetized materials and is used for large-scale and long-term data storage. Examples include Hard Disk Drives (HDDs), which are commonly used in desktops and servers.

- **Optical Memory**

Optical memory uses laser technology to read and write data stored as tiny pits on optical discs like CDs, DVDs, and Blu-ray Discs. This memory type is commonly used for distributing software, multimedia, and creating backups.

Types based on Retention power

- **Volatile Memory**

Volatile memory requires power to retain data and is primarily used for temporary storage. It retains the data/information as long as power supply is on, but when power supply is off or interrupted the stored data/information is lost. Examples of such memory are RAM (Random access memory), Cache memory and Registers.

- **Non-Volatile Memory**

Non-volatile memory retains data even when power is off, making it suitable for *permanent* storage. Examples include ROM(Read only memory), which stores essential boot-up instructions, Flash memory used in USB drives, and HDDs for storing programs, videos, and documents.

1.6.3 Types and Hierarchy of Computer Memory

Computer memory is organized in a hierarchy, balancing speed, size, and cost. Faster memory types (Main Memory) are smaller and located closer to the CPU, while slower types (Secondary Memory) are larger and used for storage. Fig.1.21 shows different types of computer memory.

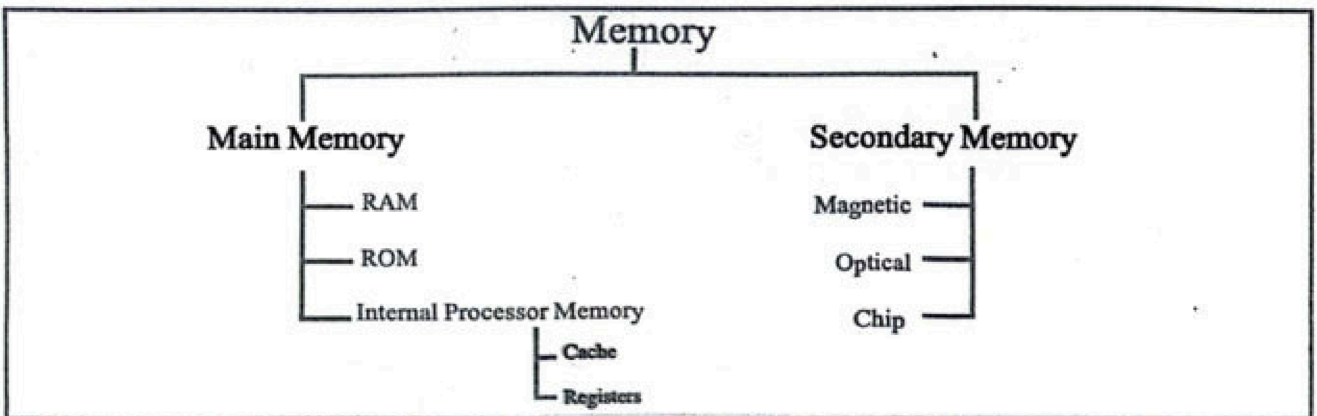


Fig. 1.21 Memory Classification

1.6.4. Main Memory

The **main memory** (also called **primary memory**) is an important part of a computer that temporarily stores data, instructions, and results for quick access by the processor. It includes **RAM (Random Access Memory), ROM (Read-Only Memory),** and **Internal Processor Memory** (Cache and Registers), each with a specific function.

RAM (Random Access Memory)

RAM is high speed memory installed on the motherboard. It is also called READ/WRITE memory. Information can be read from or written into it. The microprocessor executes programs by first loading them into the RAM from secondary storage devices like a hard disk or a USB flash drive. It is volatile memory which means information stored in it, is lost when the computer is turned off.

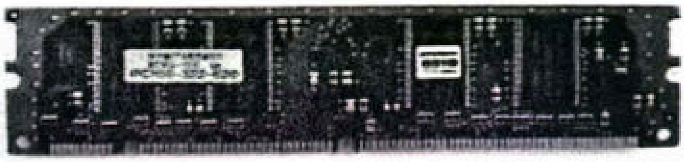


Fig.1.22 RAM modules

RAM modules are installed in the memory slots on the motherboard. RAM modules are shown in Fig.1.22.

ROM (Read Only Memory)

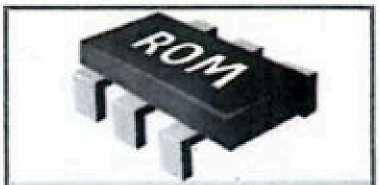


Fig.1.23 ROM chip

ROM is a single IC chip which is installed on the motherboard as shown in Fig.1.23. It stores the Basic Input/Output System (BIOS) of computer that controls input/output devices and the start-up or boot process. BIOS programs test the computer's components when it is turned on and then load the operating system into the RAM to make the computer ready for operation. It is non-volatile memory, that is, the programs stored in it are not lost when the computer is turned off.

Internal Processor Memory: Cache and Registers

Internal processor memory refers to the specialized storage within the CPU that enables fast access to data and instructions. The two main types of internal memory are cache and registers.

- **Cache Memory**

Cache is a small but extremely fast memory located inside or very close to the CPU. Its purpose is to store frequently accessed data and instructions, reducing the time needed to fetch them from the slower main memory (RAM). There are different types of cache memory as shown in Fig.1.24.

Types of Cache:

i. L1 Cache (Level 1): Located directly within the processor core, it is the smallest and fastest type of cache.

ii. L2 Cache (Level 2): Slightly larger and slower than L1, L2 cache is either built into the CPU or placed on the motherboard.

iii. L3 Cache (Level 3): Shared among multiple cores in multi-core processors, L3 cache is the largest and slowest among the three levels.

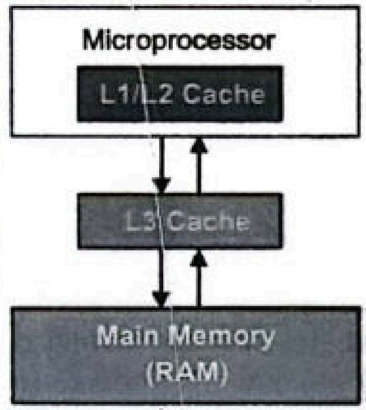


Fig.1.24 L1, L2 and L3 Cache Memories

- **Registers**

Registers are the smallest and fastest memory units in the processor. They temporarily store data, instructions, or addresses currently being used by the CPU. Registers are directly connected to the arithmetic and logic unit (ALU) and play important role in performing computations. Common registers are already discussed in topic 1.4.

1.6.5. Secondary Memory

Secondary memory refers to long-term data storage in a computer, used to permanently store programs, files, and other data. Secondary memory retains information even when the computer is turned off. The following are the main categories of secondary memory.

Chip-Based Secondary Memory

Chip-based secondary memory refers to storage solutions built on semiconductor chips, designed to retain data even when power is turned off. Unlike primary memory (RAM), which is temporary, these chips offer long-term storage and are widely used in modern computing. Common examples of chip-based secondary memory are SSDs, USB drives and Memory cards. Chips based secondary memory is shown in Fig.1.25.

Fig.1.25 Chips based secondary memory

Magnetic Memory

Magnetic memory/storage is a widely used data storage method that employs magnetized materials to store binary data. Examples include magnetic tapes and hard disks, where a thin magnetic layer on the surface holds binary information. Magnetized spots represent binary 1s, while non-magnetized spots represent binary 0s. A read-write head detects and alters the magnetization to access or modify data. Magnetic storage is cost-effective and offers large storage capacities, making it suitable for storing vast amounts of data. However, its main drawback is slower data access speeds. Hard disks are a common example of magnetic memory, as shown in Fig. 1.26.

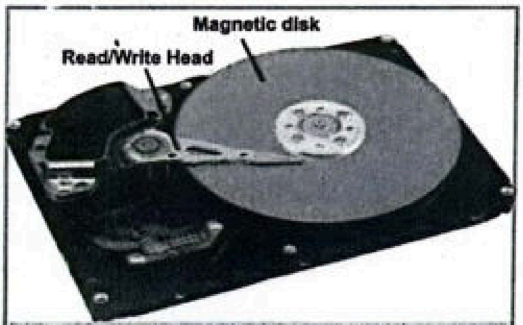


Fig.1.26 Magnetic disk with read/write

Optical Memory

In optical-storage technology, a laser beam encodes digital data onto an optical disk in the form of tiny pits and lands arranged in concentric tracks on the disk's surface as shown in Fig.1.27. A low-power laser scanner is used to "read" data or information from these pits and lands, and converts it to digital form.

Optical storage provides cheaper and greater memory capacity than magnetic storage. An entire set of encyclopedias, for example, can be stored on a standard 12-centimetre (4.72-inch) optical disk. Optical disks include CDs, DVDs and Blu-ray disks(BDs).

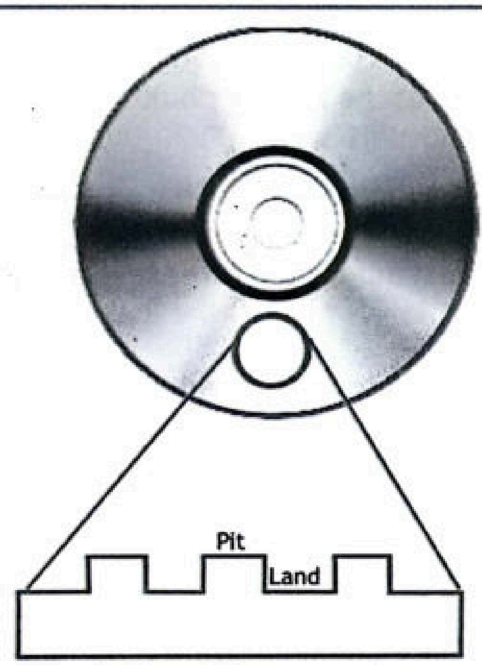


Fig.1.27 Optical Memory technology

1.7 Software Engineering and Hardware Engineering

Software Engineering: Software engineering is a systematic approach to the development, operation, and maintenance of software. It involves applying engineering principles to software development, encompassing techniques, methodologies, tools, and processes to ensure the quality, reliability, and efficiency of software systems.

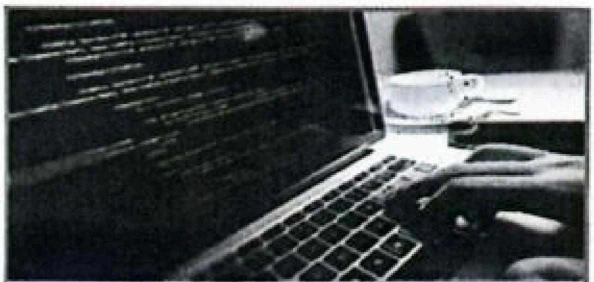


Fig.1.28 Software development

Some common types of Software Engineering:

- **Application Software Engineering:** This focuses on developing software applications that fulfill specific user requirements, such as web applications, mobile apps, desktop software, etc.
- **System Software Engineering:** This involves designing and developing software that provides a platform for other software to run on, such as operating systems, compilers, device drivers, etc.
- **Embedded Software Engineering:** This refers to the specialized field of software engineering that focuses on designing, developing, testing, and maintaining software that is embedded within hardware devices or systems. For examples Automotive Embedded Systems, Digital home appliances, Industrial Control Systems, etc.
- **Enterprise Software Engineering:** This involves developing software solutions for large-scale enterprises to automate processes, manage data, and facilitate communication within the organization.
- **Game Development:** This area involves creating video games, including game engines, graphics, audio, and gameplay programming.


Fig.1.29 Hardware construction

Hardware Engineering: Hardware engineering involves designing, developing, and testing physical components of computer systems and electronic devices. It focuses on the design and construction of hardware components such as processors, memory devices, circuit boards, sensors, etc.

Some common types of Hardware Engineering:

- **Digital Hardware Engineering:** It deals with designing and developing digital circuits and components such as processors, memory units, etc.

- **Analog Hardware Engineering:** It deals with designing analog circuits, including amplifiers, sensors, etc.
- **Integrated Circuit (IC) Design:** It focuses on designing and fabricating integrated circuits, including CPUs (Central Processing Units), GPUs (Graphics Processing Units), etc.
- **Computer Architecture:** It deals with designing the structure and organization of computer systems, including CPU architecture, memory hierarchy, input/output systems, etc.
- **Embedded Systems Design:** It focuses on designing hardware systems that are integrated into larger systems or devices, such as microcontrollers, sensors, consumer electronics, etc.

1.8 Computer Software

Computer software, often referred to simply as "software," is a collection of programs, data, and instructions that tell a computer how to perform specific tasks or functions. It is an important component of any computer system, enabling it to process data, run applications, and interact with users. Software is typically categorized into two main types: system software and application software.

Computer software can be classified into the following types.

- System Software
- Application Software

1.8.1 System Software

System software refers to a type of computer program that manages and controls the hardware components of a computer system, as well as provides a platform for running application software. It plays a crucial role in enabling the interaction between the user, application software, and the underlying hardware.

System software serves as an intermediary between the user and the hardware, making it easier for users to interact with and utilize computer systems effectively.

The following are some common types of system software.

Operating System (OS):

The operating system is a fundamental piece of system software that manages hardware resources and provides services for computer programs. It controls tasks such as process scheduling, memory management, file system management, and hardware device communication. Common examples of operating systems include Microsoft Windows, macOS, Linux, and Android. Some common functions of OS include:

- The OS facilitates user interaction by providing a user-friendly interface.
- It manages input/output operations.
- It looks after the allocation of tasks to the processor.

- It handles the allocation and deallocation of memory to programs.
- It helps in organizing files and directories, as well as provides mechanisms for storage and retrieval.
- It manages peripheral devices, such as printers and storage devices, and provides necessary device drivers.
- It provides security and access control through user authentications like User Identifications, passwords and PINs etc.

Device Drivers:

Device drivers are software components that facilitate communication between the operating system and hardware devices like printers, graphics cards, and network adapters. They ensure that the OS can interact with these devices correctly.

Utilities:

System utilities are tools that help manage and maintain the computer system. They can perform tasks such as disk cleanup, data backup, system monitoring, and virus scanning. Examples include disk defragmenters, antivirus software, and system diagnostic tools.

Compiler and Assembler:

These tools are essential for converting high-level programming languages (like C++, Java, or Python) into machine code that the computer's processor can understand. Compilers translate source code into executable programs, while assemblers do a similar job for assembly language code.

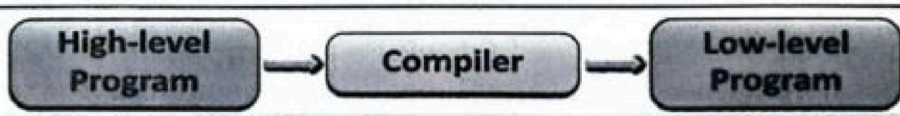


Fig. 1.30 Compilation process

Linkers and Loaders:

Linkers and loaders are programs that help with the execution of programs. Linkers combine multiple object files (compiled code) into a single executable file, while loaders load these files into memory for execution.

Firmware:

Firmware is a software that is permanently stored on hardware devices. Examples include the BIOS (Basic Input/Output System) in a computer's motherboard or the firmware in digital appliances like washing machine and microwave oven, etc.

1.8.2 Application Software

Application software, often referred to as "apps" or "software applications," is a category of computer programs designed to perform specific tasks or functions for computer users. Some examples of application software are:

- Productivity Software
- Business Software
- Entertainment Software
- Educational Software

Productivity Software

Productivity software is designed to help users perform tasks efficiently, organize information, and create contents like documents, presentations, spreadsheets and databases. It includes software that facilitate office work, document management, and collaboration.

Examples:

- Microsoft Office Suite: Includes applications like Microsoft Word (word processing), Excel (spreadsheets), and PowerPoint (presentation).
- Google Workspace: Offers tools like Google Docs, Sheets, and Slides for online collaboration and document creation.
- LibreOffice: An open-source office suite with applications similar to Microsoft Office.

Business Software

Business software are specifically designed to meet the needs of businesses and organizations. These software aim to streamline and enhance various aspects of business operations, ultimately improving efficiency, productivity, and decision-making.

Examples:

- QuickBooks: Accounting software for managing financial transactions.
- Salesforce: Customer Relationship Management (CRM) software for sales and marketing.
- Trello: Project management tool that helps teams organize tasks and collaborate.

Entertainment Software

Entertainment software is designed for leisure and enjoyment. It includes a wide range of applications, from video games to multimedia players and streaming services.

Examples:

- Minecraft: A popular game that allows players to build and explore virtual worlds.
- Spotify: A music application that offers a vast library of songs and playlists.
- Netflix: An online streaming service for movies, TV shows, and documentaries.

Educational Software

Educational software is created to support learning and skill development. It includes a variety of applications and tools that support educational activities, ranging from interactive learning games to digital resources for teaching and assessment.

Examples:

- Learning Management Systems (LMS): LMS platforms provide a centralized place for educational content, resources, assessments, and communication between educators and students. Some examples are ULearn, Virtual Academy, FBISE LMS, etc.
- Kahoot!: An online learning platform that allows educators to create interactive quizzes and games for students.
- Duolingo: Language learning app that gamifies the process of learning new languages.
- Scratch: A visual programming language for teaching coding concepts to children.

Skills Development

To meet curriculum standards, students will be required to engage in hands-on activities, practical exercises, and real-world projects to develop proficiency in using digital tools such as Word Processors, Spreadsheets, Presentation software, and graphics software for effective communication. Emphasis will be placed on fostering critical thinking, creativity, and problem-solving skills, empowering students to confidently express themselves across various mediums in the digital realm.

Introduction to Common tools:

1. **Image Processing Tools:**
   - Adobe Photoshop: A professional-grade software used for editing and manipulating images. It offers a wide range of features including photo retouching, graphic design, and digital painting.
   - Canva.com: A user-friendly online graphic design platform suitable for creating various visual content such as social media graphics, presentations, posters, and more. It provides pre-designed templates and easy-to-use editing tools.
   - GIMP (GNU Image Manipulation Program): An open-source alternative to Photoshop, offering many of the same features for image editing and manipulation. It's free to use and has a strong community of users and developers contributing to its development.
2. **Word Processors:**
   - Microsoft Word: A widely-used word processing software offering features for creating, editing, and formatting text documents. It includes tools for spell-checking, grammar checking, and collaboration.
   - Google Docs: An online word processor that allows real-time collaboration on documents. It offers similar features to Microsoft Word but is accessible through a web browser and allows multiple users to work on the same document simultaneously.
3. **Presentations:**
   - Microsoft PowerPoint: A presentation software used to create slideshows for professional or educational purposes. It provides tools for designing slides, adding multimedia elements, and delivering presentations effectively.
   - Google Slides: A web-based presentation program offered by Google as part of its office suite. It allows users to create, edit, and collaborate on presentations online. Similar to Google Docs, it enables real-time collaboration and sharing.
4. **Spreadsheets:**
   - Microsoft Excel: A powerful spreadsheet program used for organizing, analyzing, and visualizing data. It offers a wide range of functions, formulas, and charting tools to manipulate and present data effectively.
   - Google Sheets: An online spreadsheet application that allows users to create, edit, and collaborate on spreadsheets in real-time. It offers similar functionalities to Microsoft Excel but is accessible through a web browser and allows for easy sharing and collaboration.

Instructions for Schools/Instructors on utilizing various Tools for Student Learning:

By following these instructions, Schools and IT instructors can effectively introduce students to a variety of tools, provide hands-on practice opportunities, assign meaningful tasks and projects, and facilitate a conducive learning environment for skill development and academic success.

1. **Introduction to Tools:** Begin by introducing each tool to students, providing an overview of its purpose, features, and relevance to their learning objectives.
2. **Access and Installation:**
   - For software tools like Photoshop and Microsoft Office suite, ensure that they are installed on school computers or provide instructions for students to install them on their personal devices.
   - For online tools like Canva.com, Google Docs, Google Slides, and Google Sheets, ensure students have access to the Internet and guide them through the process of accessing these tools through web browsers.
3. **Hands-on Practice Sessions:**
   - Schedule dedicated hands-on practice sessions where students can familiarize themselves with each tool.
   - Provide step-by-step tutorials or demonstrations on how to navigate through the interface, use basic features, and execute common tasks.
   - Encourage students to explore the tools independently, experimenting with different functions and tools to enhance their proficiency.
4. **Assign Practical Tasks and Projects:**
   - Assign practical tasks aligned with the curriculum to reinforce learning and allow students to apply their newfound skills.
   - For example, in image processing tools like Photoshop or Canva.com, assign tasks such as designing posters, editing photographs, or creating digital artwork.
   - In word processors like Microsoft Word or Google Docs, assign writing assignments, essay projects, or collaborative document creation tasks.
   - Utilize presentation tools like Microsoft PowerPoint or Google Slides for student presentations, class reports, or multimedia projects.
   - Incorporate spreadsheets such as Microsoft Excel or Google Sheets for data analysis exercises, budget planning tasks, or scientific experiments.
5. **Provide Guidance and Support:**
   - Offer guidance and support to students as they work on their tasks and projects, addressing any questions or challenges they may encounter.
   - Encourage peer collaboration and discussion to foster a collaborative learning environment where students can learn from each other's experiences and expertise.

1.8.3 Programming Languages

Programming languages are tools used to instruct a computer to perform specific tasks. These languages are classified into **low-level languages** and **high-level languages.**

Low Level Languages

These are machine-oriented and are closed to the computer's architecture.

There are two types of low level languages as:

Machine Language:

- Consists of binary code (0s and 1s).
- Directly understood by the computer's hardware.
- Highly dependent on the computer's architecture and rarely used due to complexity.

Assembly Language:

- Uses symbolic codes (mnemonics) like MOV and ADD for easier programming.
- Requires an assembler to convert it into machine language.
- Benefits include access to computer-specific features, reduced storage, and faster execution.

High Level Languages (HLLs)

High-level languages are user-friendly programming languages that resemble English, making them easier to learn and use. They include commands like print, goto, if, and end. Examples of high-level languages include **Visual Basic**, **C**, **Java**, and **Pascal**.

High-level programs need to be converted into machine language for execution. This is done using a **compiler** or **interpreter.** Writing and debugging high-level language programs is simpler compared to low-level languages. High-level languages can be classified into three main categories based on how they structure and handle programming:

Procedural Languages:

These languages focus on a sequence of instructions or procedures to perform a task. The program is broken down into modules or functions that are executed step by step. Popular examples include **C** and **Pascal.**

Structured Languages:

These languages are based on clear, logical structures that help organize the code for readability and manageability. The program consists of sequences of instructions, conditional statements (selection), and loops (repetition). **FORTRAN** and **ALGOL** are classic examples.

Object-Oriented Languages:

These languages organize code around "objects" that represent real-world entities. Each object has properties (attributes) and methods (behaviors). This makes complex programs easier to manage, as it models the real world. Examples include Java, C++, and **Python.**

Uses of Low Level Languages

Important uses of low-level programming languages include:

Use	Explanation
Operating System Development	Writing the core software that manages hardware resources.
Device Drivers	Creating software to enable communication with hardware devices.
Embedded Systems	Programming microcontrollers and IoT devices for specialized functions.
Firmware Development	Developing software that resides on hardware components.
Real-Time Systems	Ensuring precise timing and responsiveness in industrial control, robotics, and aerospace systems.
Security Tools	Building intrusion detection, firewalls, and encryption software for robust security.
Game Development	Optimizing game engines, physics simulations, and graphics rendering for performance

Uses of High Level Languages

Important uses of high-level programming languages include:

Use	Explanation
Applications (Apps) Development	Creating desktop, mobile, and web applications (Apps) for various latforms.
Web Development	High-level languages are used to build websites, making them interactive and functional.
Data Analysis and Science	Analyzing large datasets and conducting scientific research.
Machine Learning and AI	Developing machine learning models and AI algorithms.
Automation and Scripting	Automating tasks and processes, including system administration and data manipulation.
Game Development	Developing gameplay logic, AI, and user interfaces for games.
Database Management	Creating, querying, and managing databases.
Scientific and Engineering lations	Simulating complex systems and conducting simulations.
Business Software	Developing enterprise-level software for various industries.

Teacher's Guide

- Utilize examples and demonstrations to illustrate how system software interacts with hardware.
- Encourage students to explore examples of application software to deepen their understanding.
- Provide hands-on coding exercises or interactive demonstrations to familiarize students with basic programming concepts and syntax.

1.9 Data Communication

Data communication refers to the process of exchanging data or information (through a computer network) between two or more devices or systems through a transmission medium such as cables, optical fibers, or wireless mediums. This communication can involve the transfer of various types of data, including text, numbers, images, audio, and video, and it is a fundamental component of modern information technology and telecommunications.

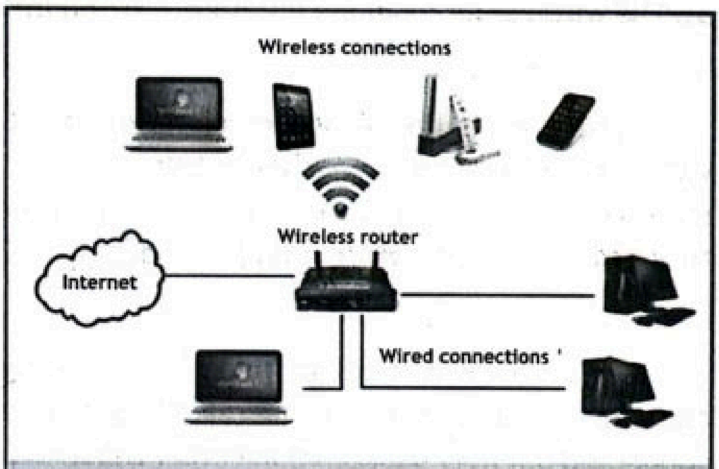


Fig.1.31 A Communication Network

A simple communication network having wired and wireless connections is shown in Fig.1.31.

1.9.1 Network Communication Components

Data communication is the process of transferring information from one point to another in a networking environment. Network communication consists of five basic components, as shown is Fig.1.32.

- Sender
- Message
- Medium
- Protocol
- Receiver

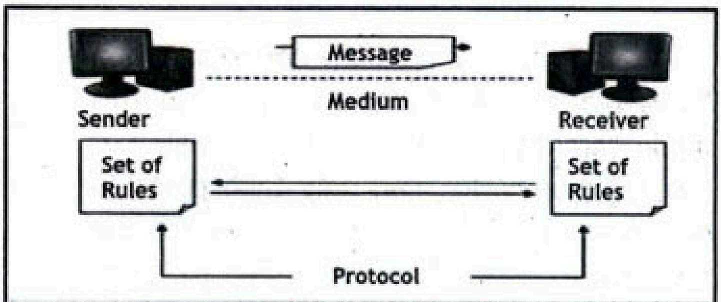


Fig.1.32 Components of Network Communication

Sender

Sender, also called transmitter is a computer/device that sends the message (data or information) from source to destination in a communication network. It may be a computer, workstation, cell phone or camera. The sender device converts the electrical signal into a form that is suitable for transmission over the communication network.

Message

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

Medium

Medium is the path through which message travels from source to destination.

Medium can be wired, for example telephone cable, coaxial cable and fibre optics. It can also be wireless for example Bluetooth, Wi-Fi, microwave, radio wave and satellite.

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.

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 are connected but may not communicating with each other.

1.9.2 Modes of Network Communication

Modes of network communication refer to the methods or the ways information is transmitted from one place to another.

The following are different modes of data communication

- Simplex, Half-duplex and Full-duplex
- Synchronous and Asynchronous

Simplex mode

In Simplex mode, the communication takes place in only one direction. In this mode communication is unidirectional, i.e. the communication can only take place in one direction and it is not possible for the receiver to send data back. For example data being sent to an electronic notice board found in train stations and Airports. Radio and television broadcastings are also examples of simplex transmission. Transmission of information from a computer to a printer is also in one direction, as shown in Fig.1.33.

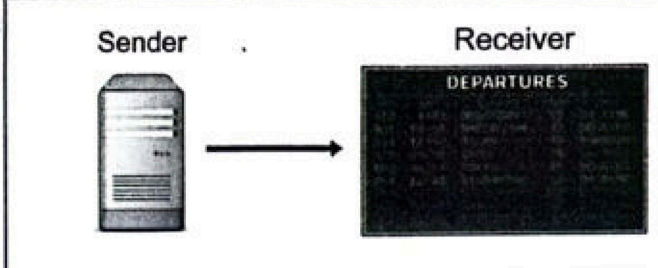


Fig.1.33 Simplex mode of data Communication

Half-duplex mode

In half-duplex mode, the communication takes place in both the directions but not at the same time. The signal can only be sent or received at one time. A common example of this type of communication is the use of walkie-talkies, where each of the persons communicating

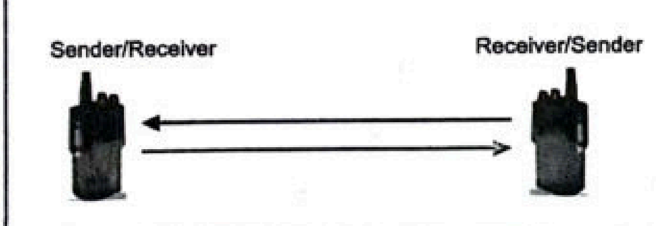


Fig.1.34 Half-duplex mode of data communication

must indicate when they have finished speaking. Half-duplex transmission is used also in transaction-oriented systems, for example communication between a computer and credit card machine as shown in the Fig.1.34.

Full-duplex mode

In full-duplex mode, the communication takes place in both the directions at the same time. In this mode, both sender and receiver 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 street, with traffic flowing in both directions at the same time.

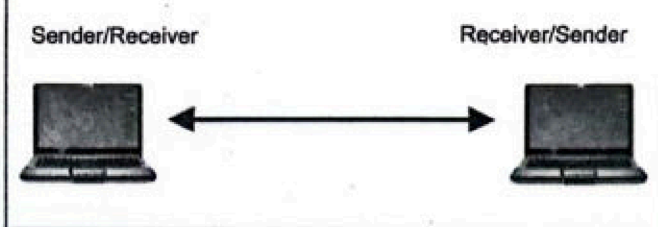


Fig.1.35 Full-duplex mode of data communication

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. Also full-duplex mode is the most suitable for data communication between computers as shown on Fig. 1.35.

Asynchronous Transmission

In asynchronous transmission, the time interval between two characters is variable and not fixed as shown in Fig.1.36. The computer devices can exchange information at their own rate, slow or fast. **Start** and **Stop** bits are used in asynchronous transmission. These bits provide timing (synchronization) for the connection between the sender and the receiver. The start bit tells the receiver that a character is coming and stop bit indicates that the transmission of character has ended. This type of transmission is ideal for slow-speed communication when gaps may occur during transmission.

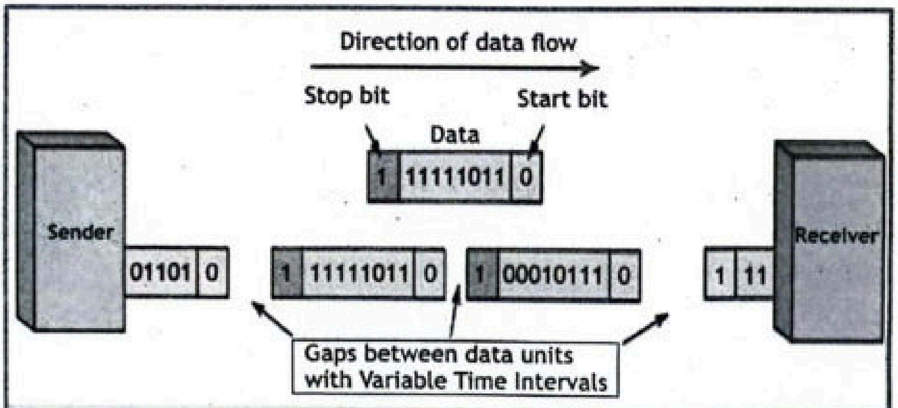


Fig.1.36 Asynchronous transmission

Synchronous Transmission

In contrast, synchronous transmission uses a consistent time interval between characters. Here, the sender and receiver devices are synchronized to send data *continuously*, even when no data is being transmitted (by sending an idle character). No start or stop bits are needed, and the data is transmitted as one continuous bit stream or block. The receiver then counts the bits and reconstructs the data. This method is faster than asynchronous transmission because fewer control bits (like start and stop bits) are needed. A common example of synchronous transmission is the data exchange between devices in network communications.

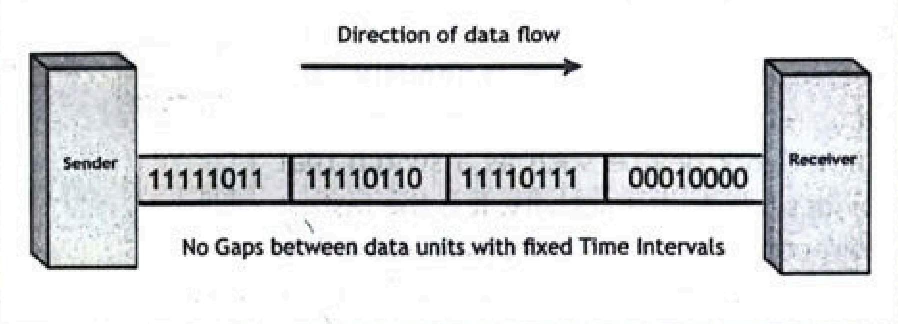


Fig.1.37 Synchronous transmission

1.9.3 Communication Devices

Communication devices are used to transmit data between locations in telecommunication systems. Common devices include **Hub, Switch, Router,** and **Gateway.**

Hub

A hub is a basic device that connects multiple devices in a Local Area Network (LAN). It broadcasts data to all connected devices, meaning every device sees the same data. Hubs are simple but inefficient since they send data to every device, regardless of the intended recipient.

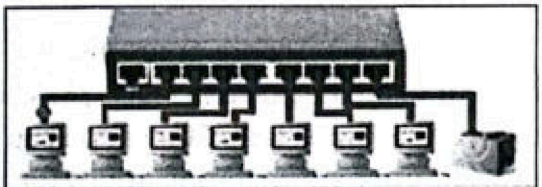


Fig.1.38 Hub

Switch

A switch is a more intelligent device compared to a hub. It inspects incoming data packets, determines which device the data is for, and sends it only to the correct device. This reduces network traffic and increases efficiency.

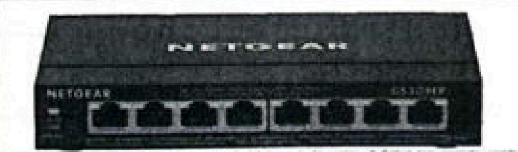


Fig.1.39 Switch

Router

A router connects multiple networks, often linking a local network to the internet. It determines the best path for data packets to travel from one network to another and forwards them accordingly. Routers help direct internet traffic and are essential for network communication. A wireless router is shown in Fig.1.40.

Fig.1.40 Wireless Router

Gateway

A gateway connects different types of networks that use different protocols. It acts as a translator, converting data formats from one network to another to ensure compatibility. For instance, it may connect a network of PCs with an IBM mainframe network.

Fig.1.41 Gateway Device

Comparison of Communication Devices

Device	Function	Example
Hub	Broadcasts data to all devices in a network.	Basic home or office network setup.
Switch	Directs data only to the intended device.	Efficient local network communication.
Router	Connects different networks and directs data.	Connecting a home network to the internet.
Gateway	Connects networks using different protocols.	Linking networks like PCs and mainframe systems.

1.9.4 Network Architecture

Network architecture refers to the design and structure of a communication system, including the hardware, cabling, network topology, and both physical and wireless connections. It also defines how computers interact within a network, including roles like server and client.

Server Computer: This is a computer that provides resources, such as information, software, or hardware (e.g., printers), to other computers on the network. It shares resources for others to access.

Client Computer: A client is a computer that accesses resources provided by server computers within the network.

The two most commonly used network architectures are:

- Client/Server Network
- Peer-to-Peer Network

Client/Server Networks

In a **client/server network**, each computer functions either as a server or as a client. Servers are dedicated to sharing resources and are not used to access resources shared by other computers. The server is responsible for providing shared resources such as files, applications, and hardware. The

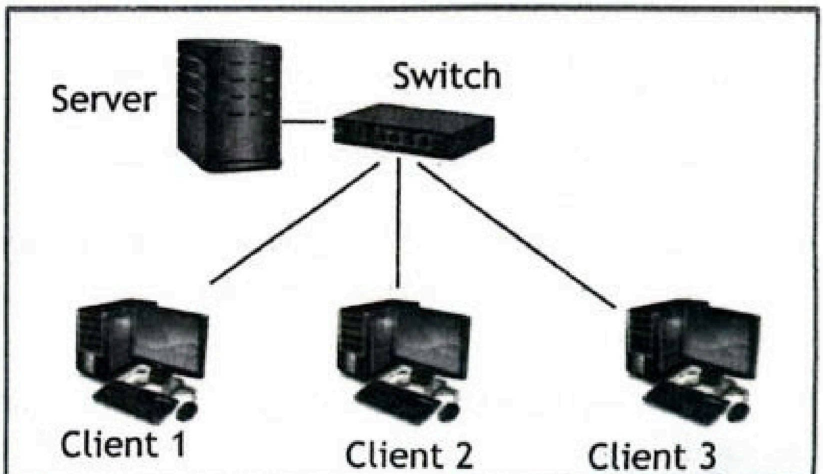


Fig.1.42 Client/Server Network

client computers request and use these resources. One key advantage is centralized control, which allows for easier management and enhanced security. **Dedicated servers** in this network setup optimize resource sharing and ensure that unauthorized users cannot access data.

Peer-to-Peer Networks

In a **peer-to-peer (P2P) network**, every computer can act as both a client and a server. Each computer, or peer, has the capability to both share and access resources. This type of network is typically smaller, usually with between two and ten computers, since managing large numbers of computers in P2P setups can become difficult. A peer can share files, printers, and other resources with other peers, while also using resources shared by others on the network.

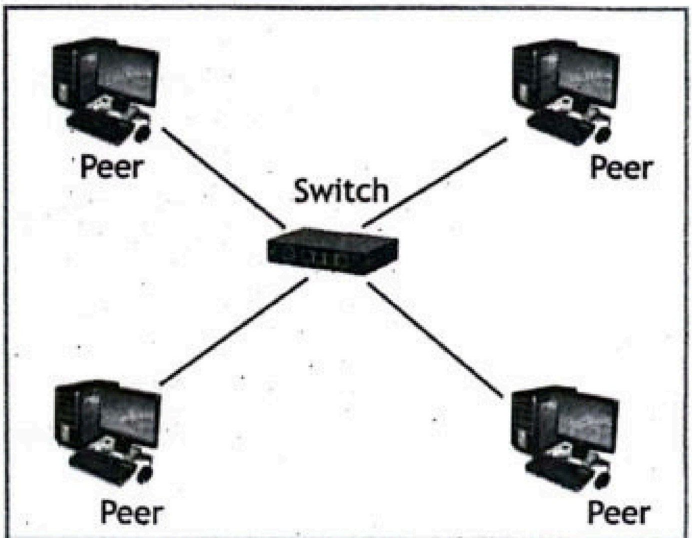


Fig.1.43 Peer-to-Peer Network

1.9.5 Types of Networks

The following are different types of networks based on the size and physical area they cover.

Local Area Networks

A **Local Area Network (LAN)** connects computers within a small area, like a building or a group of nearby buildings. It allows the sharing of resources such as printers and files. A LAN is shown in Fig.1.44.

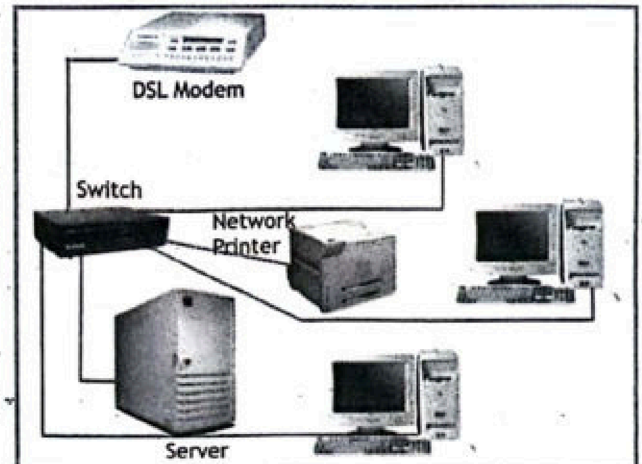


Fig.1.44 Local Area Network

Characteristics of LAN

- LANs typically cover a small physical area, like an office or home.
- It uses high-speed wired or wireless connections.
- Communication within a LAN is very reliable with few errors.
- It supports a limited number of computers.

Wide Area Networks

Wide Area Networks (WAN) connect multiple sites across large physical areas, such as cities, countries, or continents. WANs are often made by linking several Local Area Networks (LANs) together, as shown in Fig.1.45.

Characteristics of WAN

- Covers large distances, even globally (e.g., the Internet).
- Slower communication speed compared to LANs.
- Uses public networks, leased lines, or satellites for connections.
- Can connect multiple LANs, enabling global communication.
- More prone to errors due to the complexity of the system.

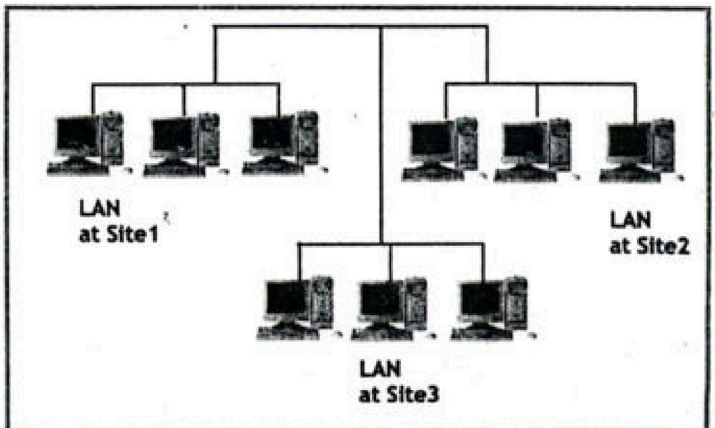


Fig.1.45 A Wide Area Network

Metropolitan Area Network

Metropolitan Area Network (MAN) can span from several buildings or a large campus to entire cities. MAN is used by many organizations. It also connects a number of local area networks with high-speed communication lines.

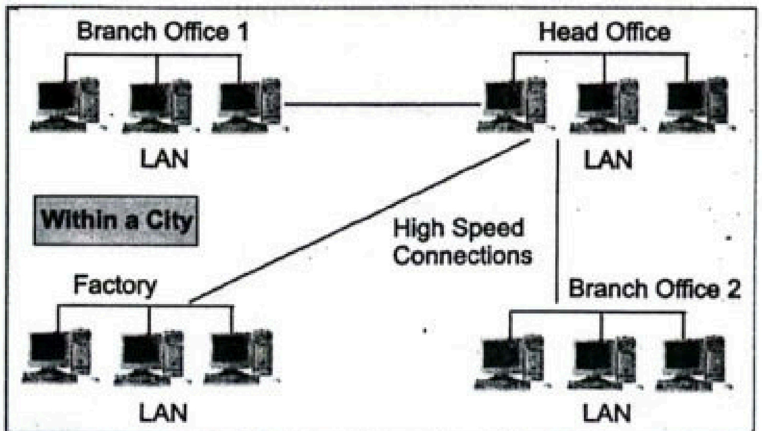


Fig.1.46 Metropolitan Area Network

Characteristics of MAN

- It is larger than a LAN and smaller than a WAN. Covers an area of between 5 to 50 km diameter.
- Uses fiber optic cable or microwave transmission.
- Provides high-speed communication.
- Used by telephone companies, Internet Service Providers and cable TV companies.

1.9.6 Wireless Networks

Wireless Networks use wireless technologies to transmit data between devices without physical wired connections, providing flexibility and mobility in various applications. These networks can operate over short distances (e.g., Wi-Fi) or large areas (e.g., cellular networks).

Fig.1.47 Wireless headset

Examples of Wireless Networks:

- **Wi-Fi:** Used for local area networks (LANs) and internet access, primarily in homes, offices, and public places.
- **Bluetooth:** A short-range wireless technology for device connectivity, including audio streaming and

peripheral connections.

- **Cellular Networks:** Provide wireless communication over wide areas, supporting mobile calls, messaging, and internet.
- **Satellite Networks:** Use orbiting satellites for wide-area communication, including satellite TV and GPS.

Advantages:

- Allows internet and network access from any location within coverage.
- Easier and cheaper to install compared to wired networks.
- Can accommodate additional devices and users.
- Enables work from home and access to corporate resources on the go.

Disadvantages:

- Wireless signals can be disrupted by external devices or environmental factors.
- Higher chances of unauthorized access and data breaches.
- Coverage may require additional equipment like access points or boosters.
- Can be slower and less reliable in crowded or busy areas.

1.9.7 Network Topologies

The arrangement of network nodes (devices) and their connections is known as **network topology**. Essentially, topology refers to the layout or map that shows how devices are interconnected within a network. It defines the physical and logical structure of the network, outlining the paths data takes to travel across various devices. The three most common types of network topologies are:

Bus Topology

In this setup, all devices are connected to a single central cable (bus), which is used to transmit data. It's simple and cost-effective for small networks but can be prone to failure if the bus cable is damaged. Bus network topology is shown in Fig.1.48.

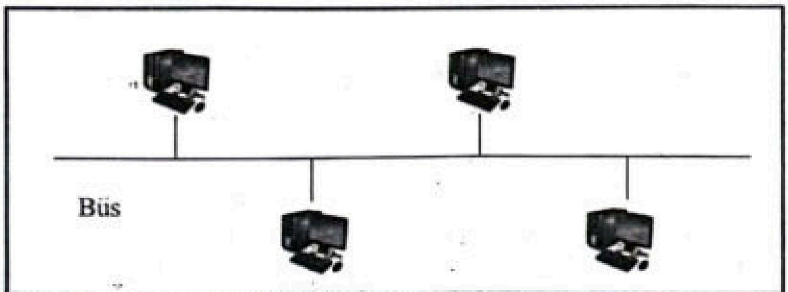


Fig.1.48 Bus network topology

Star Topology

In a star network topology, each device is connected to a central hub or switch. This design is easy to maintain and expand, but if the central hub fails, the whole network goes down. Star network topology is shown in Fig.1.49.

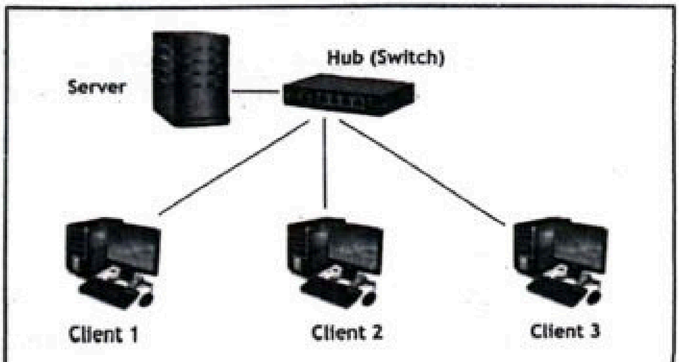


Fig. 1.49 Star network topology

Ring Topology

In Ring topology devices are connected in a circular fashion, with data traveling in one direction around the loop. While it is cost-effective, a break anywhere in the ring can bring down the entire network. Ring network topology is shown in Fig.1.50.

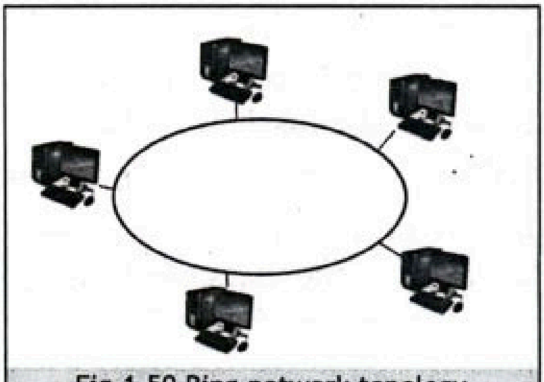


Fig.1.50 Ring network topology

1.9.8 Packet Switching and Circuit Switching

Packet Switching and **Circuit Switching** are two key technologies used for transmitting data over networks. Each method has its unique characteristics and use, particularly in the context of the internet and telecommunications.

Packet Switching: Packet Switching divides data into small packets, which are sent independently through the network, potentially taking different routes. They are reassembled at the destination.

Example: Email transmission over the internet, where data is split into packets that travel through various paths, as shown in Fig. 1.51.

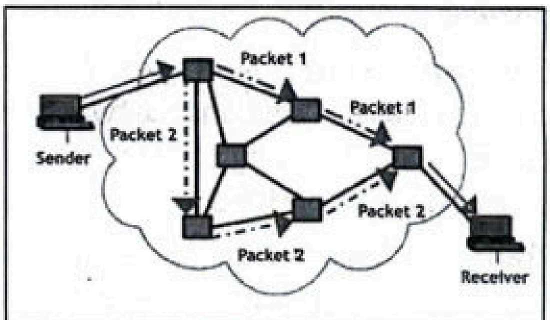


Fig.1.51 Packet Switching

Circuit Switching: Circuit Switching establishes a dedicated communication path between two devices for the duration of the session, ensuring continuous data flow until the session ends.

Example: Traditional phone calls, where a dedicated connection is maintained for the entire call, as shown in Fig.1.52.

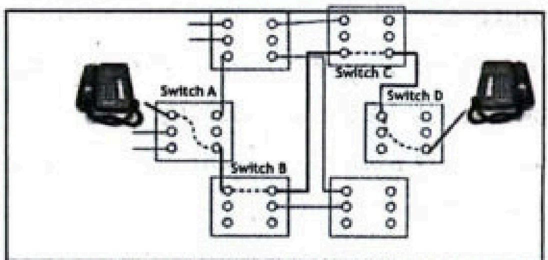


Fig.1.52 Circuit Switching

1.9.9 Data Communication Standards

Data communication standards define the rules and protocols for transmitting and processing data in networks. These standards ensure compatibility and interoperability between different devices and systems from various manufacturers. By adhering to these standards, communication can be reliable and efficient across diverse networks.

The OSI (Open Systems Interconnection) is one such standard conceptual framework used in the field of computer networking to define and understand how different networking protocols and technologies interact and work together.

1.9.10 OSI Model

The **OSI (Open Systems Interconnection) model**, developed by the International Standards Organization (ISO) in the 1970s, outlines a conceptual framework for how different networking protocols work together to ensure proper data transmission.

The OSI model consists of seven layers. Each layer performs a specific task during data communication as shown in Fig.1.53.

The seven layers of OSI model are described below.

Application Layer: Provides services to end-users, facilitating tasks like file transfers and message reading.

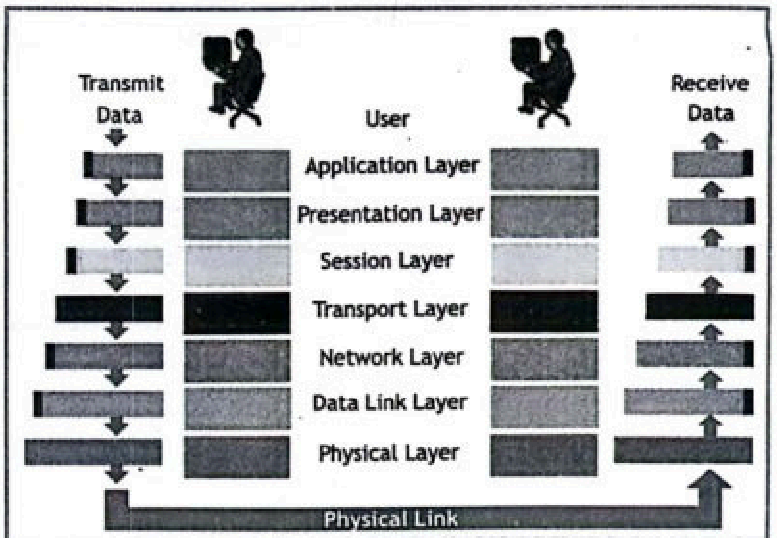


Fig.1.53 Layers of OSI Model

Presentation Layer: Converts data into a format that can be understood by other layers, ensuring compatibility across systems.

Session Layer: Manages the communication sessions between applications, handling security and connection establishment.

Transport Layer: Ensures reliable data transfer, maintaining the order and integrity of data packets.

Network Layer: Determines the optimal path for data transmission, using devices like routers.

Data Link Layer: Defines the format for data transmission, converting data into packets and verifying their accuracy.

Physical Layer: Deals with the physical transmission of data, including hardware like cables and connectors.

1.9.11 Data Communication Protocols

Different communication protocols define how data is transmitted and received over a network. Examples include:

- **TCP/IP (Transmission Control Protocol/Internet Protocol):** Used for internet communication and provides reliable, connection-oriented data transfer.
- **HTTP (Hypertext Transfer Protocol):** Used for transferring web pages and related data on the World Wide Web.
- **FTP (File Transfer Protocol):** Used for transferring files between computers on a network.
- **SMTP (Simple Mail Transfer Protocol):** Used for sending email messages.

1.9.12 The Internet

The Internet is a global network of interconnected computer networks that allows for the exchange of data, information, and communication among users and devices across the world. It is a vast and decentralized network that spans continents and connects billions of computers, servers, and other devices.

Evolution of the Internet

The Internet has evolved from its origins in the 1960s as ARPANET, a U.S. Department of Defense project for research institutions and military installations, to become a global network of interconnected computer networks. In the 1970s, the development of TCP/IP protocols established the foundation for the modern Internet, allowing different networks to communicate. The 1990s saw the emergence of the World Wide Web and web browsers, revolutionizing how people access and share information over the Internet. The 2000s brought broadband internet and social media platforms, while the 2010s saw the rise of mobile internet and the Internet of Things (IoT). In the 2020s, the Internet continues to evolve with cloud computing, artificial intelligence, and 5G technology, impacting nearly every aspect of modern life.

Working of the Internet

The Internet is the largest computer network ever built. It globally connects billions of devices and networks. It operates through a decentralized architecture using packet-switching technology. Data is divided into packets, which are routed through a network of interconnected routers and switches. Protocols like TCP/IP ensure data is packaged, addressed, and transmitted correctly. The Domain Name System (DNS) translates human-readable domain names (e.g., www.ncc.gov.pk) into IP addresses. Content is hosted on servers, and data is transmitted as packets to and from these servers. As data travels through the network, it is encapsulated in headers at each layer of the OSI model (such as the IP and TCP headers). When the data reaches its destination, these headers are removed through a process called de-capsulation. Security measures like encryption protects data during transmission. The Internet's interoperable design allows diverse devices and networks to communicate, making it a global information and communication platform.

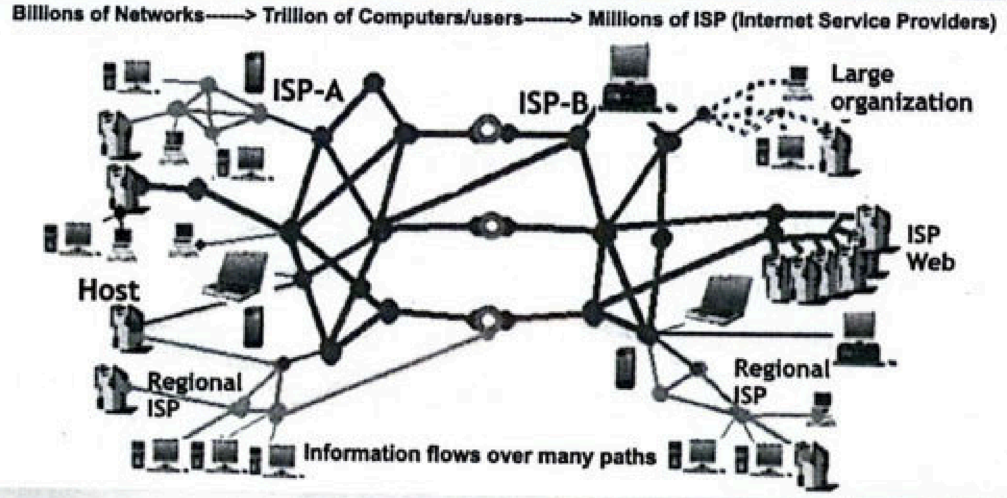


Fig.1.54 Working of the Internet

Advantages of the Internet

The main advantages of the Internet include:

- **Global Connectivity:** Enables communication and access to information worldwide.
- **Vast Information:** Provides a vast information resources and knowledge.
- **Communication:** Facilitates real-time communication and collaboration.
- **E-commerce:** Allows online shopping and digital transactions.
- **Education:** Supports online learning and research.
- **Business:** Enhances productivity and global reach.
- **Entertainment:** Offers streaming, gaming, and social media.
- **Innovation:** Promotes technological advancements and research.

Disadvantages of the Internet

The main disadvantages of the Internet include:

- **Privacy Concerns:** Threats to personal data and online privacy.
- **Cybersecurity Risks:** Vulnerability to hacking and cyberattacks.
- **Information Overload:** Overwhelming amount of data and misinformation.
- **Digital Addiction:** Excessive screen time and online dependency.
- **Digital Divide:** Unequal access to the Internet worldwide.
- **Online Harassment:** Cyberbullying and harassment issues.
- **Health Concerns:** Physical and mental health impacts.

Common Applications of the Internet

Main applications of the Internet include:

- **Communication:** Email, messaging, and video calls.
- **Information Retrieval:** Web browsing, search engines, and online databases.
- **E-commerce:** Online shopping, banking, and digital payments.
- **Social Media:** Networking, content sharing, and social interaction.
- **Entertainment:** Streaming, online gaming, and multimedia content.
- **Education:** Online courses, research, and e-learning platforms.
- **Business and Work:** Remote work, collaboration, and e-commerce.
- **Research and Innovation:** Access to research materials and innovation platforms.

Summary

- **Computer:** A programmable electronic device performing calculations and logic based on user instructions.
- **First-Generation Computers (1940-1956):** Used vacuum tubes, were slow, large, and costly.
- **Second-Generation Computers (1956-1963):** Replaced vacuum tubes with transistors, enhancing speed and reliability.
- **Third-Generation Computers (1963-1971):** Introduced integrated circuits (ICs), reducing size and power consumption.
- **Fourth-Generation Computers (1971-Present):** Integrated microprocessors, increasing speed and versatility.
- **Fifth-Generation Computers:** Focus on artificial intelligence (AI) with natural language and reasoning capabilities.
- **System:** Interconnected components working together for specific purposes.
- **Natural Systems:** Self-regulating systems in nature, such as ecosystems and weather patterns.
- **Artificial Systems:** Human-designed systems, e.g., communication and transportation systems.
- **Input Devices:** Tools like keyboards, mice, and cameras for data entry.
- **System Unit:** Central part of the computer containing CPU, RAM, and the motherboard.
- **Memory Types:** Includes ROM, RAM, cache, volatile, and non-volatile memory.
- **Output Devices:** Devices like monitors, printers, and speakers for displaying results.
- **Data Transmission:** Movement of data through buses during fetch, decode, execute, and store cycles.
- **Von Neumann Architecture:** Explains how computer hardware and software work together, comprising a CPU, registers, ALU, control unit, and buses.
- **Memory Units:** Measured in bytes, ranging from kilobytes to exabytes.
- **Chip Memory:** Fast storage devices like SSD, RAM, and cache.
- **Magnetic Memory:** Uses magnetized mediums such as hard disks and magnetic tapes.

- **Optical Memory:** Stores data on CDs, DVDs, and Blu-ray discs.
- **Volatile Memory:** Requires power to retain data, e.g., RAM and cache.
- ***Non-Volatile* Memory:** Retains data without power, e.g., ROM and flash storage.
- **Software:** A set of programs and instructions enabling computers to perform tasks.
- **System Software:** Manages hardware, including operating systems and utilities.
- **Application Software:** User-oriented programs for tasks like word processing and gaming.
- **Programming Languages:** Low-level (machine, assembly) and high-level ©++, Python) for coding tasks.
- **Data Communication:** Exchanging data via networks, involving sender, receiver, and protocols.
- **Modes of Communication:** Includes simplex, half-duplex, and full-duplex communication.
- **Communication Devices:** Devices like hubs, switches, and routers for network connectivity.
- **Network Types:** Includes LANs, WANs, MANs, and VPNs.
- **Network Topologies:** Layouts like bus, star, ring, and mesh define node connections.
- **Protocols:** Standards such as TCP/IP, HTTP, and FTP for communication.
- **Internet:** A global network enabling communication, e-commerce, and information sharing.
- **Applications of Internet:** Used for social media, education, business, and research.
- **Internet Working:** Operates via packet-switching, DNS, and security protocols.
- **Advantages of Internet:** Offers global access, real-time communication, and innovation.
- **Disadvantages of Internet:** Includes cybersecurity risks, privacy concerns, and addiction.

Exercise

Select the suitable answer for the following Multiple choice questions.

i. **Which technology replaced vacuum tubes in second-generation computers?**

a) Transistors
b) Integrated Circuits (ICs)
c) Microprocessors
d) Magnetic tapes

ii. **What is the primary goal of fifth-generation computers?**

a) Fast speed
b) Thinking power
c) Enhanced memory
d) Faster microprocessors

iii. **Which computer generation introduced the use of Integrated Circuits (ICs)?**

a) First Generation
b) Second Generation
c) Third Generation
d) Fourth Generation

iv. **In which generation of computers was the microprocessor developed?**

a) First Generation
b) Second Generation
c) Third Generation
d) Fourth Generation

v. **What is the function of the motherboard in a computer system?**

a) To store and retrieve data permanently
b) To connect and integrate all hardware components
c) To perform mathematical calculations
d) To display output on a monitor

vi. **Which component of the microprocessor controls the decision-making processes?**

a) Arithmetic Logic Unit (ALU)
b) Control Unit (CU)
c) Memory unit
d) Registers

vii. **Which type of memory retains data even when the computer is turned off?**

a) RAM
b) ROM
c) Cache
d) Register

viii. What is the main purpose of Cache memory?

a) Store program instructions b) Provide high-speed storage

c) Control input/output devices d) Perform arithmetic operations

ix. What is the smallest unit of memory in a digital computer?

a) Kilobyte b) Bit

c) Byte d) Megabyte

x. Which memory type uses laser beams to read and write data?

a) RAM b) Optical memory

c) Cache memory d) ROM

xi. What is the primary function of the buses in a computer's memory system?

a) Control memory operations b) Display graphics

c) Transmit data between components d) Perform arithmetic operations

xii. Which component of data communication converts the electrical signal into a suitable form for transmission?

a) Message b) Medium

c) Protocol d) Sender

xiii. What is the primary function of the Presentation Layer in the OSI model?

a) Establishing connections between computers

b) Converting data into a standard format

c) Deciding the physical path of data

d) Sending data in both directions simultaneously

xiv. In which network topology is data transmission unidirectional, like radio or television broadcasts?

a) Star Topology b) Bus Topology

c) Mesh Topology d) Ring Topology

xv. Which network architecture requires each computer to act as either a server or a client but not both simultaneously?

a) Client/Server Network b) Peer-to-Peer Network

c) Metropolitan Area Network (MAN) d) Wide Area Network (WAN)

Give Short answers to the following short response questions (SRQs).

i. What is the primary goal of fifth-generation computers?

ii. Differentiate between volatile and non-volatile memory.

iii. Show memory hierarchy with the help of diagram.

iv. Why is the word size of a processor important, and how does it affect the computer's performance?

v. Imagine you are building a custom computer for a friend. Give three considerations you would take into account this computer.

vi. You are a computer technician tasked with upgrading an older computer with a slow CPU. How might you improve its performance without replacing the entire CPU?

vii. Your school is planning to purchase new printers for the computer lab. Give two advantages and disadvantages of impact and non-impact printers to help them make a decision.

viii. What does OOP stand for, and which programming languages commonly use this paradigm?

ix. Define "protocol" in the context of data communication.

x. Define simplex, half-duplex, and full-duplex modes of communication with one example each.

xi. What are start and stop bits, and where are they used in data transmission?

xii. How does a switch differ from a hub in a network?

xiii. How does asynchronous transmission differ from synchronous transmission?

xiv. Give three limitations of peer-to-peer network compared to a client/server network.

xv. What is the role of the Application Layer in the OSI model?

Give Long answers to the following extended response questions (ERQs).

Q1. Describe the evolution of computer generations from the first generation to the fifth generation, highlighting the key technological developments and their impact on computing.

Q2. Discuss the importance of both natural and artificial systems by providing examples of each type.

Q3. Explain the fundamental components of network communication, and how do they work together to facilitate data transfer?

Q4. Describe the roles of common communication devices like hubs, switches, routers, and gateways in data communication. How do they contribute to the functionality of a network?

Q5. Discuss the advantages and limitations of different network topologies, including bus, star and ring. When should each topology be used in a network design?

Q6. What is the OSI model, and how does it help in understanding the process of data communication? Give the purpose of each OSI layer.

Q7. Discuss any three common applications of the Internet and their impact on various aspects of society, including communication, education, business, entertainment, and research.

Lab Activities

Activity 1

Computer History Timeline Presentation:

Objective: To help students understand the historical development of computer systems.

Instructions:

I. Divide the class into small groups (5 to 6 students) and assign each group a specific era or generation of computers (e.g., First Generation, Second Generation, etc.).

ii. Instruct each group to create a presentation (using PowerPoint or other presentation tools) that highlights the key inventions, innovations, and characteristics of their assigned era.

iii. Encourage students to include images, diagrams, and historical context to make their presentations engaging and informative.

iv. Have each group present their findings to the class, creating a comprehensive timeline of computer history from early computing devices to modern computers.

Outcome: This activity will help students visualize the progression of computer technology over time and understand the significance of each generation's contributions.

Activity 2

Computer System Components Showcase:

Objective: To familiarize students with the core components of a computer system.

Instructions:

i. Set up a "Computer System Components Showcase" in your classroom with physical representations of computer components, such as a motherboard, CPU, keyboard, mouse, microphone, scanner, and other input devices.

ii. Provide students with a checklist or worksheet that lists these components.

iii. Divide the class into small groups and assign each group to visit the showcase. Their task is to identify and describe the purpose of each component.

iv. Afterward, reconvene as a class and have each group share their observations and descriptions.

v. Discuss the role of each component in a computer system and how they work together.

Outcome: This hands-on activity enhances students' understanding of computer hardware components and their functions in a computer system.

Activity 3

Create a Data Communication Network

Objective: To understand the components and types of data communication networks.

Instructions:

i. Divide the students into groups and provide each group with a set of components mentioned in the text (Sender, Message, Medium, Protocol Receiver).

ii. Instruct each group to create a visual representation of a data communication network using these components. They can use drawings, diagrams, or digital tools.

iii. Ask each group to label the components and explain their roles in the network.

iv. Have each group present their network to the class, highlighting the type of medium they've chosen (wired or wireless).

v. Discuss the advantages and disadvantages of using different types of mediums in data communication.

Activity 4

OSI Model Role-Play

Objective: To understand the layers of the OSI model and their functions.

Instructions:

i. Explain the OSI model to the students, emphasizing its seven layers.
ii. Assign each student or pair of students a specific layer from the OSI model.
iii. Ask the students to prepare a short role-play or skit in which they act out the responsibilities and interactions of their assigned OSI layer.
iv. Encourage creativity in demonstrating how each layer interacts with the others.
v. Have the students perform their role-plays in front of the class.
vi. After each role-play, discuss how the layers work together to ensure successful data communication.