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DATA STRUCTURES
ALGORITHMS
COMPUTER NETWORKS
DATABASE SYSTEMS


Unit-I
10110
01001
10101
DATA STRUCTURES
ALGORITHMS
COMPUTER NETWORKS
DATABASE SYSTEMS
#include <iostream>
using namespace std;
int main()
{
cout << "Hello, World!";
return 0;
}

INTRODUCTION TO NETWORKING

Connecting Devices, Sharing Resources, Exchanging Information

Networking is the process of connecting two or more computers/devices so that they can communicate with each other and share resources.

1. INTRODUCTION

A computer network is a collection of two or more interconnected computers and devices that can communicate and share data and resources.

Basic Components of a Network

Examples

- Home Wi-Fi network
- Office network
- Internet (largest network in the world)

2. NEED OF COMPUTER NETWORK

Computer networks are essential in today's world. They provide many advantages and make communication and work easier, faster and more efficient.

Key Needs / Advantages

Resource Sharing
Share hardware (printers, storage), software and data.

Data Communication
Exchange information quickly and easily.

Cost Effective
Reduces cost by sharing resources and internet connection.

Centralized Data Management
Data can be stored, managed and backed up at one place.

Improved Collaboration
Users can work together, share ideas and information in real-time.

Global Connectivity
Connect with people and information anywhere in the world.

3. COMMUNICATION PROTOCOL

A communication protocol is a set of rules and standards that define how data is transmitted and received between devices in a network.

Key Points

- It defines the format, timing, sequencing, and error control of data communication.
- Ensures that devices from different manufacturers can communicate properly.
- Without protocols, communication would be chaotic and unreliable.

Functions of a Protocol

Syntax
Defines the format and structure of data.

Semantics
Defines the meaning of each field in the data.

Timing
Defines when data should be sent and how fast it should be sent.

Error Handling
Detects and corrects errors to ensure reliable communication.

EXAMPLES OF COMMUNICATION PROTOCOLS

TCP/IP
Used in Internet communication. Provides reliable data transmission.

HTTP/HTTPS
Used for web browsing. HTTPS is the secure version of HTTP.

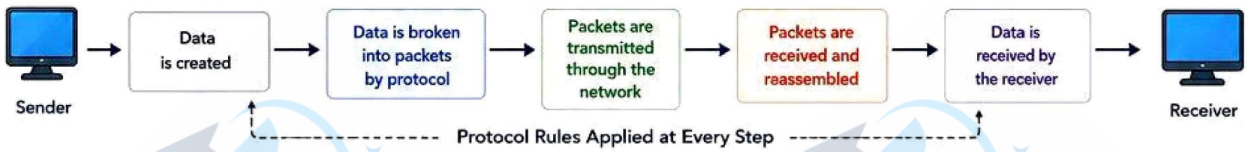
FTP
Used to transfer files between client and server.

SMTP
Used to send e-mails from one server to another.

POP3 / IMAP
Used to receive e-mails from the mail server.

DNS
Translates domain names (e.g., www.example.com) into IP addresses.

HOW COMMUNICATION WORKS IN A NETWORK



TYPES OF NETWORKS (By Coverage Area)

- PAN (Personal Area Network) – Very short range (e.g., Bluetooth)
- LAN (Local Area Network) – Small area (e.g., home, office)
- MAN (Metropolitan Area Network) – City-wide network
- WAN (Wide Area Network) – Country/World-wide network

APPLICATIONS OF NETWORKING

KEY TAKEAWAY

- ✓ Networking connects computers and devices to communicate and share resources.
- ✓ It is needed for sharing, communication, cost savings, centralization and global connectivity.
- ✓ Communication protocols provide rules for reliable and meaningful data exchange.
- ✓ Examples: TCP/IP, HTTP, FTP, SMTP, POP3/IMAP, DNS.

TYPES OF NETWORK

Computer networks can be classified based on the area they cover.
The main types of networks are **LAN**, **MAN** and **WAN**.

1. LAN (Local Area Network)

A LAN covers a small area such as a room, building or campus.

Characteristics

- Covers small geographical area
- High data transfer speed
- Owned and managed by a single organization
- Low installation and maintenance cost
- Examples: Home network, Office network, School labs

Example:
A network in an office connecting computers, printers and servers.

2. MAN (Metropolitan Area Network)

A MAN covers a larger area than LAN, such as a city or metropolitan region.

Characteristics

- Covers a city or metro area
- Medium to high data transfer speed
- Connects multiple LANs
- Usually managed by organizations or service providers
- Examples: Cable TV network, City government network

Example:
A network connecting different offices across a city.

3. WAN (Wide Area Network)

A WAN covers a very large area such as a country, continent or the whole world.

Characteristics

- Covers large geographical area (country to worldwide)
- Lower data transfer speed compared to LAN/MAN
- Connects LANs and MANs over long distances
- Uses public or leased communication links
- High installation and maintenance cost
- Examples: The Internet, Bank networks, Airline reservation system

Example:
The Internet connects networks all over the world.

QUICK COMPARISON

Feature	LAN	MAN	WAN
Coverage Area	Small (Room, Building, Campus)	Medium (City or Metro Area)	Large (Country to Worldwide)
Speed	High	Medium to High	Low to Medium
Ownership	Private (Single Organization)	Private or Service Provider	Service Providers
Cost	Low	Medium	High
Example	Office Network	City Network	Internet

In Short

- LAN is used in limited area like home, office or building.
- MAN is used to connect many LANs within a city or metro area.
- WAN is used to connect networks over very large distances like countries or the world.

TOPOLOGY: RING AND BUS

Topology refers to the physical or logical layout of a network. It describes how devices (nodes) are connected and how data flows between them.

1. RING TOPOLOGY

In a ring topology, each device is connected to exactly two other devices, forming a circular ring. Data travels in one direction around the ring from one device to the next.

DIAGRAM

KEY FEATURES

- Each device has two neighbors.
- Data flows in one direction (clockwise or counter-clockwise).
- A token (special data) controls which device can send data.
- If one device fails, it can break the entire ring.

ADVANTAGES

- ✓ Easy to install and expand.
- ✓ No collision between data.
- ✓ Performs well under heavy load.
- ✓ Equal access for all devices.

DISADVANTAGES

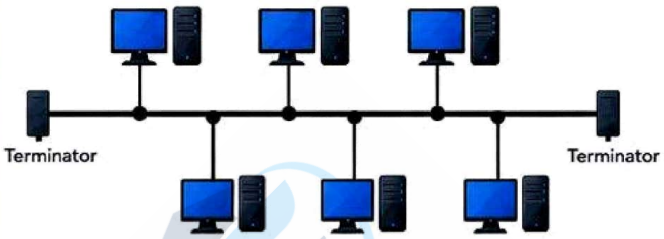
- ✗ Failure of one device can stop the whole network.
- ✗ Troubleshooting is difficult.
- ✗ Adding or removing a device may disturb the network.

- Used in Token Ring networks (older technology).
- Suitable for networks that require predictable performance.
- Used in some industrial and automation systems.

2. BUS TOPOLOGY

In a bus topology, all devices are connected to a single central cable called the backbone. Data sent by any device travels along the bus and is received by all devices.

DIAGRAM



KEY FEATURES

- All devices share a single cable.
- Data travels along the backbone in both directions.
- Terminators are placed at both ends of the bus.
- If the backbone cable fails, the entire network fails.

ADVANTAGES

- ✓ Simple and inexpensive to install.
- ✓ Requires less cable compared to other topologies.
- ✓ Easy to extend the network.

DISADVANTAGES

- ✗ If the backbone cable fails, the whole network fails.
- ✗ Performance decreases with more devices.
- ✗ Difficult to detect faults.

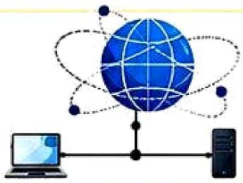
- Used in small networks.
- Used in Ethernet (10Base2, 10Base5) in the past.
- Suitable for temporary or small-scale setups.

RING vs BUS TOPOLOGY

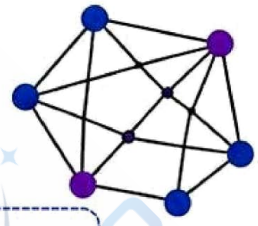
Feature	Ring Topology	Bus Topology
Layout	Devices connected in a circular ring	All devices connected to a single backbone cable
Data Flow	In one direction (clockwise or counter-clockwise)	In both directions along the bus
Failure Impact	Failure of one device can stop the entire network	Failure of backbone cable stops the entire network
Installation Cost	Moderate	Low
Performance	Better under heavy load	Degrades as more devices are added
Scalability	Moderate	Limited
Troubleshooting	Difficult	Difficult

IN SHORT

- Ring topology connects devices in a circle. It offers good performance but a single failure can break the network.
- Bus topology connects all devices to a single cable. It is simple and low-cost but the entire network depends on the backbone cable.



TOPOLOGY: STAR & MESH



Topology refers to the physical or logical layout of a network.
It describes how devices (nodes) are connected and how data flows between them.

1. STAR TOPOLOGY

In a star topology, every device is connected to a central device called the hub or switch. All data passes through this central device.

DIAGRAM

KEY FEATURES

- All devices are connected to a central hub/switch.
- Easy to add or remove devices.
- Failure of one device does not affect others.
- If the central device fails, the entire network stops working.

ADVANTAGES

- ✓ Easy to install and manage.
- ✓ Failure of one device does not affect others.
- ✓ Easy to troubleshoot.
- ✓ Good performance.
- ✓ Easily expandable.

DISADVANTAGES

- × Requires more cable than bus topology.
- × If the central hub/switch fails, the whole network fails.
- × Cost of hub/switch can be high.

- Common in modern Ethernet networks.
- Used in offices, schools, homes and labs.
- Suitable for networks that need high reliability.

2. MESH TOPOLOGY

In a mesh topology, each device is connected to every other device in the network. Data can travel through multiple paths from source to destination.

DIAGRAM

KEY FEATURES

- Every device is connected to every other device.
- Multiple paths exist for data transmission.
- Very reliable.
- Complex and expensive due to more connections.

ADVANTAGES

- ✓ Very reliable and fault-tolerant.
- ✓ Multiple paths ensure data delivery even if one link fails.
- ✓ High security and privacy.
- ✓ Suitable for mission-critical applications.

DISADVANTAGES

- × Very expensive (requires more cables and ports).
- × Complex to install and manage.
- × Difficult to expand.
- × Requires more space.

- Used in WANs and backbone networks.
- Used in banks, military, aviation, and critical systems.
- Suitable where reliability is the highest priority.

STAR vs MESH TOPOLOGY

Feature	Star Topology	Mesh Topology
Layout	All devices connected to a central hub/switch.	Every device connected to every other device.
Cabling	Requires less cable.	Requires much more cable.
Cost	Less expensive.	Very expensive.
Reliability	Good (failure of hub affects the whole network).	Very high (failure of one link does not affect others).
Installation	Easy to install.	Complex to install.
Troubleshooting	Easy to troubleshoot.	Difficult to troubleshoot.
Scalability	Easily scalable.	Difficult to scale.
Best Suited For	Small to medium networks.	Large, critical and backbone networks.

IN SHORT

STAR TOPOLOGY
Simple, easy to manage and cost-effective.
Best for networks where easy maintenance is required.

MESH TOPOLOGY
Highly reliable and fault-tolerant but expensive and complex.
Best for critical and high-security networks.


Unit - II
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int main()
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}

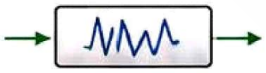
NETWORK DEVICES: REPEATER, HUB, SWITCH

Network devices are hardware components that are used to connect devices in a network, manage data communication and improve network performance.

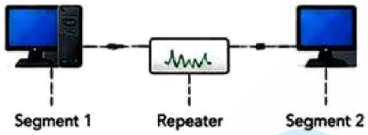
1. REPEATER

A Repeater is a physical layer device that receives a weak signal, regenerates it and retransmits it to extend the network distance.

SYMBOL



DIAGRAM



KEY FEATURES

- Operates at the Physical Layer (OSI Layer 1).
- Regenerates and amplifies the signal.
- Extends the length of the network.
- Does not filter or process data.
- Does not reduce network traffic.

ADVANTAGES

- ✓ Extends network distance.
- ✓ Inexpensive.
- ✓ Easy to install.

DISADVANTAGES

- × Does not improve network performance.
- × Repeats errors also.
- × Cannot reduce network congestion.

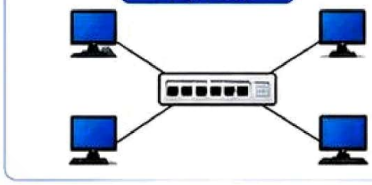
- Used in long distance networks.
- Used where signal loss occurs.
- Used in both wired and wireless networks to extend range.

2. HUB

A Hub is a multi-port repeater. It connects multiple devices together and broadcasts the data received from one port to all other ports.

SYMBOL

DIAGRAM



KEY FEATURES

- Operates at the Physical Layer (OSI Layer 1).
- All ports share the same bandwidth.
- Broadcasts data to all ports.
- No intelligence to find the destination.
- Creates more network traffic.

ADVANTAGES

- ✓ Simple and easy to use.
- ✓ Low cost.
- ✓ Plug and play device.

DISADVANTAGES

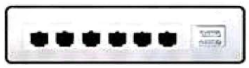
- × Broadcasts data to all ports.
- × More collisions and traffic.
- × Poor performance in large networks.

- Used in small networks.
- Used where cost is a major factor.
- Used in environments where security is not a major concern.

3. SWITCH

A Switch is a multi-port bridge. It connects devices in a network and forwards data only to the specific device using MAC address.

SYMBOL



DIAGRAM

KEY FEATURES

- Operates at the Data Link Layer (OSI Layer 2).
- Uses MAC address to forward data.
- Sends data only to the destination port.
- Each port has dedicated bandwidth.
- Reduces collisions and network traffic.

ADVANTAGES

- ✓ High performance.
- ✓ More secure.
- ✓ Reduces collisions.
- ✓ Supports multiple devices efficiently.

DISADVANTAGES

- × More expensive than hub.
- × Complex configuration.
- × Requires more power.

- Used in modern and enterprise networks.
- Used where high performance and security are required.
- Used in LANs to connect multiple devices.

REPEATER vs HUB vs SWITCH

Feature	Repeater	Hub	Switch
OSI Layer	Physical Layer (Layer 1)	Physical Layer (Layer 1)	Data Link Layer (Layer 2)
Function	Regenerates and amplifies signal	Broadcasts data to all ports	Forwards data to specific port
Intelligence	No	No	Yes (uses MAC address)
Ports	Usually 2 ports	Multiple ports	Multiple ports
Bandwidth	Does not change bandwidth	Shared bandwidth	Dedicated bandwidth per port
Collision	Repeats errors	High collisions	Very low collisions
Performance	Low	Low	High
Cost	Low	Low	High
Best For	Extending distance	Small, simple networks	Large, secure and high-performance networks

IN SHORT

REPEATER
Extends the network distance by regenerating the signal.

HUB
Connects multiple devices and sends data to all ports.

SWITCH
Connects multiple devices and sends data only to the destination.

NETWORK DEVICES: BRIDGE & ROUTER

Network devices are hardware components that connect devices in a network, manage data communication and improve network performance.

1. BRIDGE

A Bridge is a Data Link Layer (Layer 2) device that connects two or more LAN segments and forwards data based on MAC addresses.
It filters and reduces unnecessary traffic between network segments.

DIAGRAM

KEY FEATURES

- Operates at the Data Link Layer (Layer 2).
- Connects two or more LAN segments.
- Uses MAC addresses to forward or filter frames.
- Reduces network traffic and collisions.
- Does not connect different network types.

ADVANTAGES

- ✓ Reduces network congestion.
- ✓ Improves network performance.
- ✓ Increases effective bandwidth.
- ✓ Easy to install and manage.

DISADVANTAGES

- ✗ Cannot connect different network types.
- ✗ Limited to LAN segments.
- ✗ Does not perform routing.

- Used to connect two LAN segments.
- Used to filter and forward data based on MAC address.
- Used in networks where high traffic is between segments.

2. ROUTER

A Router is a Network Layer (Layer 3) device that connects different networks and forwards data packets based on IP addresses.
It determines the best path for data to reach its destination.

DIAGRAM

KEY FEATURES

- Operates at the Network Layer (Layer 3).
- Connects two or more different networks.
- Uses IP addresses to forward packets.
- Chooses the best path (routing) for data delivery.
- Supports routing protocols (RIP, OSPF, etc.).

ADVANTAGES

- ✓ Connects different networks.
- ✓ Reduces broadcast traffic.
- ✓ Improves network security.
- ✓ Finds the best path for data.

DISADVANTAGES

- ✗ More expensive than bridges.
- ✗ Complex to configure.
- ✗ Requires more resources.

- Used to connect multiple networks (LAN to LAN, LAN to WAN).
- Used in Internet connections (homes, offices, organizations).
- Used to route data between different network types.

BRIDGE vs ROUTER

Feature	Bridge	Router
OSI Layer	Data Link Layer (Layer 2)	Network Layer (Layer 3)
Primary Function	Connects LAN segments and filters frames	Connects different networks and routes packets
Address Used	MAC Address	IP Address
Type of Networks Connected	Same type of network (LAN to LAN)	Different type of networks (LAN to LAN / LAN to WAN)
Broadcast Domain	Does not break broadcast domain	Breaks broadcast domain
Routing	Does not perform routing	Performs routing
Performance	Improves performance by filtering traffic	Improves performance by finding best path
Cost	Less expensive	More expensive
Example	Used in large LAN networks to connect segments	Used in Internet, WAN, and inter-network connections

IN SHORT

BRIDGE

Works at Layer 2.
Connects LAN segments.
Filters data using MAC address.
Does not connect different networks.

ROUTER

Works at Layer 3.
Connects different networks.
Routes data using IP address.
Finds best path to deliver data.

OSI REFERENCE MODEL

Introduction, OSI Model & Functions of Seven Layers

1. INTRODUCTION

OSI (Open Systems Interconnection) Reference Model is a conceptual framework developed by ISO (International Organization for Standardization) to understand and design network communication.

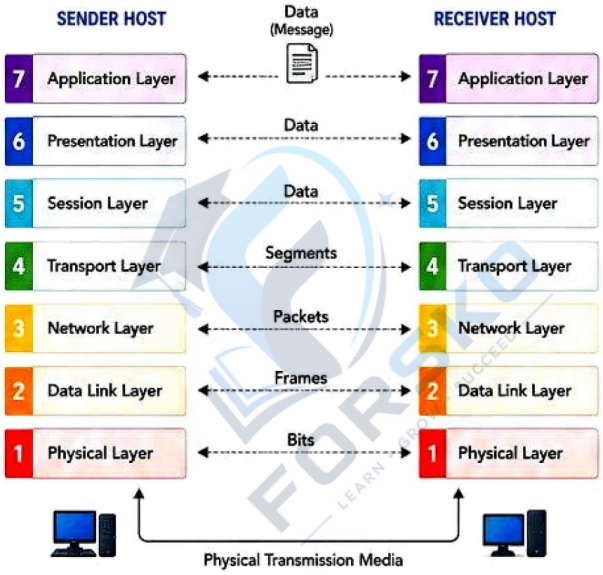
- It divides the network communication process into seven distinct layers.
- Each layer has specific functions and communicates with the layer above and below it.
- It enables different systems to communicate with each other, regardless of their underlying architecture.

BENEFITS OF OSI MODEL

- Provides a common standard for network communication.
- Simplifies network design and troubleshooting.
- Ensures interoperability between different systems.
- Changes in one layer do not affect other layers.
- Helps in teaching and learning of networking.

2. OSI MODEL

The OSI model consists of 7 layers. Data flows from the top layer (Application) down to the bottom layer (Physical) at the sender side and vice-versa at the receiver side.

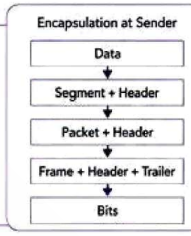


3. FUNCTIONS OF SEVEN LAYERS OF OSI

Layer	Functions	Examples / Protocols
7 Application Layer	• Provides network services to user applications. • Acts as an interface between user and network.	HTTP, FTP, SMTP, DNS, Telnet, SNMP
6 Presentation Layer	• Translates data into a format understandable by the receiver. • Handles encryption, decryption, compression, and data encoding.	SSL/TLS, ASCII, JPEG, MPEG, Encryption
5 Session Layer	• Establishes, manages and terminates sessions between applications. • Controls dialog (who speaks when) and synchronization.	NetBIOS, PPTP, RPC, SIP
4 Transport Layer	• Ensures end-to-end delivery of data. • Handles segmentation, flow control, and error control.	TCP, UDP, SPX
3 Network Layer	• Handles logical addressing and routing of data. • Selects best path and forwards packets.	IP (IPv4, IPv6), ICMP, IGMP, OSPF, RIP
2 Data Link Layer	• Provides node-to-node delivery. • Handles framing, MAC addressing, error detection and correction.	Ethernet, PPP, MAC, LLC
1 Physical Layer	• Transmits raw bits over the physical medium. • Specifies electrical, mechanical, and procedural characteristics.	RJ45, Hubs, Repeaters, Cables, Modems

KEY POINTS

- Data is encapsulated while moving down the layers at the sender side.
- Data is de-encapsulated while moving up the layers at the receiver side.
- Each layer adds a header (and sometimes trailer) to the data it receives from the layer above.
- The Physical layer actually transmits bits over the medium.



OSI MODEL – QUICK SUMMARY

Layer	Layer Name	PDU (Data Unit)	Main Function Summary	Device (Example)
7	Application	Data	Provides network services to user applications.	Gateway
6	Presentation	Data	Data translation, encryption, compression, encoding.	Gateway
5	Session	Data	Manages sessions, dialog control, synchronization.	Gateway
4	Transport	Segment	End-to-end delivery, segmentation, flow & error control.	Gateway
3	Network	Packet	Logical addressing and routing of packets.	Router
2	Data Link	Frame	Framing, MAC addressing, error detection/correction.	Switch, Bridge
1	Physical	Bits	Transmits raw bits over the physical medium.	Hub, Repeater

REMEMBER

Application to Physical ↓

The OSI model helps us understand how data travels from one device to another in a structured way. Each layer plays a vital role in successful communication.

Physical to Application ↑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DATA TRANSMISSION MEDIA

— GUIDED MEDIA —

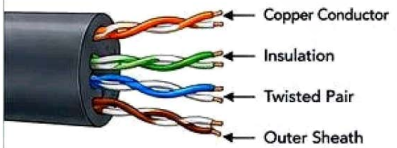
Data transmission media are the physical paths through which data travels from sender to receiver. Guided (Wired) media use physical cables to transmit data. They provide higher security and reliability.

GUIDED MEDIA (WIRED MEDIA)

1. TWISTED PAIR CABLE

It consists of two insulated copper wires twisted around each other. It is the most commonly used wired media.

STRUCTURE



TYPES

- UTP (Unshielded Twisted Pair) – Most common type used in LANs.
- STP (Shielded Twisted Pair) – Has an extra shielding to reduce external interference.

FEATURES

- Low cost and easy to install.
- Flexible and lightweight.
- Data rate: Up to 10 Gbps (UTP Cat 6A/7).
- Distance: Up to 100 meters.
- Susceptible to electromagnetic interference (UTP).

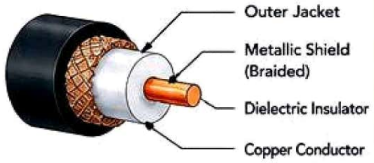
APPLICATIONS

- Telephone wiring.
- Ethernet LAN connections.
- Used in offices and homes.

2. COAXIAL CABLE

It consists of a central copper conductor, insulated by a dielectric layer, surrounded by a metallic shield and outer covering.

STRUCTURE



TYPES

- Baseband Coaxial Cable – Used for digital signals.
- Broadband Coaxial Cable – Used for analog signals (TV, Cable TV).

FEATURES

- Better shielding than twisted pair.
- Higher bandwidth than twisted pair.
- Data rate: Up to several Gbps.
- Distance: Up to 500 meters.
- Thicker and less flexible than twisted pair.

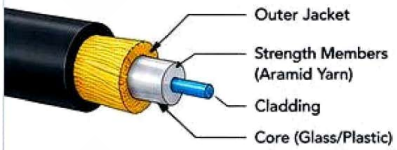
APPLICATIONS

- Cable TV networks.
- CCTV systems.
- Internet broadband (cable modem).
- Used in older Ethernet networks (10Base2, 10Base5).

3. FIBER OPTIC CABLE

It uses light signals to transmit data through thin glass or plastic fibers. It provides high speed and long distance communication.

STRUCTURE



TYPES

- Single Mode Fiber (SMF) – Uses a single light path. Long distance, high speed.
- Multimode Fiber (MMF) – Uses multiple light paths. Shorter distance.

FEATURES

- Very high bandwidth and speed.
- Data rate: Up to 100 Gbps and beyond.
- Distance: Several kilometers (up to 100 km+).
- Immune to electromagnetic interference.
- High cost and delicate installation.

APPLICATIONS

- Long distance communication.
- Internet backbone.
- Telecommunication networks.
- Used in high speed and high security systems.

COMPARISON OF GUIDED MEDIA

Feature	Twisted Pair Cable	Coaxial Cable	Fiber Optic Cable
Medium	Copper wires	Copper with shielding	Glass or Plastic fiber
Signal Type	Electrical	Electrical (Analog/Digital)	Light
Bandwidth	Low to Moderate	Moderate to High	Very High
Data Rate	Up to 10 Gbps	Up to Several Gbps	Up to 100 Gbps and beyond
Distance	Up to 100 m	Up to 500 m	Up to 100 km or more
Cost	Low	Moderate	High
Installation	Easy	Moderate	Difficult (Special tools required)
Interference	High (UTP), Low (STP)	Low	None (Immune)
Security	Low	Moderate	High
Flexibility	High	Low	Very Low
Typical Uses	LANs, Telephones	Cable TV, Internet (Cable)	Internet Backbone, Long Distance Links

KEY POINTS

- Guided media uses physical cables to transmit data.
- Twisted pair is inexpensive and easy to install.
- Coaxial cable offers better shielding and higher bandwidth.
- Fiber optic cable provides the highest speed, longest distance and is immune to interference.

IN SHORT

Twisted Pair – Low cost, easy, used in LANs.

Coaxial – Better shielding, used in Cable TV & broadband.

Fiber Optic – High speed, long distance, interference free.

DATA TRANSMISSION MEDIA

— WIRELESS MEDIA —

Wireless media transmit data through the air without using physical cables. They provide mobility, ease of installation and are suitable for environments where wiring is difficult.

TYPES OF WIRELESS MEDIA

1. RADIO WAVES

DESCRIPTION

Radio waves are the most widely used wireless transmission medium. They can penetrate buildings, walls and can travel long distances.

CHARACTERISTICS

- Frequency Range: 3 kHz to 1 GHz
- Long range communication
- Can penetrate obstacles
- Omni-directional (in all directions)
- Lower bandwidth compared to microwaves

APPLICATIONS

- Radio and TV broadcasting
- Mobile communication (2G, 3G, 4G)
- Walkie-talkies
- Wi-Fi (2.4 GHz band)
- Bluetooth

EXAMPLES / DEVICES

FM Radio · Television · Wi-Fi · Walkie-Talkie

2. MICRO WAVES

DESCRIPTION

Microwaves are high frequency radio waves. They are used for point-to-point communication and satellite communication.

CHARACTERISTICS

- Frequency Range: 1 GHz to 300 GHz
- High data rate and bandwidth
- Used for line-of-sight communication
- Do not penetrate solid objects (buildings, mountains)
- More secure than radio waves

APPLICATIONS

- Satellite communication
- Microwave ovens
- Point-to-point communication links
- Cellular backhaul
- WiMAX

EXAMPLES / DEVICES

Satellite Dish · Microwave Oven · Communication Tower

3. INFRARED

DESCRIPTION

Infrared uses light waves beyond the visible red light for short-range communication.

CHARACTERISTICS

- Frequency Range: 300 GHz to 400 THz
- Short range communication
- Requires line-of-sight
- Cannot penetrate walls or obstacles
- Immune to electromagnetic interference

APPLICATIONS

- Remote controls (TV, AC, etc.)
- IrDA (short range data transfer)
- Wireless sensors
- Point-of-sale devices

EXAMPLES / DEVICES

TV Remote · IrDA · Motion Sensor

COMPARISON OF WIRELESS MEDIA

Feature	Radio Waves	Microwaves	Infrared
Frequency Range	3 kHz – 1 GHz	1 GHz – 300 GHz	300 GHz – 400 THz
Wavelength	Long	Medium	Very Short
Range	Long (km to thousands of km)	Medium (few meters to 50 km)	Short (few meters)
Data Rate	Low to Moderate	High	Low to Moderate
Penetration	High (can pass through walls)	Low (blocked by solid objects)	Very Low (blocked by walls)
Direction	Omni-directional	Directional (narrow beam)	Directional (line-of-sight)
Interference	Susceptible	Less susceptible	Not affected by RF interference
Security	Low	Medium to High	High
Typical Uses	Broadcasting, Mobile, Wi-Fi, Bluetooth	Satellite, Microwave links, WiMAX	Remote controls, IrDA, Sensors

KEY POINTS

- Wireless media do not use physical cables.
- Radio waves provide long range but with lower bandwidth.
- Microwaves provide high speed and are used for point-to-point and satellite communication.
- Infrared is used for short range, low power communication and requires line-of-sight.

IN SHORT

Radio Waves – Long range, can penetrate obstacles, used in broadcasting and mobile communication.

Microwaves – High speed, line-of-sight, used in satellite and point-to-point communication.

Infrared – Short range, line-of-sight, used in remote controls and short distance data transfer.

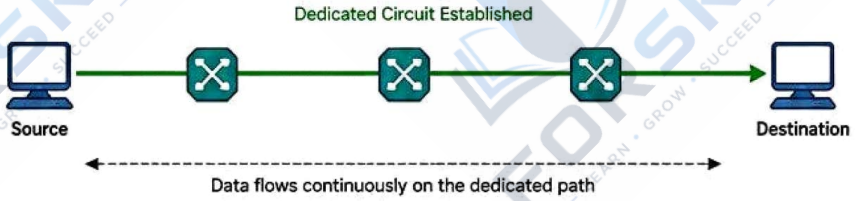
SWITCHING: CIRCUIT, MESSAGE, PACKET

Switching is a technique used in computer networks to transfer data from a source to a destination through intermediate nodes.

1. CIRCUIT SWITCHING

A dedicated end-to-end path (circuit) is established between source and destination before data transmission. The circuit remains reserved for the duration of the communication.

HOW IT WORKS



FEATURES

- Dedicated path
- Reliable & in-order delivery
- Call setup time required
- Inefficient for bursty data

EXAMPLE / USE CASES

- Traditional Telephone Network (PSTN)
- Leased Lines

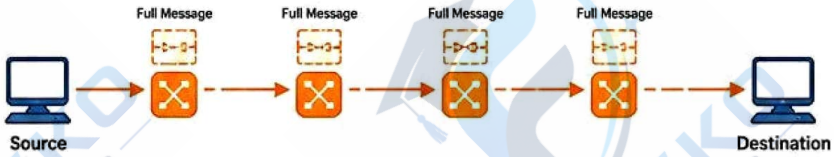
PROS / CONS

+ Predictable performance
+ No congestion once path is set
– Setup time is high
– Wastage of bandwidth if idle

2. MESSAGE SWITCHING

The entire message is treated as a single unit and transmitted from one node to the next until it reaches the destination. Each node stores the whole message before forwarding it.

HOW IT WORKS



FEATURES

- Store-and-forward approach
- No dedicated path required
- High delay for large messages
- High memory requirement

EXAMPLE / USE CASES

- Email Systems
- Store-and-Forward Systems

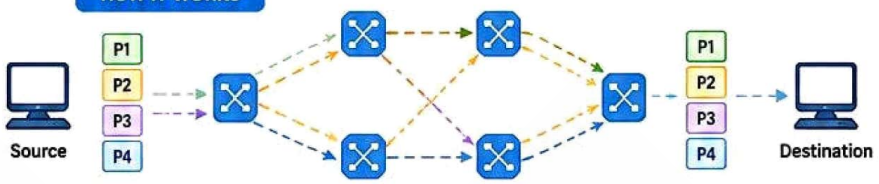
PROS / CONS

+ No dedicated path needed
+ Simple to implement
– High delay
– Not suitable for real-time data

3. PACKET SWITCHING

The message is divided into small packets. Each packet is transmitted independently through the network and may take different paths to reach the destination.

HOW IT WORKS



FEATURES

- Efficient bandwidth usage
- Supports multi-path routing
- Packets may arrive out of order
- Overhead of packet headers

EXAMPLE / USE CASES

- Internet (TCP/IP)
- Streaming, Video Calls, Online Gaming

PROS / CONS

+ Efficient & scalable
+ Robust in case of failures
– Possible delay variation
– Packets may arrive out of order

QUICK COMPARISON

Aspect	Circuit Switching	Message Switching	Packet Switching
Connection	Dedicated path	No dedicated path	No dedicated path
Data Unit	Continuous stream	Entire message	Small packets
Delivery	In-order, continuous	In-order	May be out of order
Efficiency	Low (if idle)	Low for large msgs	High
Examples	Telephone network	Email	Internet

Legend (Packet Diagram)

- Path 1
- Path 2
- Path 3
- Path 4

Packet Switching is the basis of Internet and most modern computer networks.

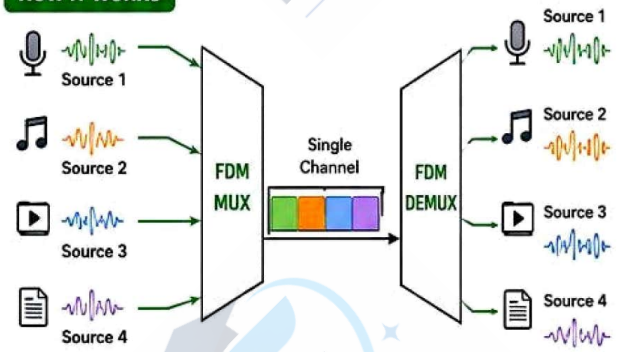
MULTIPLEXING: FREQUENCY DIVISION, TIME DIVISION

Multiplexing is a technique that allows multiple signals or data streams to share a single communication channel to improve bandwidth utilization and efficiency.

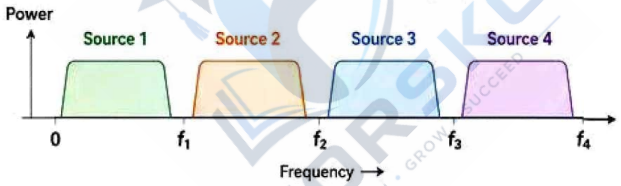
1. FREQUENCY DIVISION MULTIPLEXING (FDM)

The available bandwidth of a channel is divided into several frequency sub-bands. Each signal uses a different frequency band simultaneously.

HOW IT WORKS



FREQUENCY BAND ALLOCATION (Example)



ADVANTAGES

- ✓ Signals are transmitted simultaneously.
- ✓ High bandwidth utilization.
- ✓ Suitable for analog signals.

DISADVANTAGES

- ✗ Requires guard bands to prevent overlap.
- ✗ Complex and costly filters.
- ✗ Not efficient for digital data with bursts.

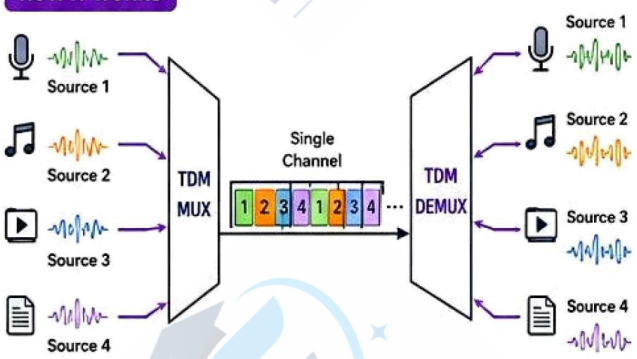
EXAMPLES / USE CASES

- Radio broadcasting (FM/AM)
- Cable TV
- Satellite communication
- Cellular networks (4G/5G)

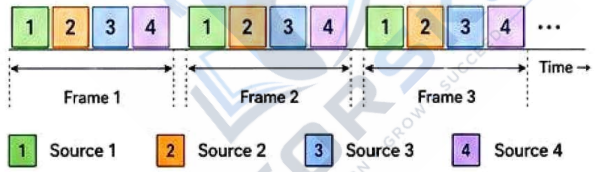
2. TIME DIVISION MULTIPLEXING (TDM)

The entire bandwidth is used by all signals, but each signal is allocated a specific time slot. Signals are transmitted in an interleaved manner.

HOW IT WORKS



TIME SLOT ALLOCATION (Example)



ADVANTAGES

- ✓ No guard bands required.
- ✓ Efficient for digital data.
- ✓ Easy to add/remove users.
- ✓ Better security.

DISADVANTAGES

- ✗ Requires precise time synchronization.
- ✗ Higher delay for more users.
- ✗ Not suitable for real-time continuous analog signals.

EXAMPLES / USE CASES

- Digital Telephony (T1, E1)
- SDH / SONET
- Computer Networks
- Multiplexing in Optical Fibers

QUICK COMPARISON

Aspect	FDM	TDM
Division Basis	Frequency (Different sub-bands)	Time (Different time slots)
Usage	All signals transmit simultaneously on different frequencies	Signals transmit in turns in time slots
Bandwidth	Total bandwidth is divided into sub-bands	Entire bandwidth is used by all signals
Guard Bands	Required between sub-bands	Not required
Best For	Analog signals, Broadcasting	Digital signals, Telephony, Data networks
Complexity	Requires complex filters	Requires synchronization
Examples	FM Radio, TV Broadcasting, Satellite	T1/E1 Lines, SDH, Optical Fiber Networks

KEY TAKEAWAY

FDM splits the channel by FREQUENCY.

TDM splits the channel by TIME.

Multiplexing increases efficiency by allowing multiple signals to share a single channel effectively.


1010101010
0101010101
1010101010
0101010101
</>
</>
Unit - IV
10110
01001
10101
DATA STRUCTURES
ALGORITHMS
COMPUTER NETWORKS
DATABASE SYSTEMS
#include <iostream>
using namespace std;
int main()
{
cout << "Hello, World!";
return 0;
}

INTERNET

The Internet is a global network of interconnected computers that communicate and share information with each other.

1. HISTORY OF INTERNET

- **1960s** — ARPANET was developed by the U.S. Department of Defense to connect research computers.
- **1969** — ARPANET goes live on 29 October 1969 with 4 nodes (UCLA, SRI, UCSB, Utah).
- **1970s** — Development of E-mail (1971) and TCP/IP protocol (1974) by Vint Cerf and Bob Kahn.
- **1983** — ARPANET adopted TCP/IP as the standard protocol.
- **1989–1991** — Tim Berners-Lee invented the World Wide Web (WWW). The first webpage and web server created.
- **1990s** — Internet becomes popular worldwide. Web browsers like Mosaic, Netscape and Internet Explorer were developed.
- **2000s–Present** — High-speed internet, mobile internet, social media, cloud computing and IoT have expanded the Internet to billions of users.

2. APPLICATIONS OF INTERNET

- **Communication** — E-mail, instant messaging, social media, video conferencing, VoIP.
- **Education** — E-learning, online courses, digital libraries, research, virtual classrooms.
- **Business & E-Commerce** — Online shopping, banking, digital payments, advertising, trading, cloud services.
- **Information Access** — Search engines, news, weather updates, online databases, government portals.
- **Entertainment** — Streaming movies, music, online games, social media, live events.
- **Social Networking** — Platforms like Facebook, Instagram, Twitter, LinkedIn connect people globally.
- **Healthcare** — Telemedicine, online appointments, health information, digital records.
- **Other Applications** — Online booking (travel, tickets), maps, IoT devices, smart homes, e-governance.

3. HOW INTERNET WORKS (In Brief)

A user sends a request → It goes through the device, ISP and Internet → reaches the server → required information is sent back to the user.

KEY POINTS

- ✓ Internet uses standard protocols like TCP/IP.
- ✓ It is a network of networks.
- ✓ It provides various services like WWW, E-mail, FTP, etc.

4. IMPORTANT INTERNET SERVICES

- **WWW (World Wide Web)** — Access to interlinked hypertext documents and multimedia resources.
- **E-mail** — Electronic mail to send and receive messages globally.
- **FTP (File Transfer Protocol)** — To transfer files between computers over the internet.
- **Telnet** — Remote login to access and manage another computer.
- **Cloud Services** — Store, manage and share data over the cloud.

5. ADVANTAGES

- Global communication becomes easy and fast.
- Provides vast amount of information instantly.
- Saves time and reduces costs.
- Supports education, business and entertainment.
- Enables online services 24x7.

6. DISADVANTAGES

- Security threats like hacking, malware, viruses.
- Privacy issues and data theft.
- Spread of misinformation and inappropriate content.
- Internet addiction and health issues.
- Dependence on technology.

The Internet has become an essential part of modern life, connecting the world and opening endless opportunities for learning, communication and growth.

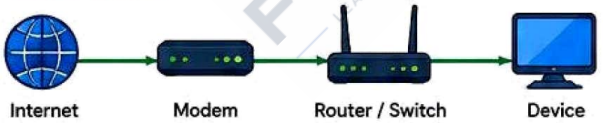
TYPES OF INTERNET CONNECTION: WIRED AND WIRELESS

Internet connections allow our devices to access the Internet.
They are mainly of two types: Wired and Wireless.

1. WIRED INTERNET CONNECTION

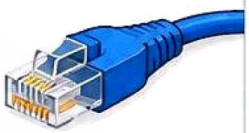
A wired connection uses physical cables to connect a device to the Internet. It provides a stable and fast connection with minimal interference.

HOW IT WORKS



COMMON WIRED CONNECTION TYPES

- Dial-up Connection
- Digital Subscriber Line (DSL)
- Cable Internet
- Fiber Optic Connection
- Leased Line



FEATURES

- ✓ Uses physical cables (e.g., Ethernet cable, coaxial cable, fiber optic).
- ✓ More stable and reliable.
- ✓ Faster speed and low latency.
- ✓ Less affected by interference.
- ✓ More secure than wireless connections.

ADVANTAGES

- ✓ High speed and performance
- ✓ Stable and reliable
- ✓ Low latency
- ✓ High security
- ✓ Suitable for gaming, streaming, and offices

DISADVANTAGES

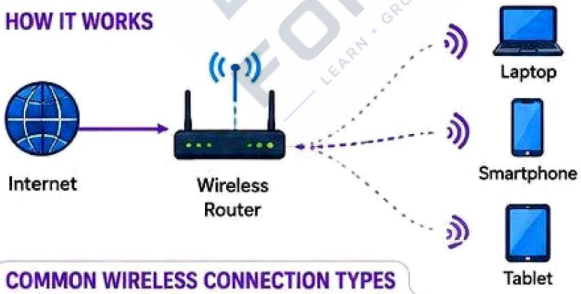
- ✗ Requires cables and hardware
- ✗ Limited mobility
- ✗ Installation cost may be high (especially fiber)
- ✗ Not convenient for moving devices

EXAMPLES / USE CASES

2. WIRELESS INTERNET CONNECTION

A wireless connection uses radio waves or signals to connect devices to the Internet without physical cables.

HOW IT WORKS



COMMON WIRELESS CONNECTION TYPES

- Wi-Fi (Wireless LAN)
- Mobile Data / 4G / 5G
- Satellite Internet
- WiMAX
- Bluetooth Tethering

FEATURES

- ✓ Uses radio waves or signals.
- ✓ Allows mobility and flexibility.
- ✓ Easy to set up and use.
- ✓ Speed and stability may be affected by distance, obstacles, and interference.

ADVANTAGES

- ✓ No cables required
- ✓ Easy installation
- ✓ Mobility and flexibility
- ✓ Connect multiple devices simultaneously
- ✓ Suitable for remote areas (mobile/satellite)

DISADVANTAGES

- ✗ Speed may be lower than wired
- ✗ Affected by distance and obstacles
- ✗ More prone to interference
- ✗ Security risks if not properly secured
- ✗ Data limits in mobile connections

EXAMPLES / USE CASES

QUICK COMPARISON

Aspect	Wired Connection	Wireless Connection
Medium	Uses physical cables	Uses radio waves / signals
Speed	Generally faster	Varies (depends on signal & distance)
Stability	Very stable	May be affected by interference
Mobility	Limited	High
Security	More secure	Less secure (needs encryption)
Installation	Complex (cable setup required)	Easy (no cables)
Cost	Higher initial cost (in some cases)	Lower initial cost

KEY POINTS

- Wired connections are ideal for high-speed, stable, and secure communication.
- Wireless connections are ideal for mobility, convenience, and easy access.

★ Choose the connection type based on your need for speed, mobility, stability, and convenience.

INTERNET PROTOCOLS: TCP/IP, FTP

Internet protocols are a set of rules that govern the format and exchange of data over the Internet. TCP/IP and FTP are the most widely used protocols.

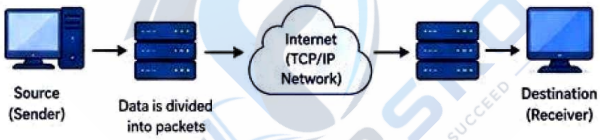
1. TCP/IP (Transmission Control Protocol / Internet Protocol)

TCP/IP is the foundation protocol suite of the Internet. It enables communication between devices across different networks.

TCP/IP MODEL (4 LAYERS)

4. Application Layer	Provides network services to user applications. Examples: HTTP, FTP, SMTP, DNS, Telnet
3. Transport Layer	Provides end-to-end communication. Ensures reliable data transfer using TCP; faster transfer using UDP.
2. Internet Layer	Responsible for logical addressing and routing of packets across networks using IP.
1. Network Access Layer	Handles data transmission over the physical network. Examples: Ethernet, Wi-Fi, PPP.

HOW TCP/IP WORKS



Data is broken into packets, addressed, transmitted, routed through multiple networks and reassembled at the destination.

KEY FEATURES

- ✓ Connection-oriented (TCP)
- ✓ Reliable and orderly delivery
- ✓ Error detection and correction
- ✓ Flow control and congestion control
- ✓ Works across different networks

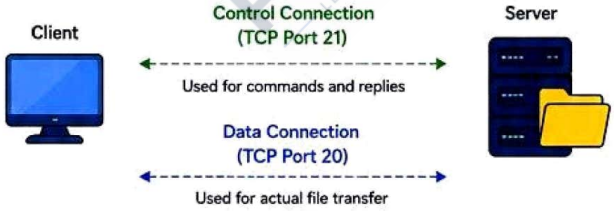
COMMON EXAMPLES

- Web browsing (HTTP uses TCP/IP)
- E-mail (SMTP, IMAP, POP3 use TCP/IP)
- File transfer (FTP uses TCP/IP)
- Online gaming, video streaming, etc.

2. FTP (File Transfer Protocol)

FTP is an application layer protocol used to transfer files between a client and a server over a TCP/IP network.

HOW FTP WORKS



FTP OPERATION

1. User connects to FTP server using a client.
2. Control connection is established on port 21.
3. User sends commands (e.g., USER, PASS, LIST, RETR, STOR).
4. Server replies to commands.
5. Data connection is established on port 20 for file transfer.
6. File is transferred and connection is closed.

FEATURES

- ✓ File transfer protocol
- ✓ Supports upload and download
- ✓ Separate control and data connections
- ✓ Supports authentication
- ✓ Can transfer text and binary files

FTP COMMANDS (Examples)

USER	– Sends username
PASS	– Sends password
LIST	– Lists files in directory
RETR	– Downloads a file
STOR	– Uploads a file
QUIT	– Closes the connection

TYPES OF FTP

- **Active FTP** : Server initiates the data connection to the client.
- **Passive FTP** : Client initiates both control and data connections.

USES / APPLICATIONS

Website Management | Uploading Web Pages | Downloading Files | Backup and Data Transfer

QUICK COMPARISON

Aspect	TCP/IP	FTP
Full Form	Transmission Control Protocol / Internet Protocol	File Transfer Protocol
Type	Protocol Suite (Collection of protocols)	Application Layer Protocol
Purpose	Provides end-to-end communication across networks	Transfers files between client and server
Layer (OSI)	All layers (Internet Model – 4 layers)	Application Layer
Connection	Connection-oriented (TCP) / Connectionless (IP)	Connection-oriented (TCP)
Ports	Uses multiple ports (e.g., 80, 443, 25, 53, etc.)	20 (Data), 21 (Control)
Examples	HTTP, HTTPS, SMTP, DNS, Telnet, FTP, etc.	File upload/download, website management
Dependence	Works as the base for most Internet services	Runs on top of TCP/IP

KEY TAKEAWAY

TCP/IP

It is the backbone of the Internet. It ensures that data is delivered from source to destination reliably and efficiently using the TCP and IP protocols.

FTP

It is used to transfer files between systems on the Internet. It provides simple and efficient file transfer using commands.

TCP/IP connects the world. FTP helps move your files across it.

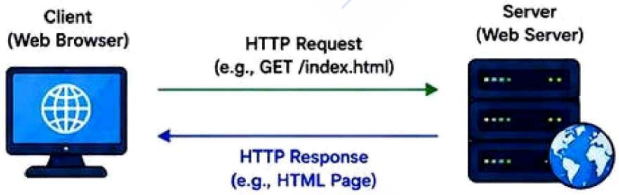
INTERNET PROTOCOLS: HTTP, URL

Internet protocols are rules and conventions that allow communication and exchange of data over the Internet.

1. HTTP (HYPERTEXT TRANSFER PROTOCOL)

HTTP is an application layer protocol used for transmitting hypertext (web pages) and other resources on the World Wide Web.

HOW HTTP WORKS



The client (browser) sends an HTTP request to the server.
The server processes the request and sends back an HTTP response.

FEATURES OF HTTP

- ✓ Connectionless protocol (uses TCP for reliable transfer)
- ✓ Stateless (server does not keep track of previous requests)
- ✓ Works on request-response model
- ✓ Uses methods like GET, POST, PUT, DELETE, etc.
- ✓ Default port: 80 (HTTP), 443 (HTTPS – secure HTTP)

COMMON HTTP METHODS

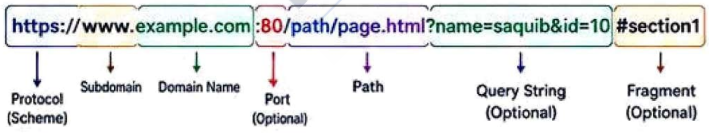
Method	Description
GET	Requests data from the server.
POST	Sends data to the server to create/update a resource.
PUT	Updates the entire resource on the server.
DELETE	Deletes the specified resource from the server.
HEAD	Requests headers only (no response body).
OPTIONS	Describes the communication options for the target resource.

USES / APPLICATIONS

2. URL (UNIFORM RESOURCE LOCATOR)

URL is the address of a resource on the Internet. It specifies where a resource is located and how to access it.

STRUCTURE OF URL



Component	Description
Protocol (Scheme)	Defines the protocol to access the resource (e.g., http, https, ftp).
Subdomain	Identifies a subdomain (e.g., www, mail).
Domain Name	Main address of the website (e.g., example.com).
Port	Specifies the port number (optional). (Default: 80 for HTTP, 443 for HTTPS)
Path	Specifies the exact location of the resource on the server.
Query String	Sends additional data to the server in key=value pairs.
Fragment	Points to a specific part of a page (used in HTML).

EXAMPLE & EXPLANATION

https://www.example.com:80/path/page.html?name=saquib&id=10#section1

https	: Protocol used for secure connection.
www	: Subdomain.
example.com	: Domain name of the website.
:80	: Port number (optional).
/path/page.html	: Path of the specific page on the server.
?name=saquib&id=10	: Query string with parameters.
#section1	: Fragment – points to a section on the page.

USES / APPLICATIONS

QUICK COMPARISON

Aspect	HTTP	URL
Full Form	HyperText Transfer Protocol	Uniform Resource Locator
Type	Protocol	Address (Locator)
Purpose	Defines how data is transferred between client and server	Defines where a resource is located on the Internet
Layer (OSI)	Application Layer	Not a protocol (name/format)
Example	HTTP, HTTPS	https://www.example.com/index.html
Port	80 (HTTP), 443 (HTTPS)	May include port (e.g., :80)
Works With	TCP (Reliable transport)	Uses various protocols (HTTP, HTTPS, FTP, etc.)

KEY TAKEAWAY

- HTTP is the protocol used to communicate between a client (browser) and a web server.
- It defines the rules for sending requests and receiving responses.
- HTTPS is the secure version of HTTP.

- URL is the address of a resource on the Internet.
- It tells the browser what resource to access and where it is located.
- It has components like protocol, domain, path, query, and fragment.

HTTP handles the communication, while URL tells where the resource is located.

INTERNET CONCEPTS: WEB BROWSERS, SEARCH ENGINES

The Internet becomes useful for us through tools that help us access information. Web browsers help us access web pages, and search engines help us find the information we need on the web.

1. WEB BROWSERS

A web browser is a software application that allows users to access, retrieve and view information on the World Wide Web.

HOW WEB BROWSERS WORK

1. You enter a URL or click a link.
2. Browser asks DNS to find the IP address.
3. Browser sends request to the web server.
4. Server sends the web page (HTML, CSS, JS).
5. Browser displays the web page to the user.

FEATURES OF WEB BROWSERS

- ✓ Access and display web pages.
- ✓ Navigate using links.
- ✓ Support for multimedia (images, audio, video).
- ✓ Store bookmarks and history.
- ✓ Manage downloads.
- ✓ Provide security and privacy features.

POPULAR WEB BROWSERS

Google Chrome, Mozilla Firefox, Microsoft Edge, Safari, Opera

WEB BROWSER FUNCTIONS

Function	Description
Address Bar	Enter URL of the website.
Navigation Buttons	Back, Forward, Reload, Home.
Tabs	Open multiple web pages in one window.
Bookmarks	Save important websites for quick access.
History	View previously visited websites.
Downloads	Download files from the Internet.
Settings	Customize privacy, security and appearance.

ADVANTAGES

- ✓ Easy access to information.
- ✓ User-friendly interface.
- ✓ Supports rich content.
- ✓ Saves time and effort.
- ✓ Secure browsing options.

EXAMPLES OF USE

- Online learning
- Online shopping
- Reading news
- Access web applications

2. SEARCH ENGINES

A search engine is a web-based tool that helps users find information on the Internet by entering keywords or phrases.

HOW SEARCH ENGINES WORK

1. User types a query (keywords).
2. Search engine scans its index (database).
3. Finds relevant pages matching the query.
4. Displays results ranked by relevance.

MAIN FUNCTIONS

- Crawl: Search engine bots (spiders) crawl the web pages.
- Index: Information from pages is stored in a huge database.
- Retrieve: Relevant pages are fetched when a query is made.
- Rank: Pages are ranked based on relevance and algorithms.
- Display: Results are shown to the user.

POPULAR SEARCH ENGINES

Google, Bing, Yahoo!, DuckDuckGo, Baidu

TYPES OF SEARCH ENGINES

- General Search Engines: Google, Bing, Yahoo (search all types of content).
- Specialized Search Engines: Search within a specific domain or topic. (e.g., PubMed for medical, Google Scholar for academic)
- Meta Search Engines: Collect results from multiple search engines. (e.g., Dogpile, MetaCrawler)

ADVANTAGES

- ✓ Find information quickly.
- ✓ Access to vast amount of data.
- ✓ Free and easy to use.
- ✓ Helps in learning, research and decision making.

EXAMPLES OF USE

- Finding information
- Academic research
- Travel planning
- Product search
- Latest news

QUICK COMPARISON

Aspect	Web Browsers	Search Engines
Definition	Software used to access and view web pages.	Web-based tools used to find information on the Internet.
Purpose	To display content from websites.	To search and provide relevant information.
Input	URL or web address.	Keywords or phrases.
Output	Web pages, multimedia content.	List of relevant web pages.
Examples	Chrome, Firefox, Edge, Safari, Opera	Google, Bing, Yahoo, DuckDuckGo
Type	Client application (installed software)	Web service (accessed online)
Role	Helps you access the Internet.	Helps you find information on the Internet.

KEY TAKEAWAY

Web browsers are the gateway to the Internet. They help you open, view and interact with web pages.

Search engines help you find the right information from billions of web pages in seconds.

Browser + Search Engine = Powerful way to explore the Internet and gain knowledge!

Web browsers take you to the web, and search engines help you find what you need on the web.

INTERNET CONCEPTS: E-MAIL ADDRESS, WWW

The Internet provides many services to communicate, share and access information.
E-mail helps us send messages, while WWW helps us access information on web pages.

1. E-MAIL ADDRESS

E-mail (Electronic Mail) is a service that allows users to send and receive messages over the Internet.

STRUCTURE OF E-MAIL ADDRESS

saquib.official123 @ gmail . com

Username (Unique name of the user)	At the Rate Symbol	Domain Name (Name of the mail server)	Top Level Domain (Type of organization)

EXAMPLE OF E-MAIL ADDRESSES

- student2024@rediffmail.com
- info@college.ac.in
- helpdesk123@yahoo.com

HOW E-MAIL WORKS

Sender → Outgoing Mail Server → Internet → Incoming Mail Server → Receiver

FEATURES

- ✓ Allows sending text, documents, images, videos, etc.
- ✓ Fast and cost-effective.
- ✓ Supports multiple recipients (To, CC, BCC).
- ✓ Can be accessed anytime, anywhere.
- ✓ Secure through passwords and encryption.

ADVANTAGES

- ★ Quick communication.
- ★ Saves time and paper.
- ★ Easy to store and manage.
- ★ Environment friendly.
- ★ Supports attachments.

COMMON E-MAIL SERVICES

Gmail · Outlook · Yahoo Mail · Rediffmail · Zoho Mail

2. WWW (WORLD WIDE WEB)

WWW (World Wide Web) is a system of interlinked hypertext documents accessed through the Internet using a web browser.

HOW WWW WORKS

1	2	3	4	5
User enters a URL in the web browser.	DNS translates the domain name into IP address.	Web server processes the request.	Server sends the web page (HTML) to the browser.	Browser displays the web page to the user.

EXAMPLE OF URL

https:// www . example . com/index.html

Protocol (Method of access)	Subdomain (Web server)	Domain Name (Name of the website)	Top Level Domain (Type)	Path / File (Web page on server)

FEATURES

- ✓ Access to information worldwide.
- ✓ Uses hyperlinks to connect documents.
- ✓ Multimedia support (text, images, audio, video).
- ✓ Available 24×7.
- ✓ Easy to use through browsers.

USES / APPLICATIONS

- Browse websites.
- Read news, articles, blogs.
- Online shopping and banking.
- E-learning and research.
- Entertainment (videos, music, games, etc.)

POPULAR WEB BROWSERS

Google Chrome · Mozilla Firefox · Microsoft Edge · Safari · Opera

QUICK COMPARISON

Aspect	E-Mail	WWW
Full Form	Electronic Mail	World Wide Web
Purpose	Send and receive messages	Access and view web pages
Type	Communication Service	Information Service
Address/Identifier	E-mail Address (username@domain.com)	URL (Uniform Resource Locator)
Protocol Used	SMTP, POP3, IMAP	HTTP/HTTPS
Accessed Using	E-mail Client / Webmail	Web Browser
Example	saquib123@gmail.com	https://www.example.com

KEY TAKEAWAY

E-mail helps us communicate with others by sending messages and attachments.

WWW helps us access a huge amount of information through web pages on the Internet.

★ E-mail connects people, and WWW connects information to the world.