UNIT-I

Data Communication and Computer Networks

Data is raw, unorganized facts, figures, observations, or symbols that lack inherent meaning until processed and analyzed. It acts as the building block of information and can exist in formats such as numbers, text, images, audio, and video. Data is widely collected for analysis to identify trends and drive decisions.

In simple terms, data is **raw information** before it is processed into something meaningful.

Data is any collection of facts, figures, or information that can be recorded and used for analysis or decision-making.

Key idea:

- **Data → processed → becomes information**

For example:

- Data: 85, 90, 78
- Information: "The average score is 84.3"

Types of data:

1. **Qualitative data** – descriptive (e.g., color, name)
2. **Quantitative data** – numerical (e.g., age, marks)

Raw data is data in its **original, unprocessed form** — it has not been organized, analyzed, or interpreted yet.

Simple explanation:

Raw data = **data before it is made meaningful**

Examples:

- Exam scores collected: 45, 78, 90, 66
- Survey answers: "Yes, No, Yes, Yes"

- Temperature readings taken every hour
- Names entered into a system without sorting

After processing:

- Raw data: 45, 78, 90, 66
- Processed (information): “The highest score is 90 and the average is 69.75”

Key characteristics of raw data:

- Unorganized
- Not summarized
- May contain errors
- Hard to understand directly

Facts are **true pieces of information** that can be **proven or verified**.

Simple explanation:

Facts = **statements that are real and correct**

Examples of facts:

- The sun rises in the east
- Water boils at 100°C (under normal conditions)
- Dar es Salaam is a city in Tanzania
- 2 + 2 = 4

In relation to data:

- **Data is made up of facts**
- When facts (data) are processed, they become **information**

Key characteristics of facts:

- True and objective
- Can be checked or proven
- Not based on opinion or feelings

What is Data Communication?

Communication is the process of sending, receiving, and understanding information between two or more people or devices**.**

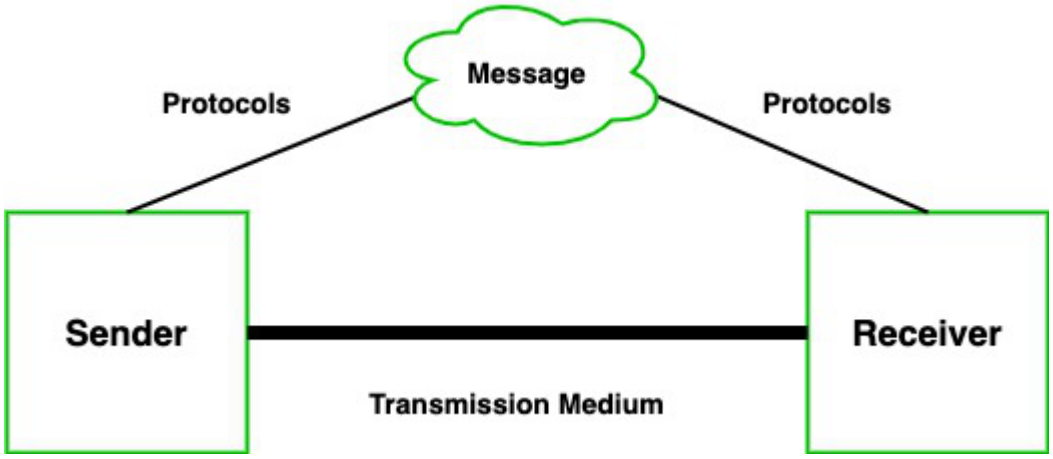
Data Communications is the transferring data over a transmission medium between two or more devices, systems.

Nowadays, computing and telecommunications depend heavily on this data transmission, which makes a variety of applications conceivable, including email, video chatting, the Internet, and many more things.

Components of Data Communication

A communication system is made up of the following components:

1. **Message:** A message is a piece of information that is to be transmitted from one person to another. It could be a text file, an audio file, a video file, etc.
2. **Sender:** It is simply a device that sends data messages. It can be a computer, mobile, telephone, laptop, video camera, or workstation, etc.
3. **Receiver:** It is a device that receives messages. It can be a computer, telephone mobile, workstation, etc.
4. **Transmission Medium / Communication Channels:** Communication channels are the medium that connect two or more workstations. Workstations can be connected by either wired media or wireless media.
5. **Set of rules (Protocol):** When someone sends the data (The sender), it should be understandable to the receiver also otherwise it is meaningless. For example, Sonali sends a message to Chetan. If Sonali writes in Hindi and Chetan cannot understand Hindi, it is a meaningless conversation.



Therefore, there are some set of rules (protocols) that is followed by every computer connected to the internet and they are:

- **TCP (Transmission Control Protocol)**: It is responsible for dividing messages into packets on the source computer and reassembling the received packet at the destination or recipient computer. It also makes sure that the packets have the information about the source of the message data, the destination of the message data, the sequence in which the message data should be re-assembled, and checks if the message has been sent correctly to the specific destination.
- **IP (Internet Protocol)**: Do you ever wonder how computer determines which packet belongs to which device. What happens if the message you sent to your friend is received by your father? Scary Right. Well! IP is responsible for handling the address of the destination computer so that each packet is sent to its proper destination.

Type of data communication

As we know that data communication is communication in which we can send or receive data from one device to another. The data communication is divided into three types:

1. **Simplex Communication:** It is one-way communication or we can say that unidirectional communication in which one device only receives and another device only sends data and devices uses their entire capacity in transmission. For example, IoT, entering data using a keyboard, listening music using a speaker, etc.
2. **Half Duplex communication:** It is a two-way communication, or we can say that it is a bidirectional communication in which both the devices can send and receive data but not at the same time. When one device is sending data then another device is only receiving and vice-versa. For example, walkie-talkie.
3. **Full-duplex communication:** It is a two-way communication or we can say that it is a bidirectional communication in which both the devices can send and receive data at the same time. For example, mobile phones, landlines, etc.

Communication Channels

Communication channels are the medium that connects two or more workstations. Workstations can be connected by either wired media or wireless media. It is also known as a transmission medium. The transmission medium or channel is a link that carries messages between two or more devices.

We can group the communication media into two categories:

- Guided media transmission
- Unguided media transmission

1. Guided Media: In this transmission medium, the physical link is created using wires or cables between two or more computers or devices, and then the data is transmitted using these cables in terms of signals.

Guided media transmission of the following types:

i. **Twisted pair cable:** It is the most common form of wire used in communication. In a twisted-pair cable, two identical wires are wrapped together in a double helix. The twisting of the wire reduces the crosstalk. It is known as the leaking of a signal from one wire to another due to which signal can corrupt and can cause network errors. The twisting protects the wire from internal crosstalk as well as external forms of signal interference. Types of Twisted Pair Cable :

ii. **Unshielded Twisted Pair (UTP):** It is used in computers and telephones widely. As the name suggests, there is no external shielding so it does not protects from external interference. It is cheaper than STP.

iii. **Shielded Twisted Pair (STP):** It offers greater protection from crosstalk due to shield. Due to shielding, it protects from external interference. It is heavier and costlier as compare to UTP.

2. Coaxial Cable: It consists of a solid wire core that is surrounded by one or more foil or wire shields. The inner core of the coaxial cable carries the signal and the outer shield provides the ground. It is widely used for television signals and also used by large corporations in building security systems. Data transmission of this cable is better but expensive as compared to twisted pair.

3. Optical fibers: Optical fiber is an important technology. It transmits large amounts of data at very high speeds due to which it is widely used in internet cables. It carries data as a light that travels inside a thin glass fiber.

The fiber optic cable is made up of three pieces:

i. **Core:** Core is the piece through which light travels. It is generally created using glass or plastic.

ii. **Cladding:** It is the covering of the core and reflects the light back to the core.

iii. **Sheath:** It is the protective covering that protects fiber cable from the environment.

4. **Unguided Media:** The unguided transmission media is a transmission mode in which the signals are propagated from one device to another device wirelessly. Signals can wave through the air, water, or vacuum. It is generally used to transmit signals in all directions.

Unguided Media is further divided into various parts:

i. **Microwave:** Microwave offers communication without the use of cables. Microwave signals are just like radio and television signals. It is used in long-distance communication. Microwave transmission consists of a transmitter, receiver, and atmosphere. In microwave communication, there are parabolic antennas that are mounted on the towers to send a beam to another antenna. The higher the tower, the greater the range.

ii. **Radio wave:** When communication is carried out by radio frequencies, then it is termed radio waves transmission. It offers mobility. It is consists of the transmitter and the receiver. Both use antennas to radiate and capture the radio signal.

iii. **Infrared:** It is short-distance communication and can pass through any object. It is generally used in TV remotes, wireless mouse, etc.

Data Representation

Data representation is the **method of converting data into a form that a computer can understand and process**.

Simple explanation:

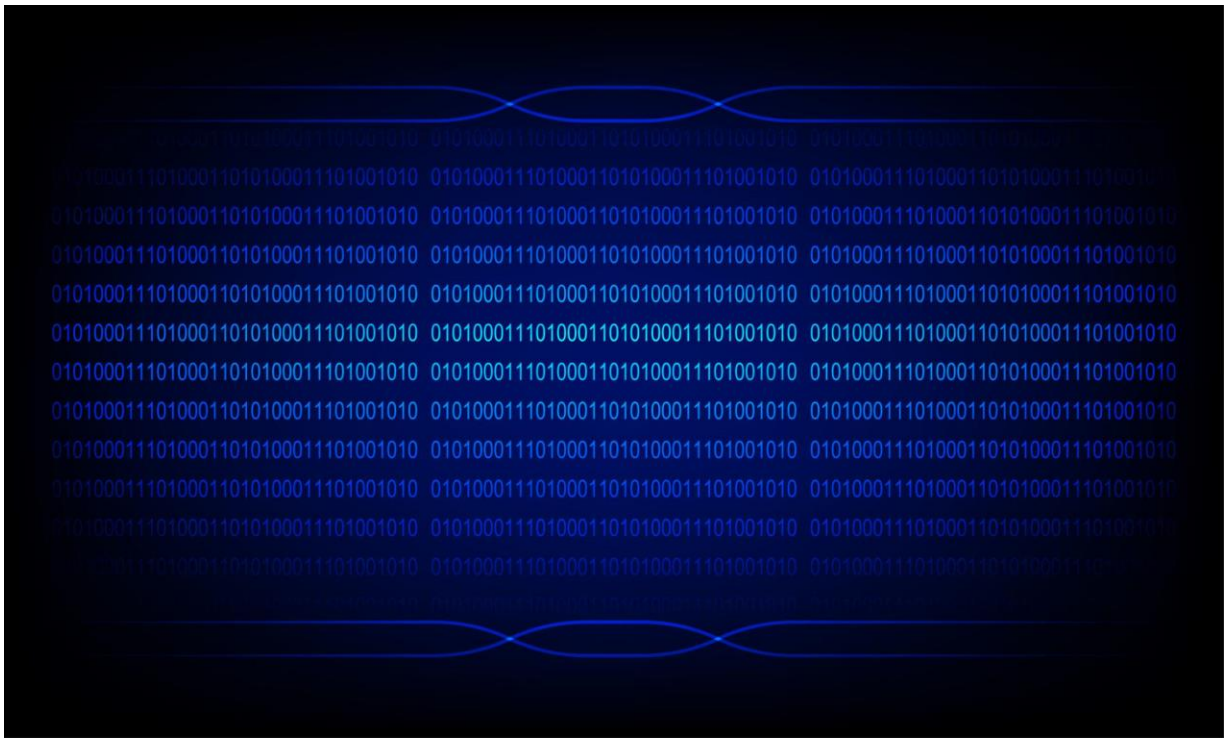
Data representation = **how data is stored inside a computer**

Why it is needed:

Computers do not understand letters, images, or sounds directly — they only understand **binary (0 and 1)**. So all data must be converted into binary form.

Common types of data representation:

1. Binary representation





- Uses only **0 and 1**
- Example: Number 5 = **101**

2. Text representation

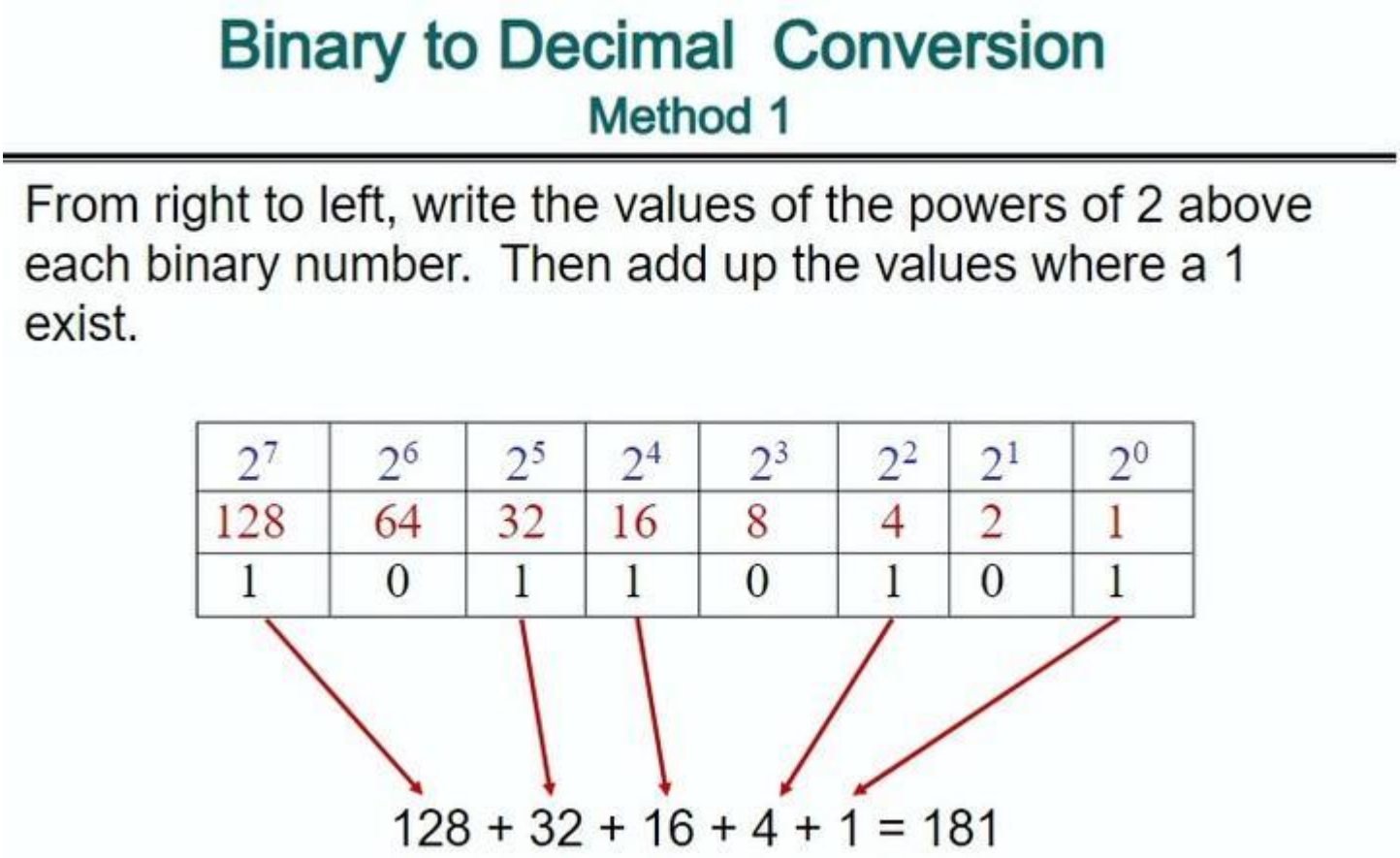
Regular ASCII Chart (character codes 0 - 127)

000		(nul)	016	►	(dle)	032	sp	048	0	064	@	080	P	096	`
001	☺	(soh)	017	◄	(dc1)	033	!	049	1	065	A	081	Q	097	a
002	☻	(stx)	018	↕	(dc2)	034	"	050	2	066	B	082	R	098	b
003	♥	(etx)	019	‼	(dc3)	035	#	051	3	067	C	083	S	099	c
004	♦	(eot)	020	¶	(dc4)	036	$	052	4	068	D	084	T	100	d
005	♣	(enq)	021	§	(nak)	037	%	053	5	069	E	085	U	101	e
006	♠	(ack)	022	▬	(syn)	038	&	054	6	070	F	086	V	102	f
007	•	(bel)	023	↨	(etb)	039	'	055	7	071	G	087	W	103	g
008	◘	(bs)	024	↑	(can)	040	(	056	8	072	H	088	X	104	h
009		(tab)	025	↓	(em)	041	)	057	9	073	I	089	Y	105	i
010		(lf)	026		(eof)	042	*	058	:	074	J	090	Z	106	j
011	♂	(vt)	027	←	(esc)	043	+	059	;	075	K	091	[	107	k
012	♀	(np)	028	∟	(fs)	044	,	060	<	076	L	092	\	108	l
013		(cr)	029	↔	(gs)	045	-	061	=	077	M	093	]	109	m
014	♫	(so)	030	▲	(rs)	046	.	062	>	078	N	094	^	110	n
015	☼	(si)	031	▼	(us)	047	/	063	?	079	O	095	_	111	o

ASCII Vs UNICODE

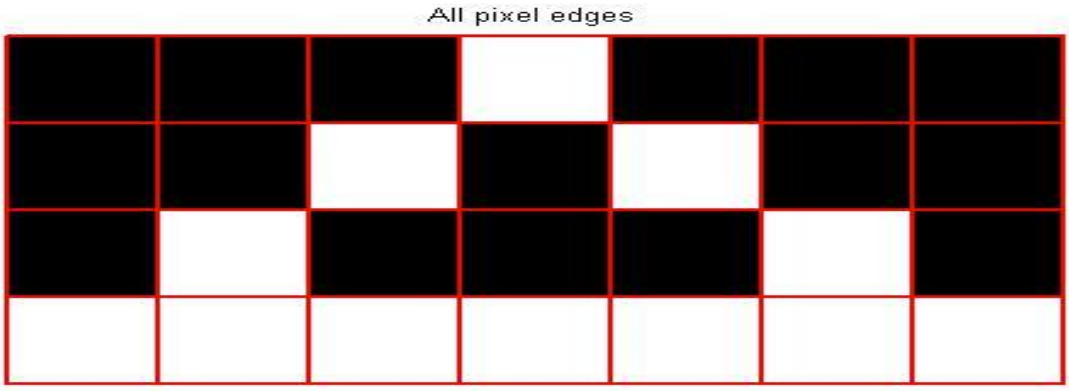
ASCII	UNICODE
A character encoding standard for electronic communication	A computing industry standard for consistent encoding, representation, and handling of text expressed in most of the world's writing systems
Stands for American Standard Code for Information Interchange	Stands for Universal Character Encoding
Supports 128 characters	Supports a wide range of Character set
Uses 7 bits to represent a character	Uses 8 bit, 16 bit or 32 bit depending on the encoding type
Requires less space	Requires more space

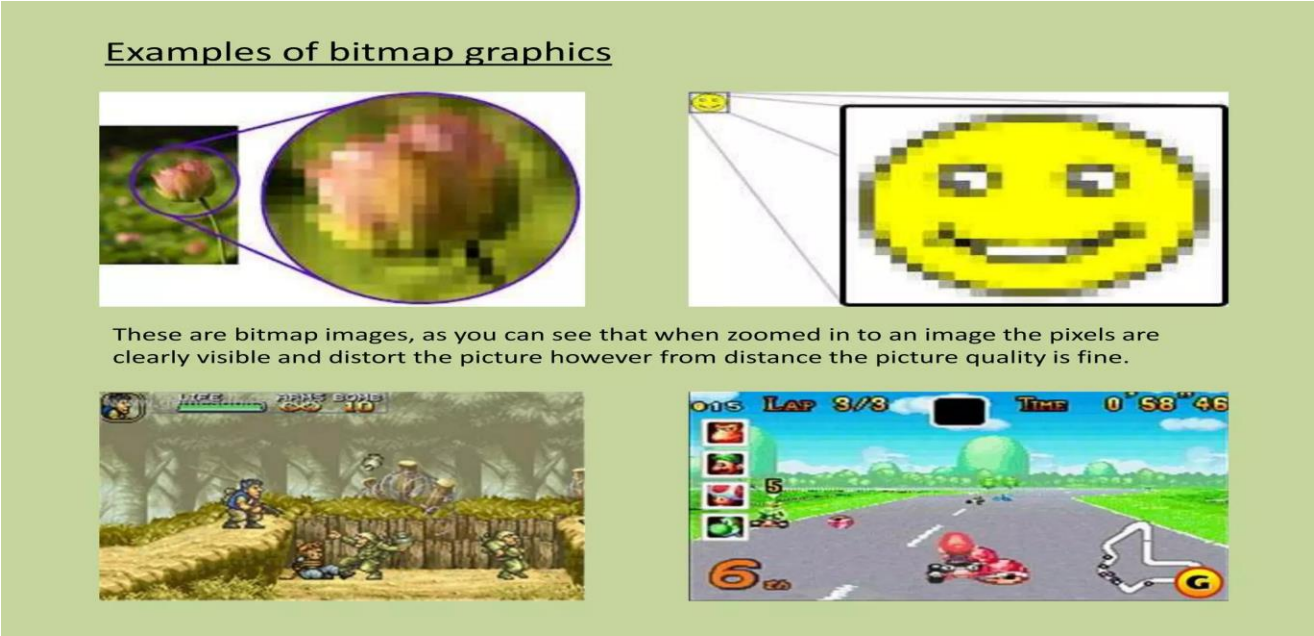
3. Number representation



- Numbers stored in binary, decimal, or hexadecimal
- Used for calculations

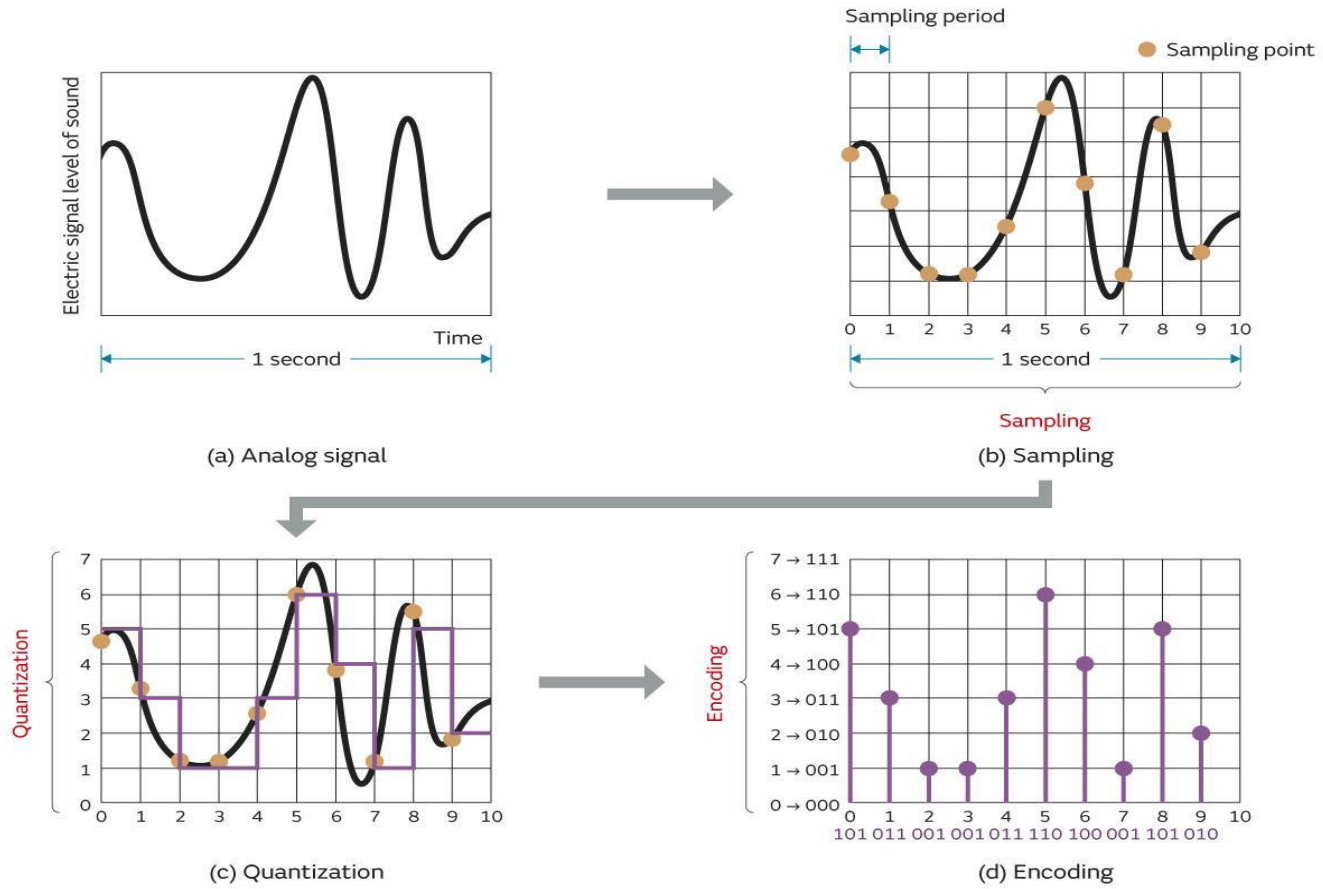
4. Image representation





- Images are made of **pixels**
- Each pixel has a color value

5. Sound representation



Network

Network (computer network) **is a** group of interconnected devices (computers, phones, printers, servers) that communicate and share resources.

Simple explanation:

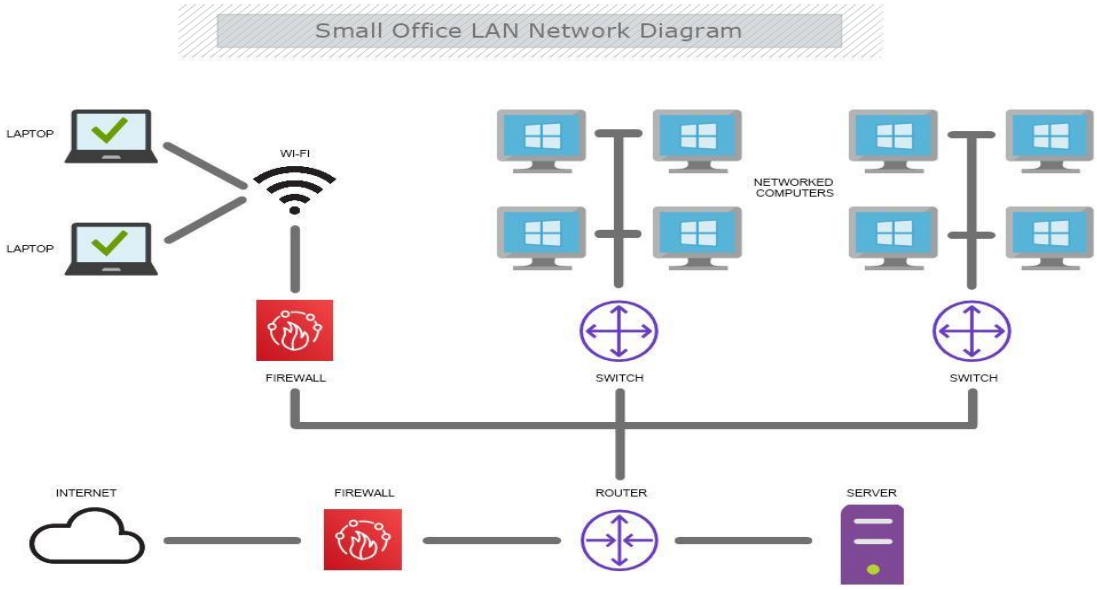
Network = **devices connected together to share data**

Example:

- Computers in a school lab connected together
- Phones connected through Wi-Fi
- Offices sharing printers and internet

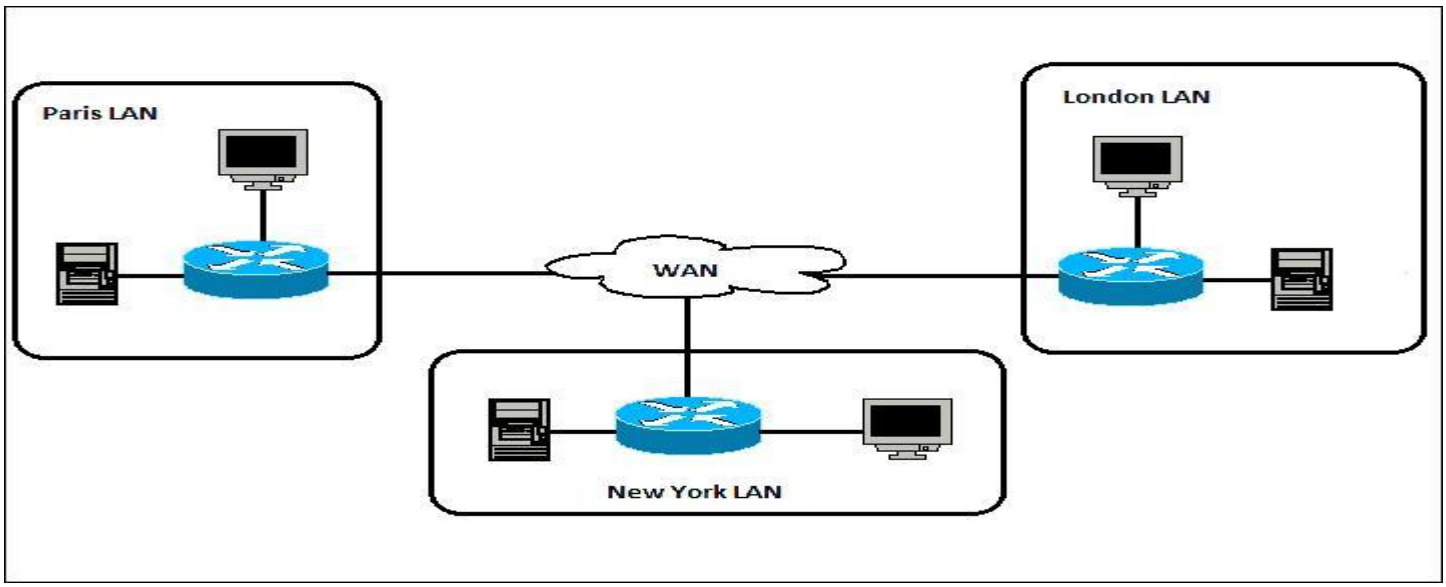
Types of networks:

1. LAN (Local Area Network)



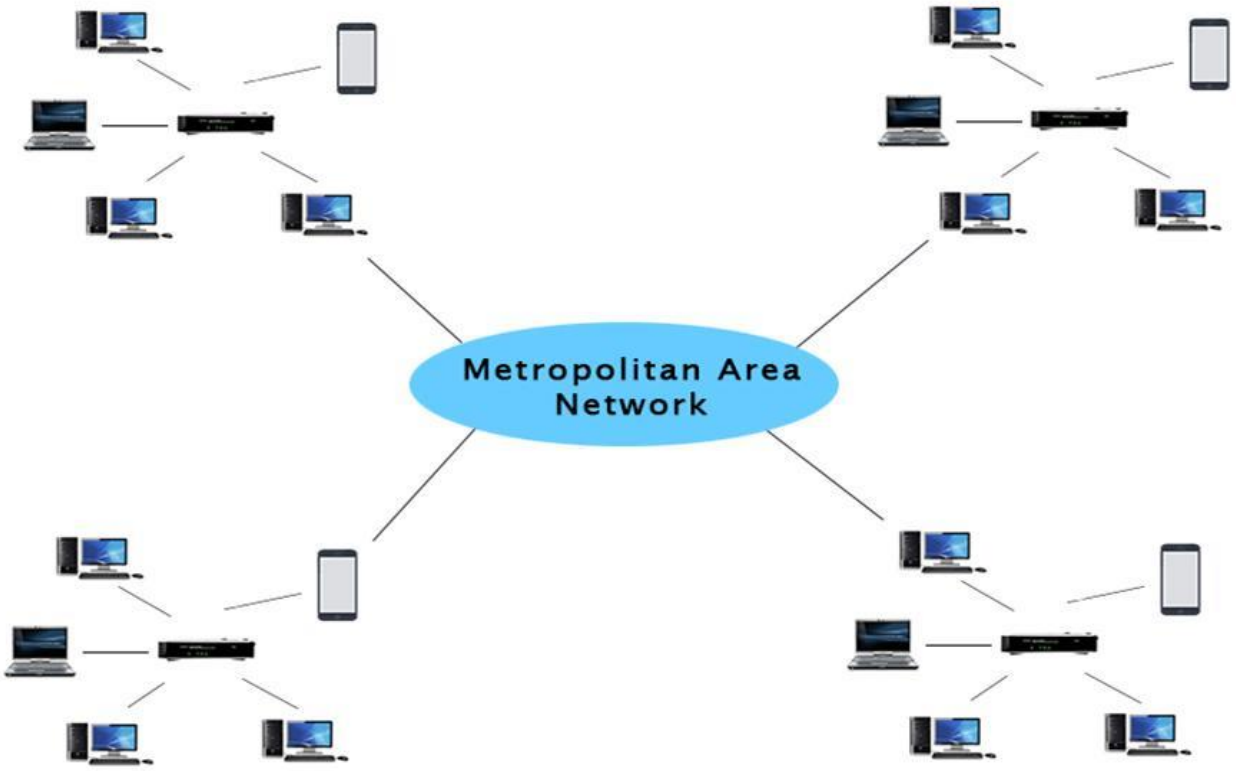
- Covers a small area (home, office, school)
- Fast and reliable

2. WAN (Wide Area Network)



- Covers large areas (countries, world)
- Example: the **Internet**

3. MAN (Metropolitan Area Network)



- Covers a city or large town

Components of a network:

- **Devices** – computers, phones
- **Transmission media** – cables (fiber, Ethernet) or wireless
- **Network devices** – routers, switches
- **Protocols** – rules for communication (e.g., TCP/IP)

Uses of a computer network

1. Resource sharing

- Share hardware like printers and scanners
- Share files and storage
- Saves cost and improves efficiency

2. Communication

- Email, messaging, video calls
- Fast communication worldwide

3. Internet access

- Access websites and online services
- Research, learning, entertainment

4. Data sharing

- Easy transfer of data between users
- Supports teamwork and collaboration

5. Centralized management

- Control users, data, and security from one place
- Easier backup and maintenance

6. Entertainment

- Online games
- Streaming music and videos

6. Remote access

Network Topologies

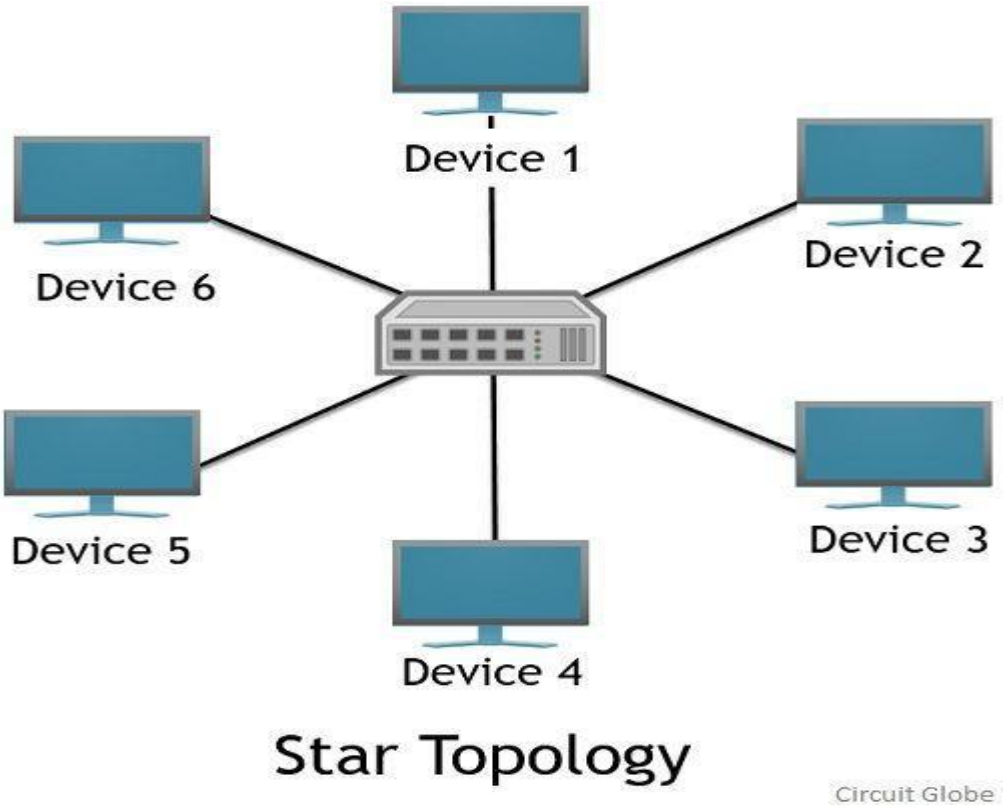
Network topologies are the physical or logical layouts of how devices are connected in a network**.**

Simple explanation:

Network topology = **the shape or structure of a network**

Common types of network topologies:

1. Star Topology



- All devices connect to a **central device** (switch or hub)
- Most common in modern networks

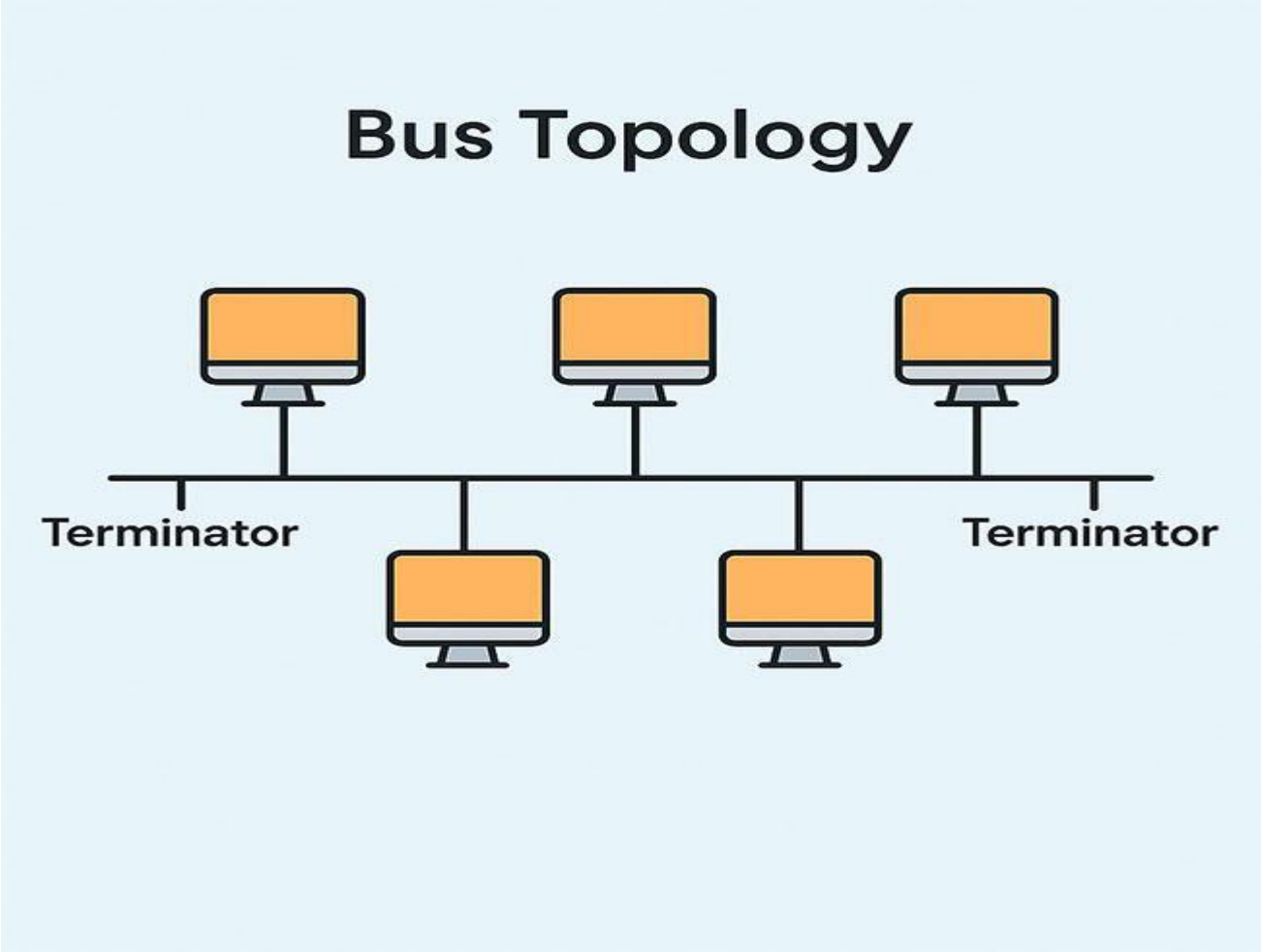
Advantages:

- Easy to manage
- Easy to add/remove devices

Disadvantages:

- If central device fails, network stops

2. Bus Topology



- All devices share a **single cable (backbone)**

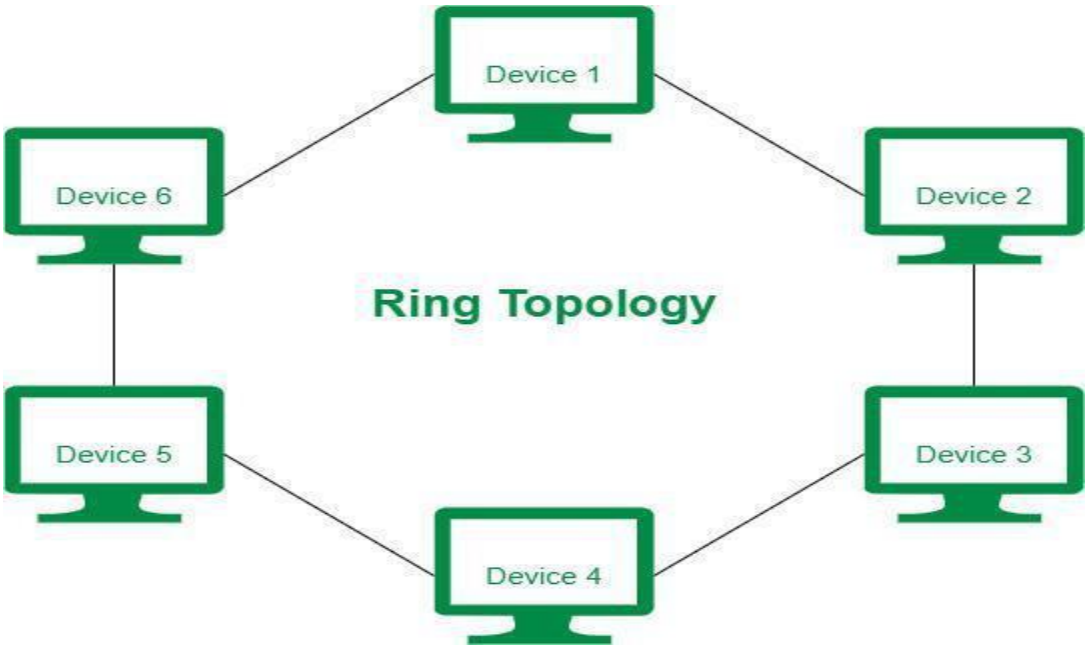
Advantages:

- Simple and cheap

Disadvantages:

- If cable fails, whole network fails
- Slow with many devices

3. Ring Topology



- Devices connected in a **circular form**

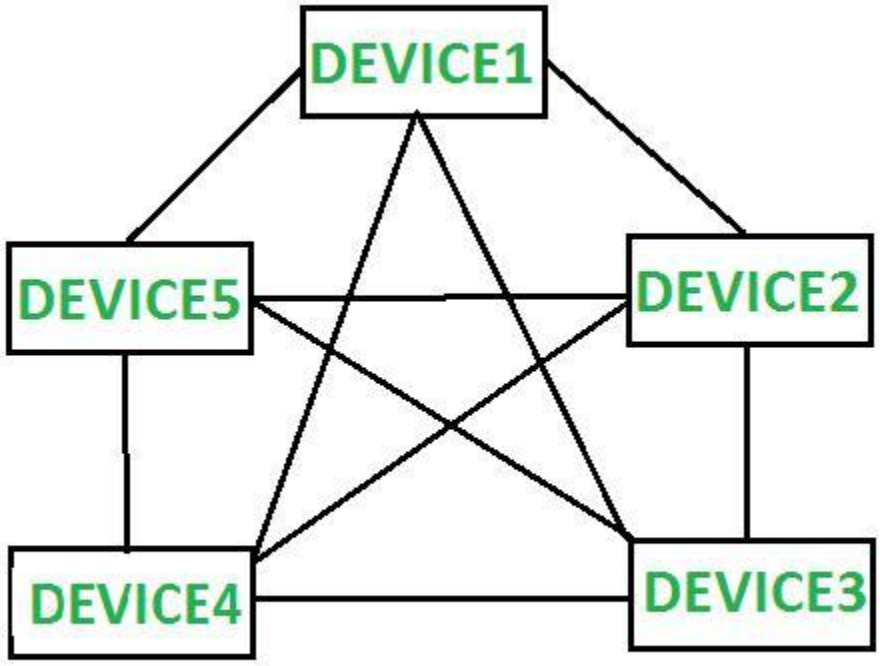
Advantages:

- Data flows in one direction, reducing collisions

Disadvantages:

- Failure of one device affects all

4. Mesh Topology



Every device connects to **many or all others**

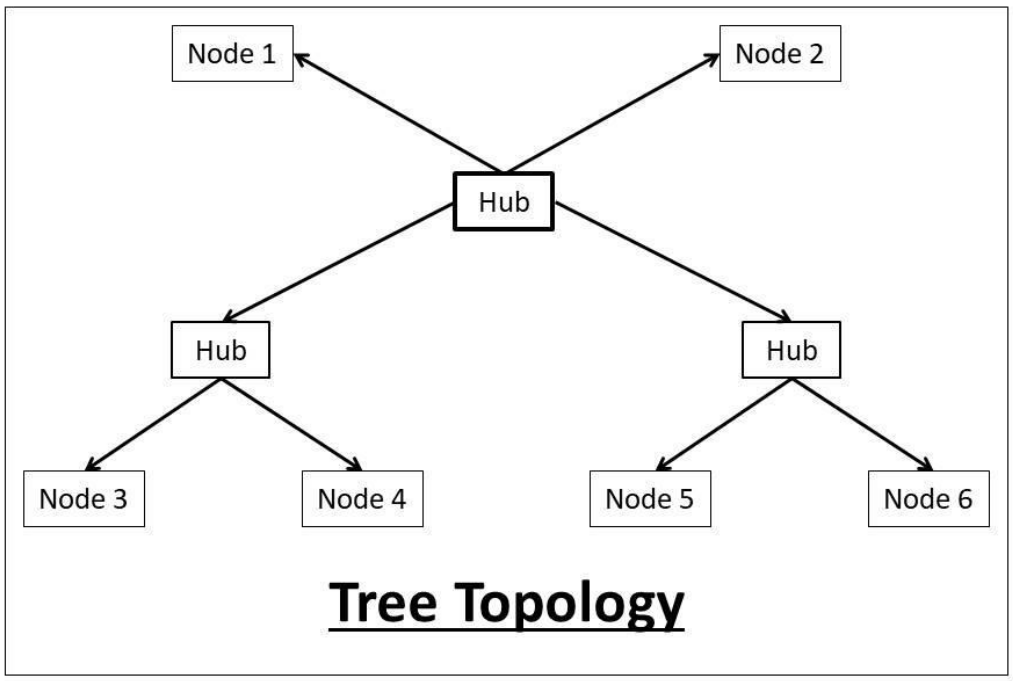
Advantages:

- Very reliable
- High redundancy

Disadvantages:

- Expensive and complex

5. Tree Topology



- Combination of **star and bus**
- Has a hierarchical structure

Advantages:

- Scalable
- Easy to manage large networks

Disadvantages:

- Depends on main backbone

Hybrid Topology

Hybrid topology is a **network topology that combines two or more different topologies** (such as star, bus, or ring) into one network.

Simple explanation:

Hybrid topology = **a mixture of different network layouts**

Example:

- A network that uses **star topology** in each department
- Then connects those departments using a **bus or ring topology**

How it looks:

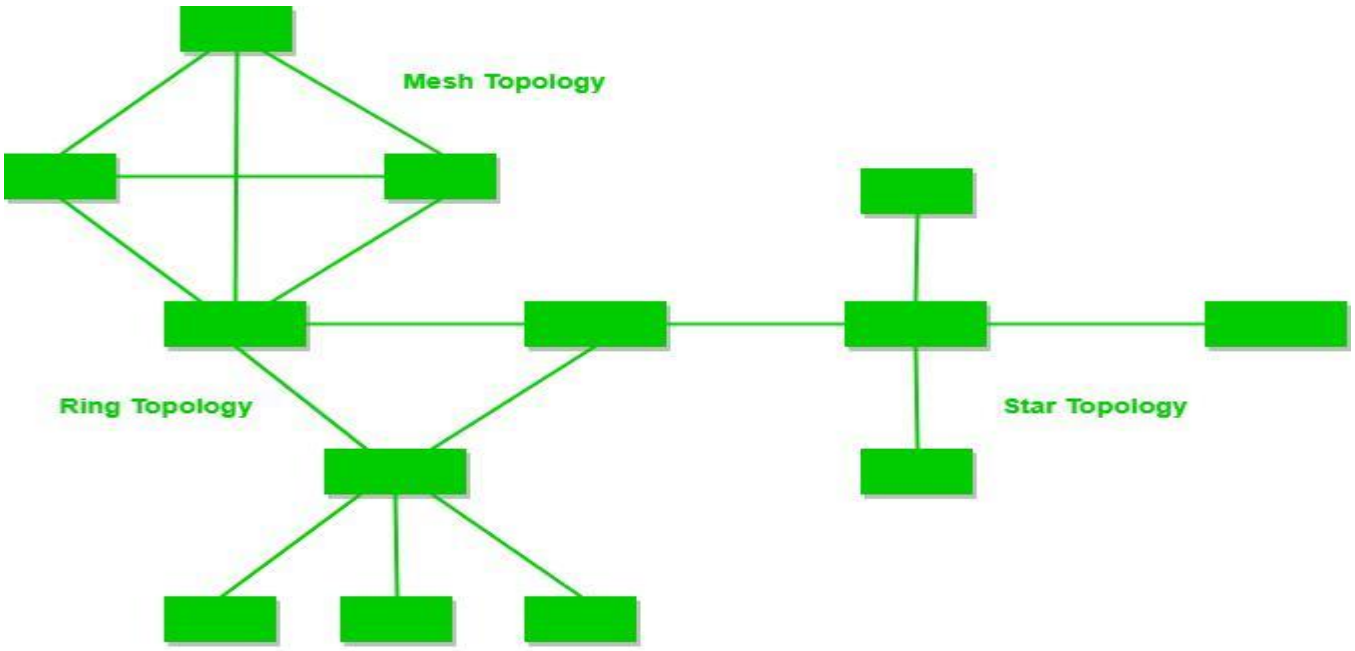


Figure - A Hybrid Topology

Advantages:

- Flexible (can be designed based on needs)
- Scalable (easy to expand)
- Reliable (failure in one part doesn't affect the whole network)

Disadvantages:

- Expensive to install
- Complex to design and manage

Multiplexing

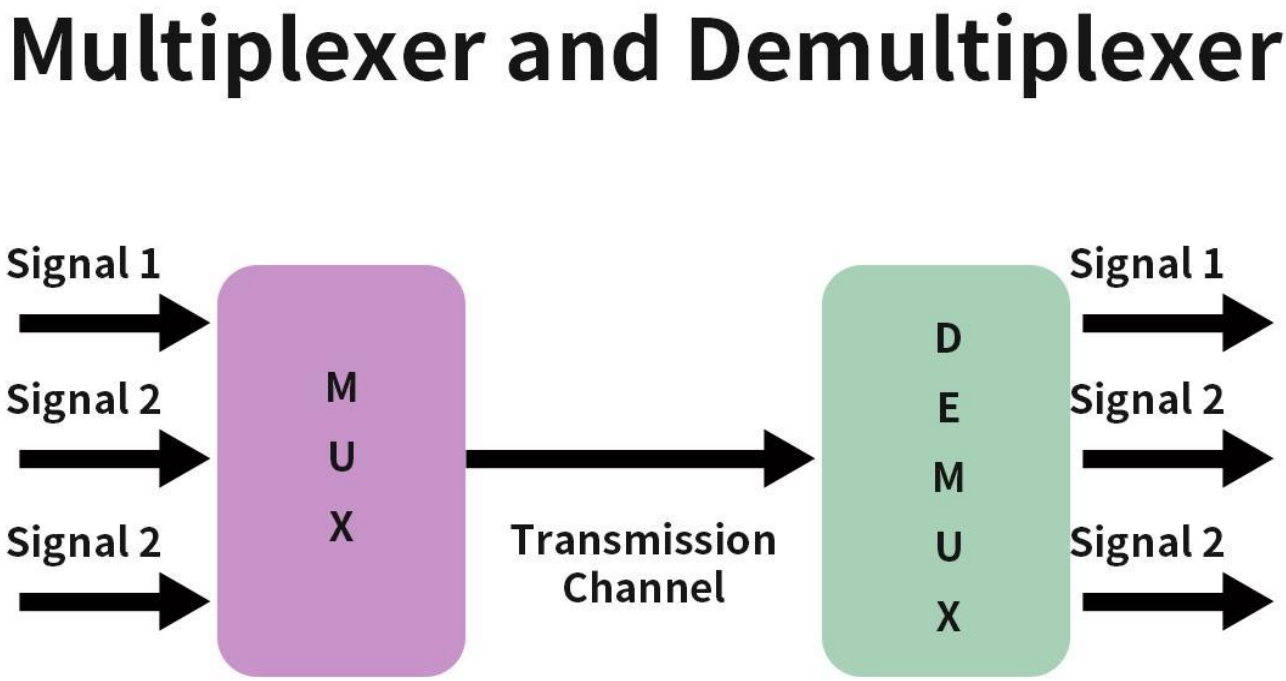
Multiplexing is a networking technique used to combine multiple data signals and send them over a single communication channel at the same time**.**

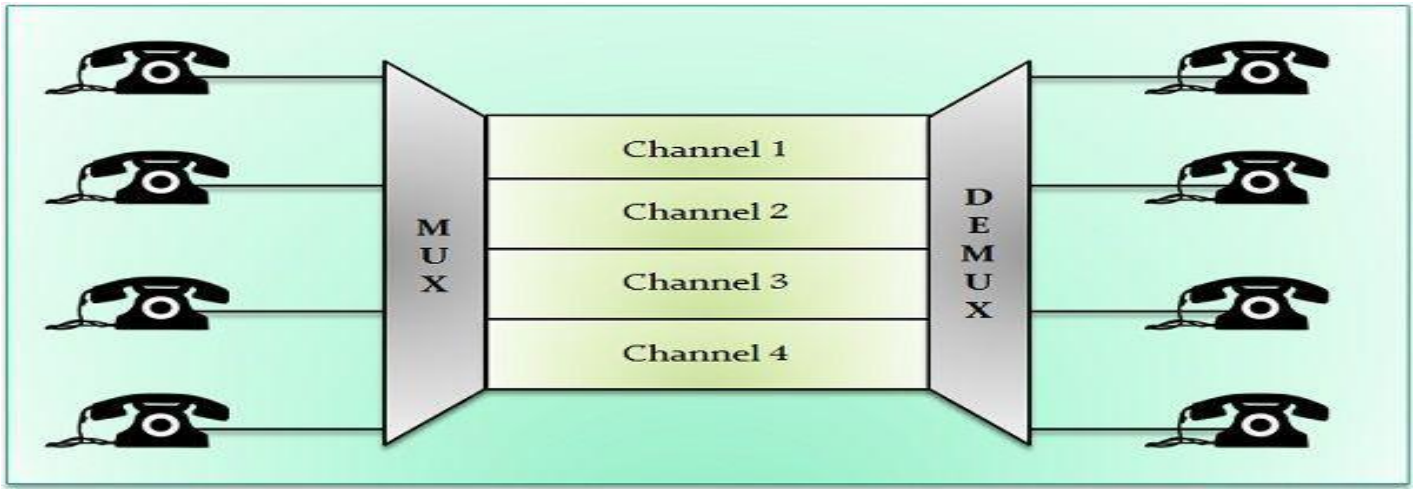
Simple explanation:

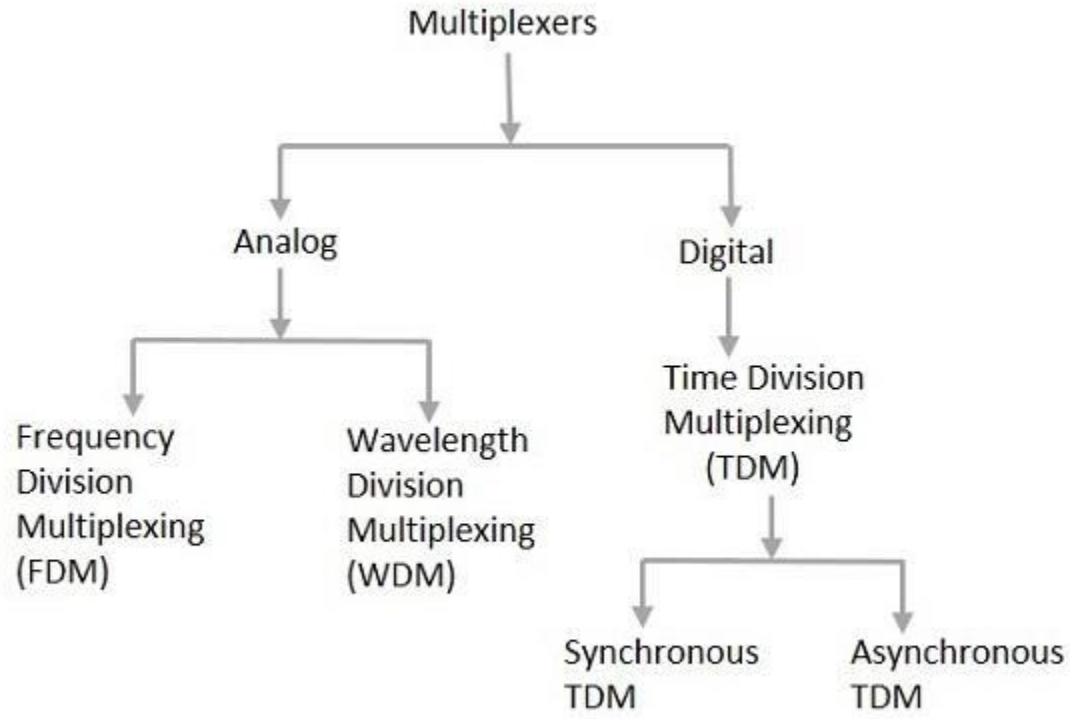
Multiplexing = **many signals → one channel → sent together**

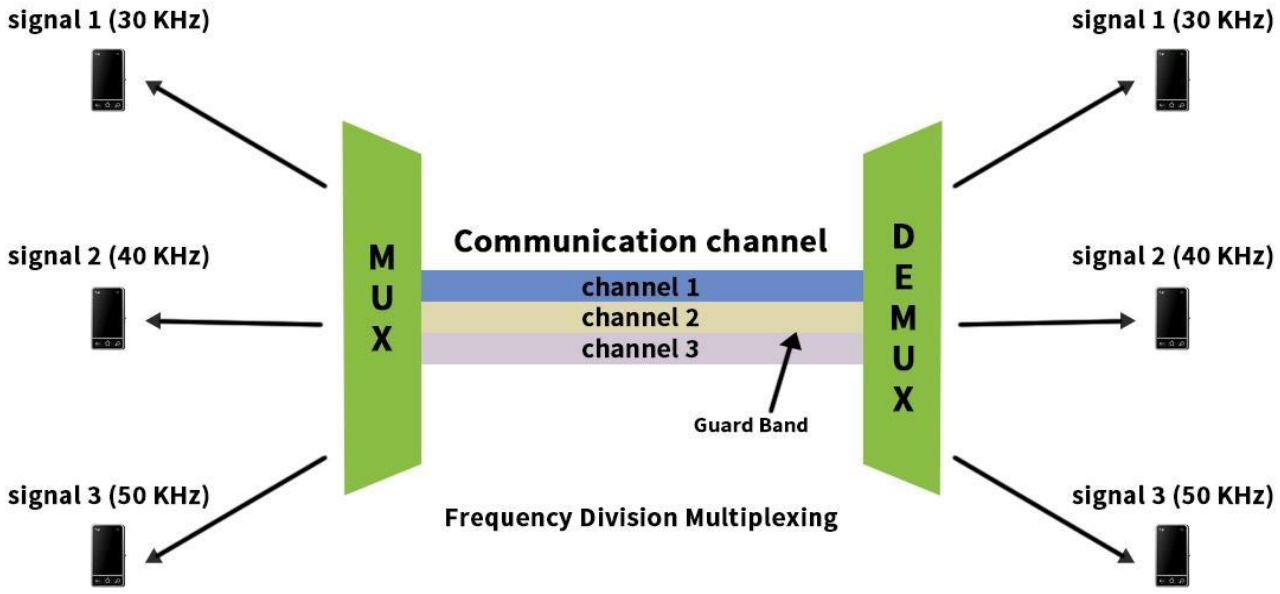
At the receiving end, the signals are separated again.

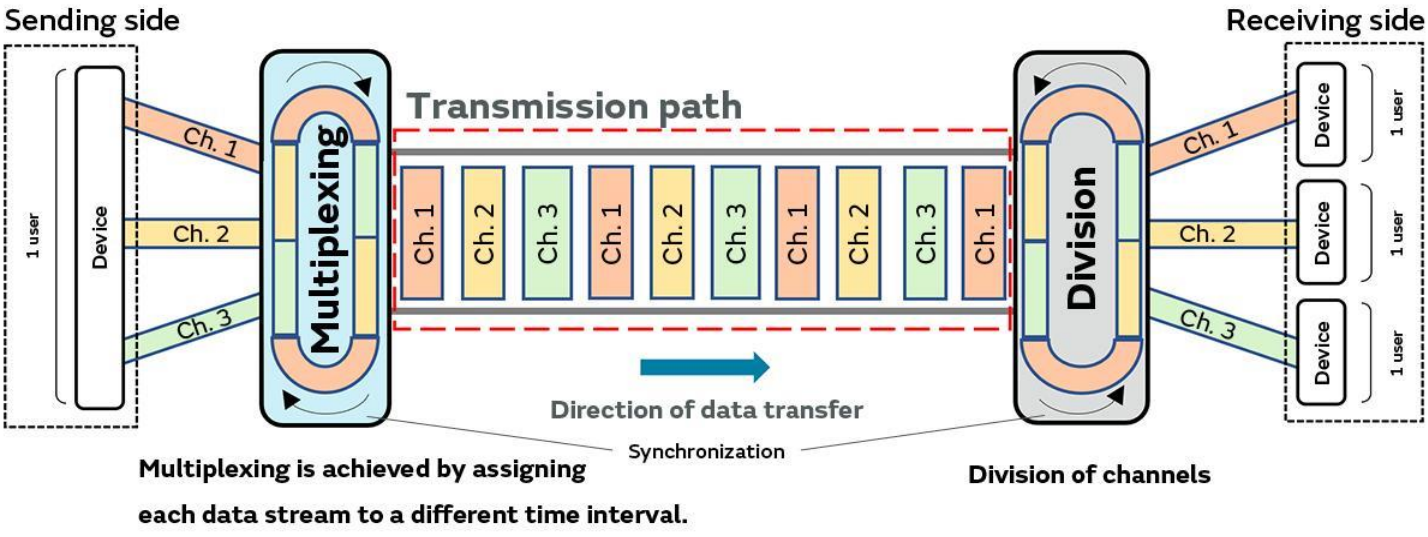
How it works:




Channel 1
Channel 2
Channel 3
Channel 4
MUX
DEMUX

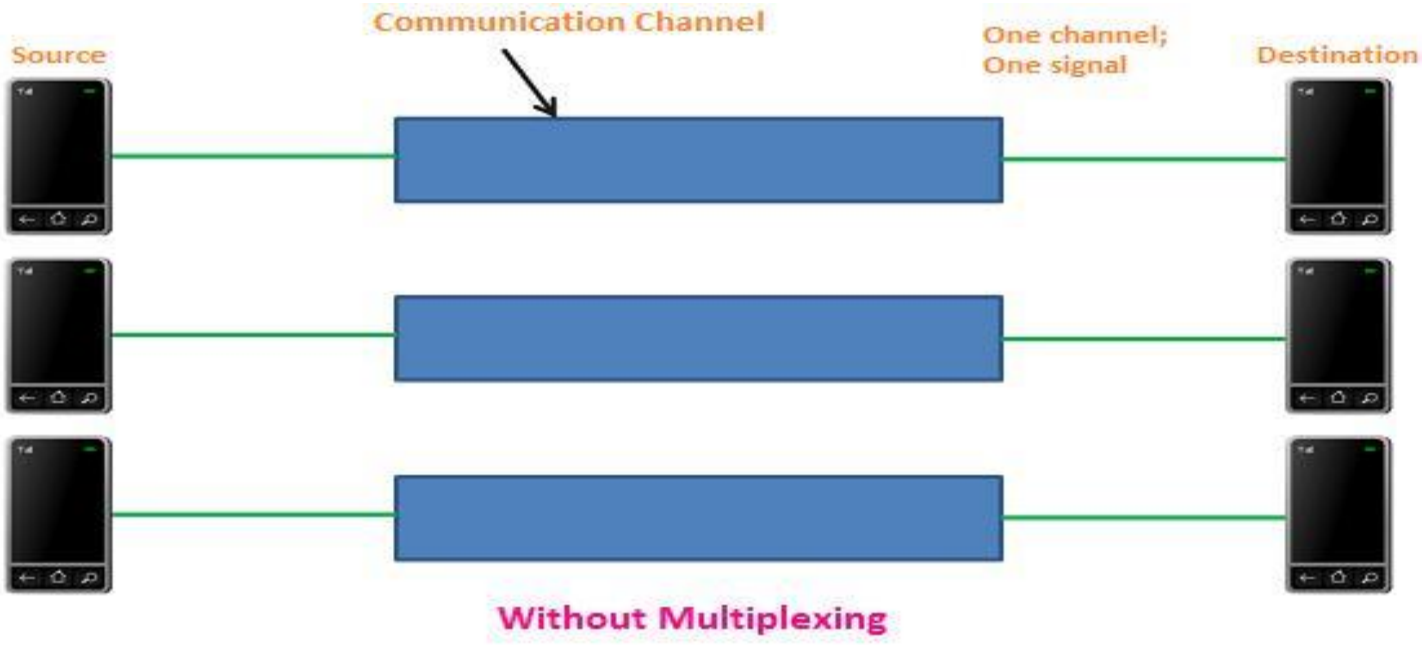

Multiplexers
Analog
Digital
Frequency Division Multiplexing (FDM)
Wavelength Division Multiplexing (WDM)
Time Division Multiplexing (TDM)
Synchronous TDM
Asynchronous TDM





Multiplexing is achieved by assigning each data stream to a different time interval.

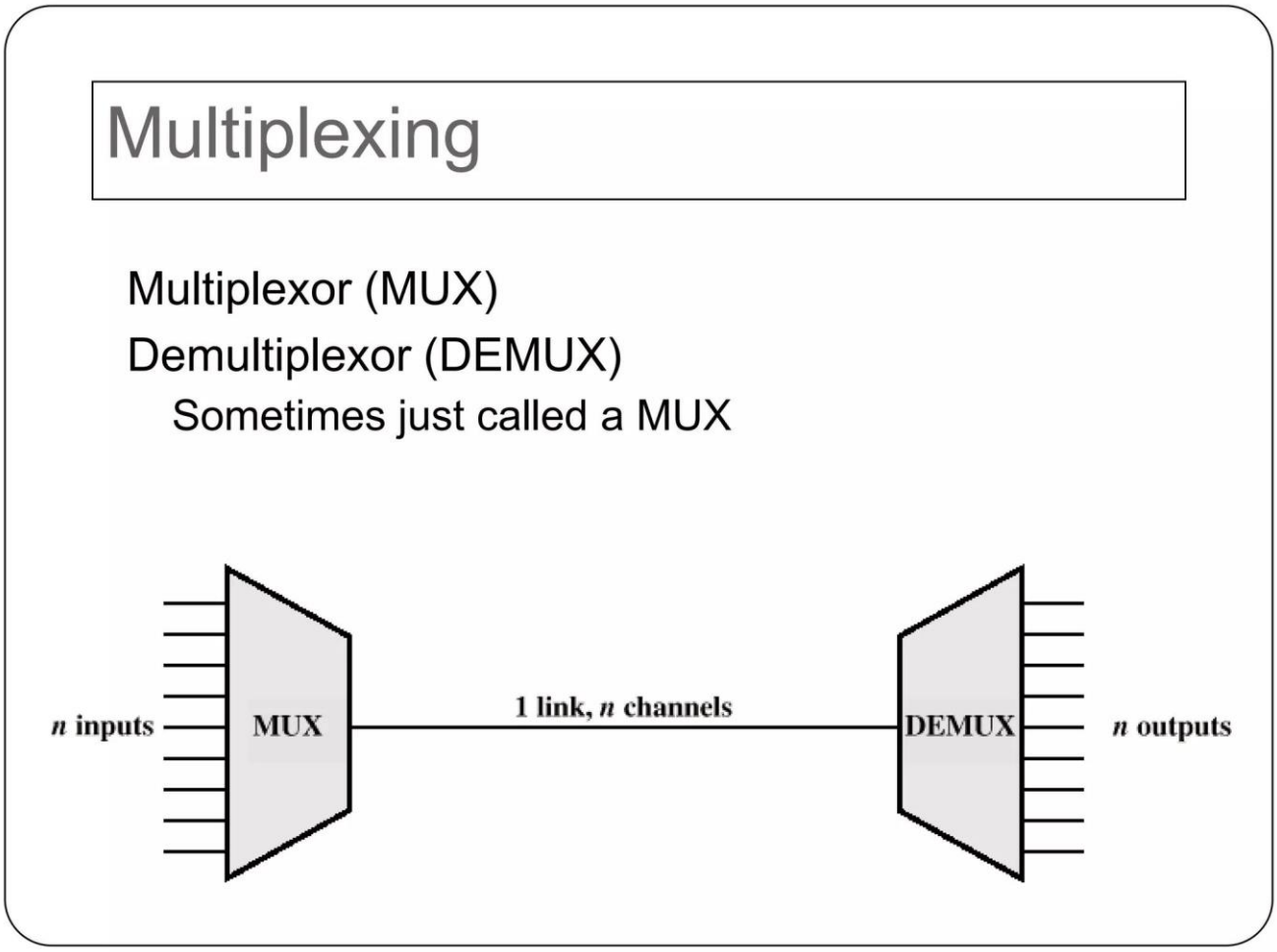
Division of channels



- Many devices send data
- A **multiplexer (MUX)** combines them
- Data travels through one channel
- A **demultiplexer (DEMUX)** separates them again

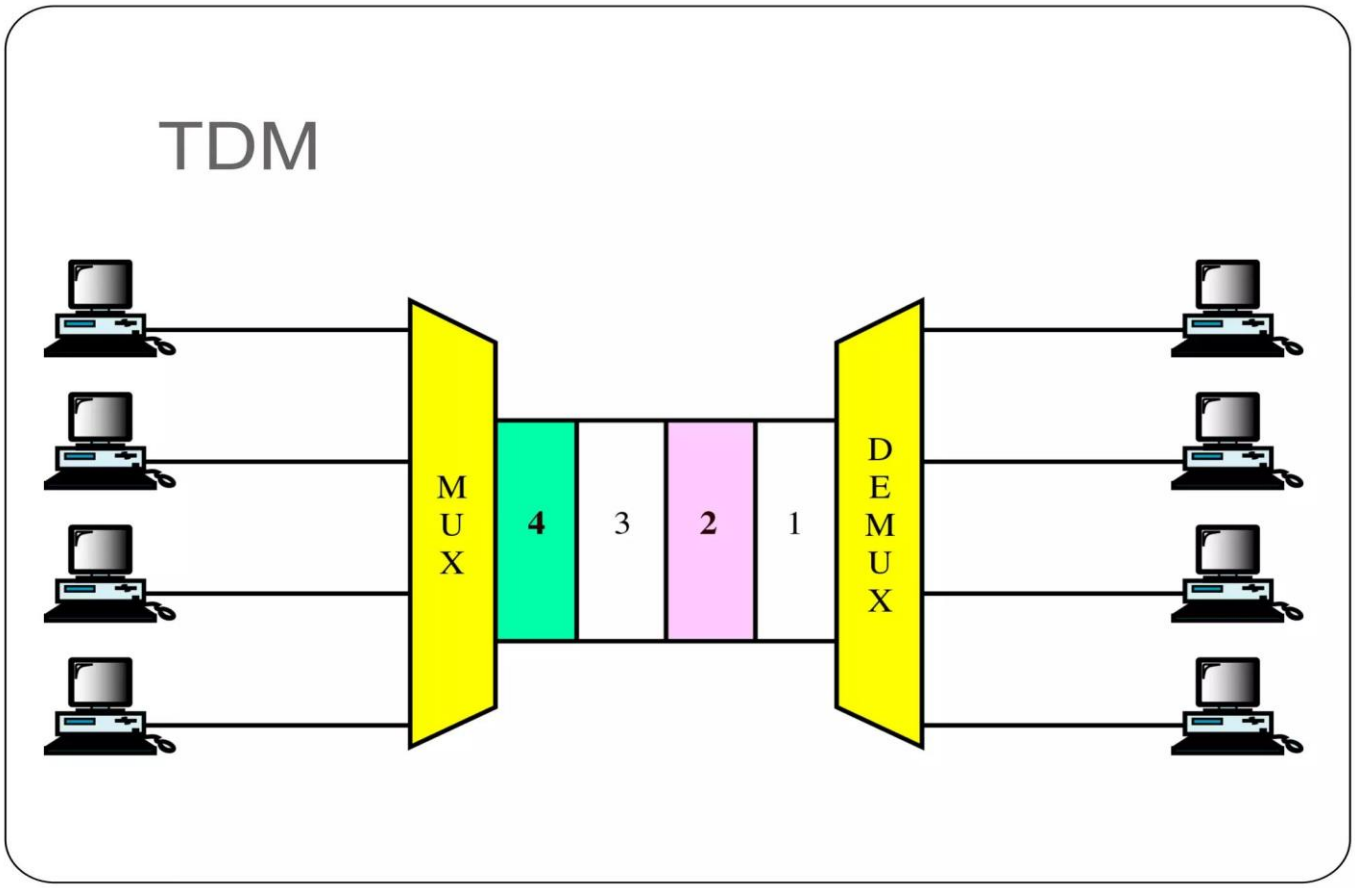
Types of multiplexing:

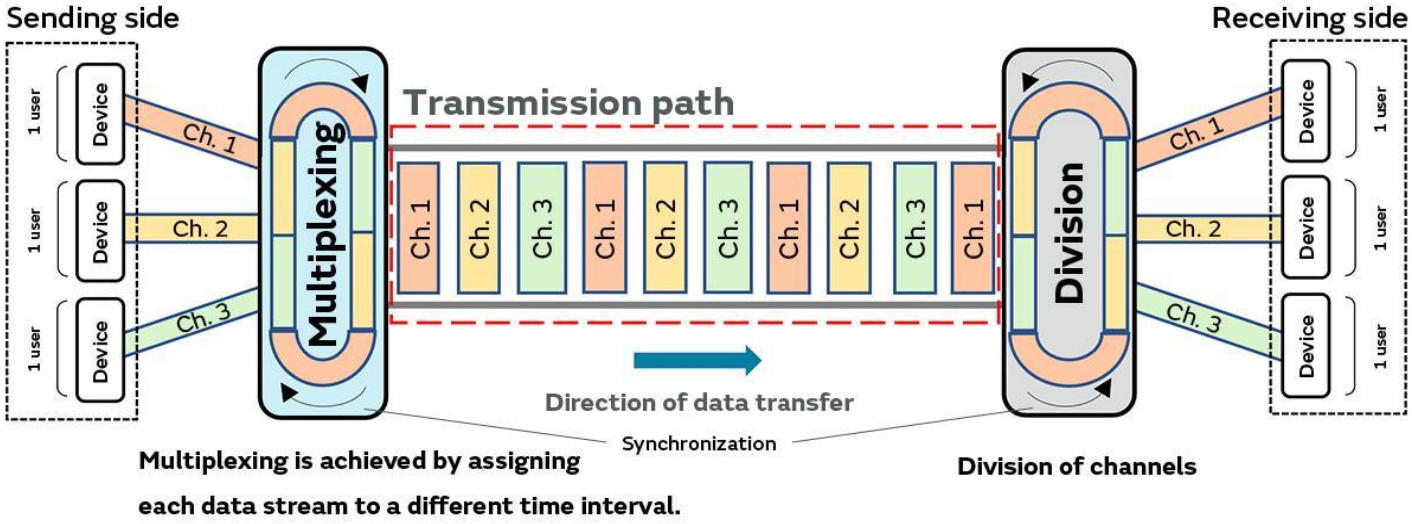
1. Frequency Division Multiplexing (FDM)



- Each signal uses a **different frequency**
- Example: Radio stations

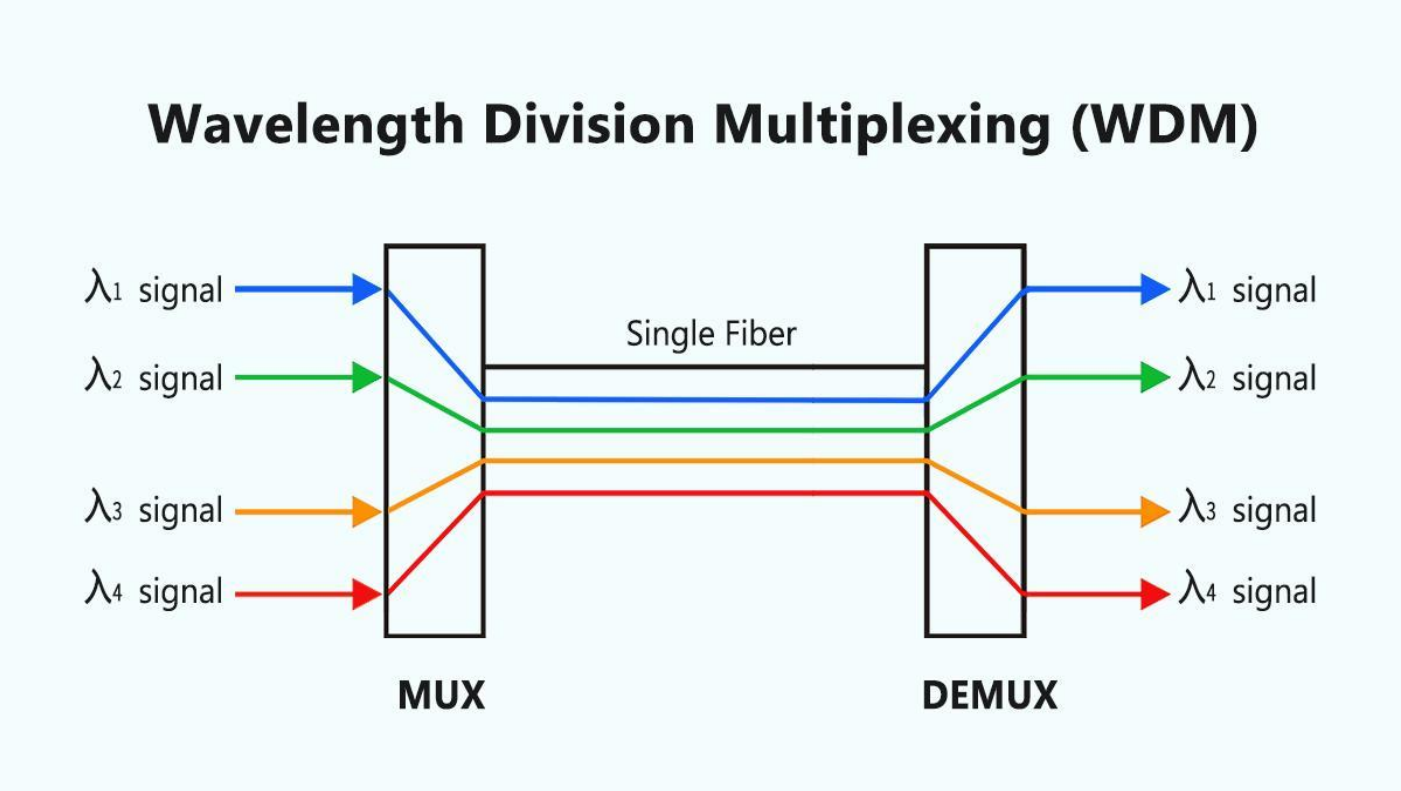
2. Time Division Multiplexing (TDM)





- Each signal uses a **time slot**
- Example: Telephone systems

3. Wavelength Division Multiplexing (WDM)



- Used in **fiber optic cables**
- Different signals use different **light wavelengths**

Advantages:

- Efficient use of bandwidth
- Reduces cost (one channel used for many signals)
- Improves communication speed

Key idea:

Multiplexing allows **many signals to share a single communication medium without interference**.

Reference Models

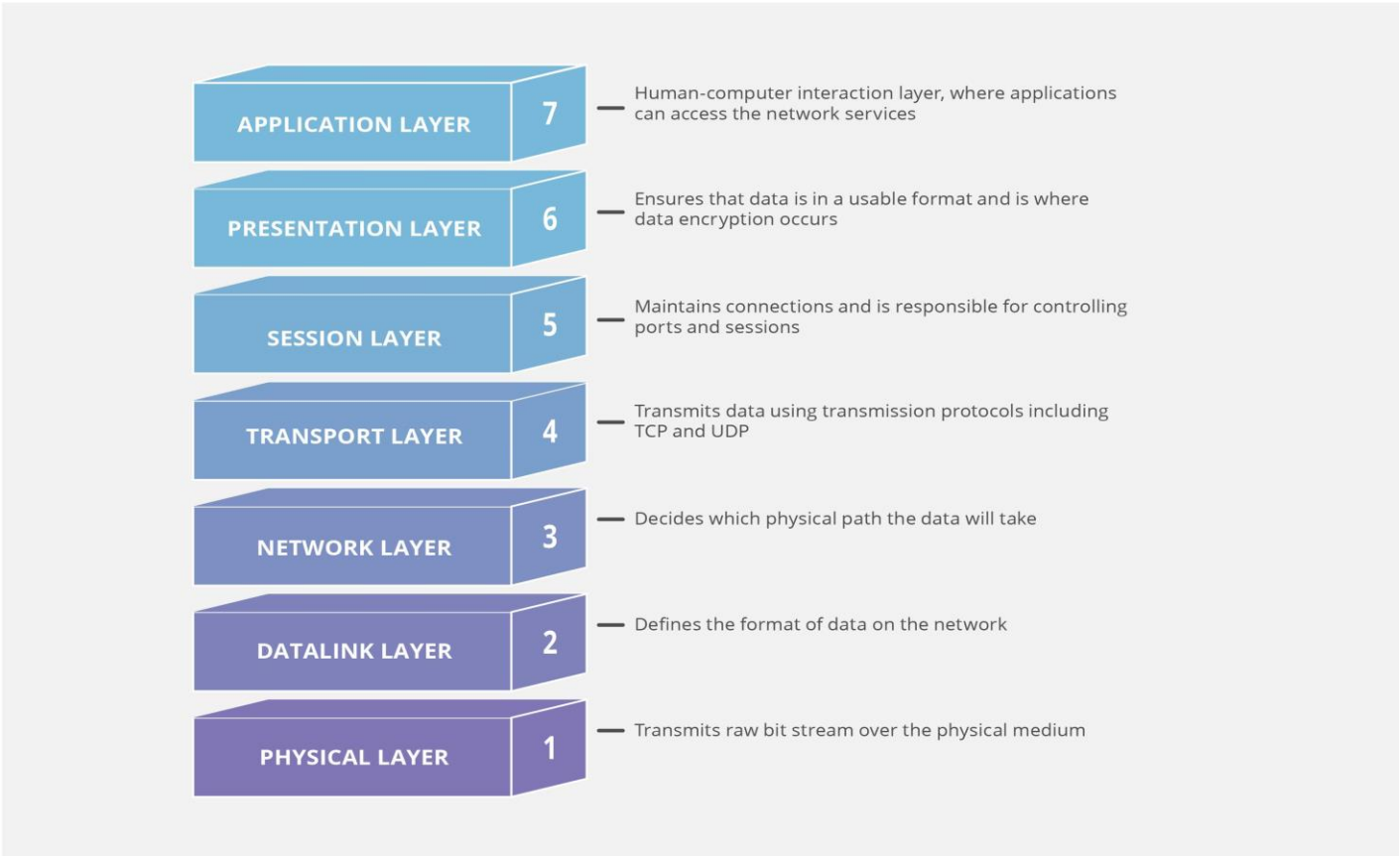
Reference models in computer networking are standard frameworks that explain how data is transmitted and communicated between devices in a network**.**

They are used to help different systems communicate even if they are built by different manufacturers.

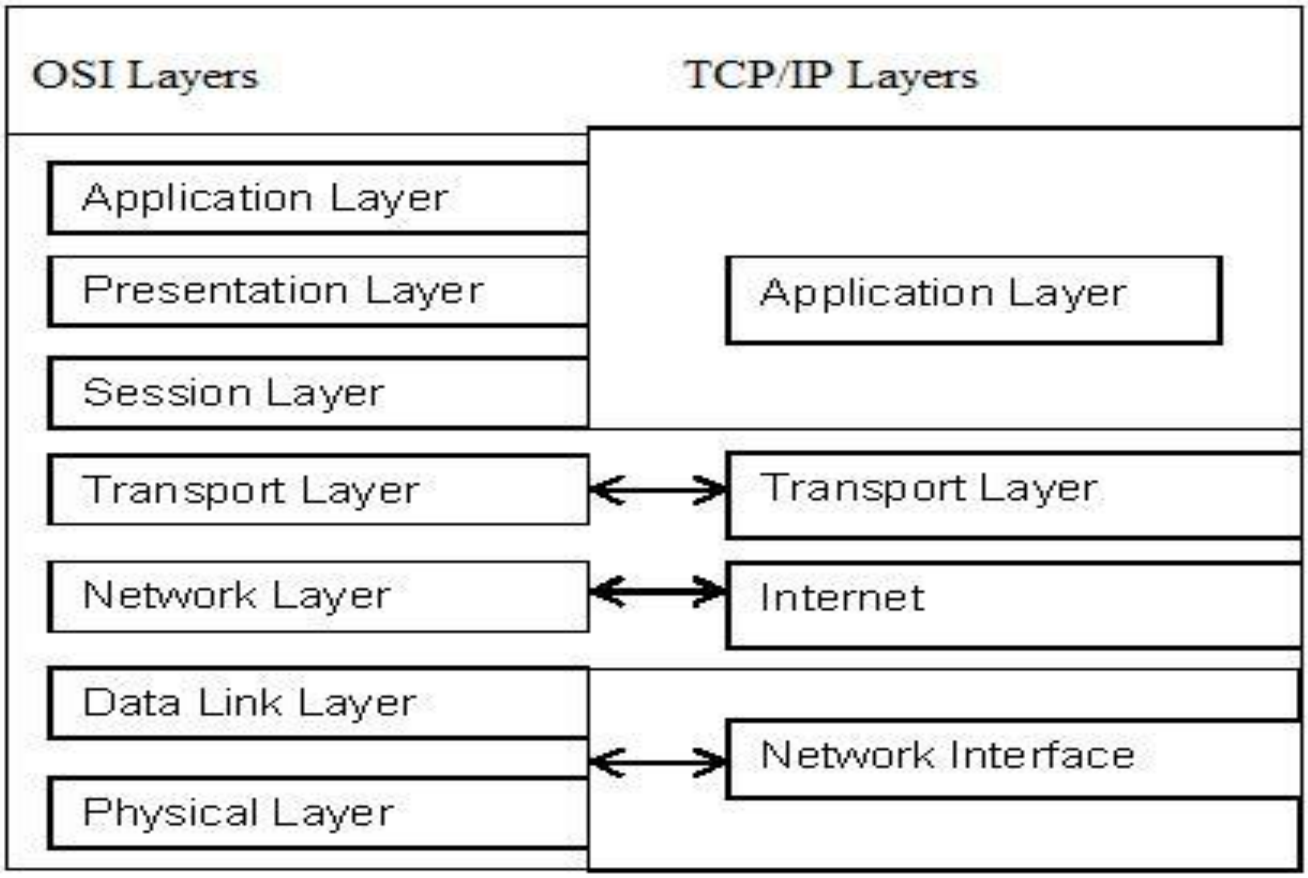
1. OSI Reference Model (Open Systems Interconnection)

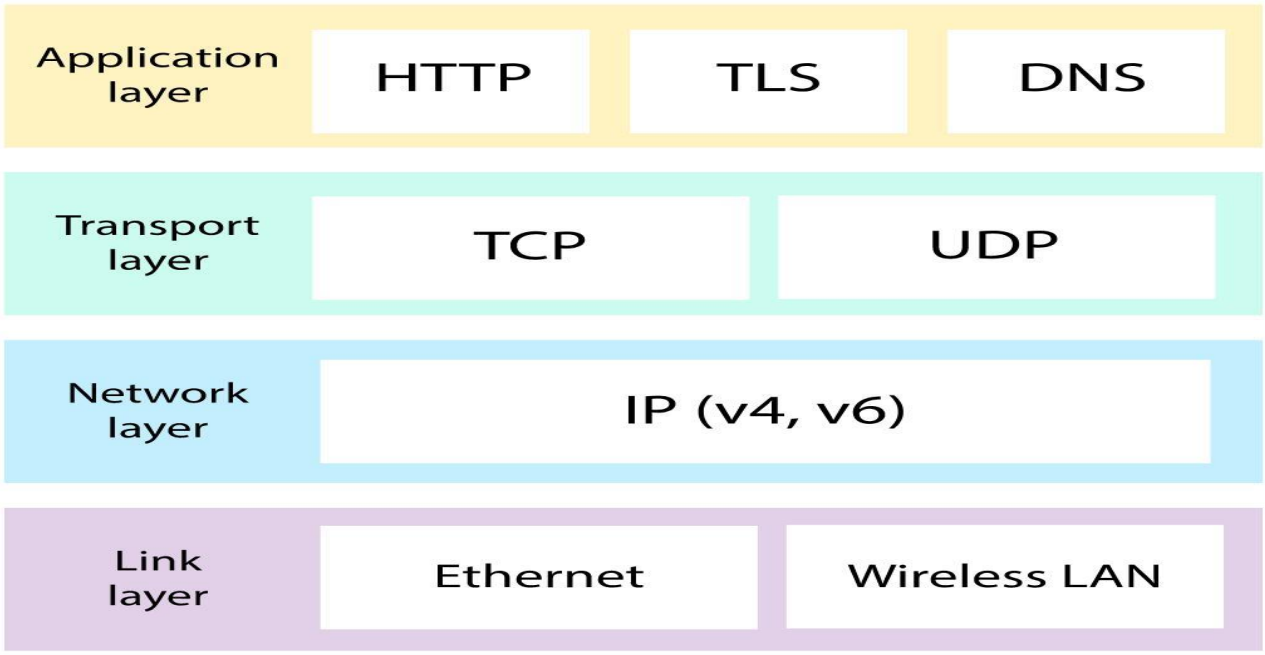
The OSI model has **7 layers**, each with a specific function:

1. **Application** – user interface (e.g. web browser)
2. **Presentation** – data formatting, encryption
3. **Session** – manages connections
4. **Transport** – reliable delivery (error control)
5. **Network** – routing (IP addressing)
6. **Data Link** – MAC addressing, switching
7. **Physical** – cables, signals, bits



2. TCP/IP Reference Model





This model is used in real-world internet systems and has **4 layers**:

1. **Application** – HTTP, FTP, email
2. **Transport** – TCP, UDP
3. **Internet** – IP addressing and routing
4. **Network Access (Link)** – physical transmission

Comparison between OSI and TCP/IP models:

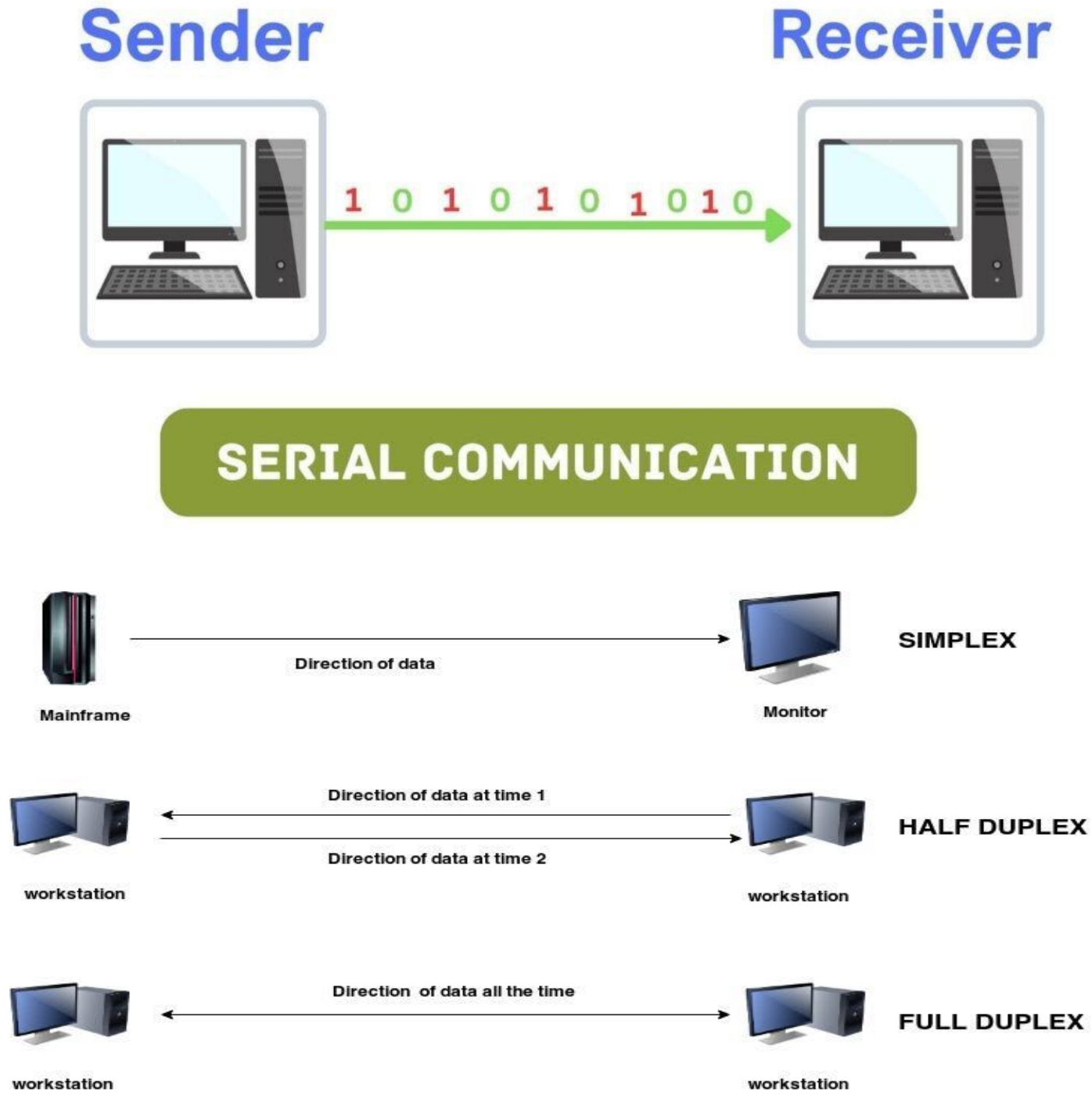
OSI vs TCP/IP Model

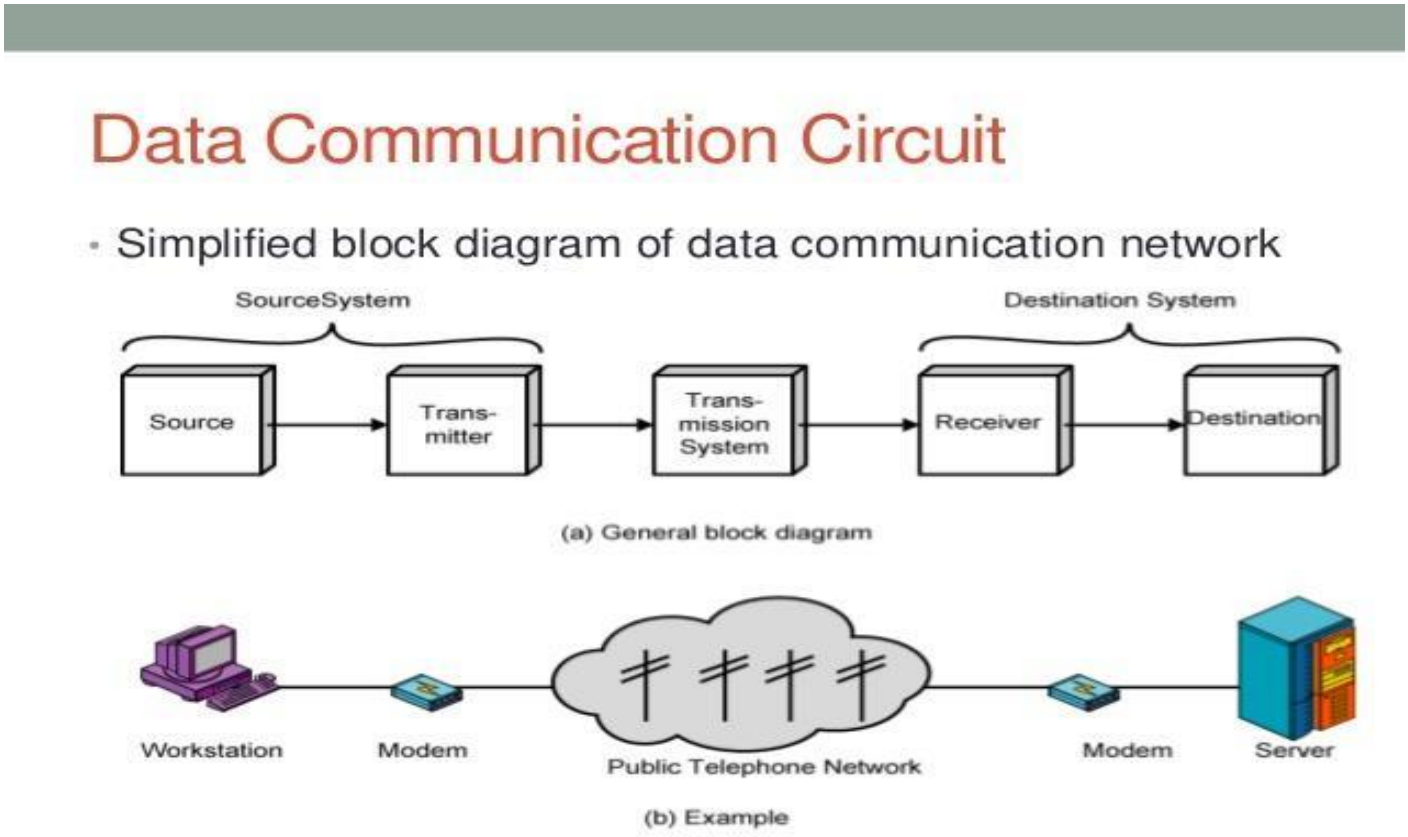
Feature	**OSI Model**	**TCP/IP Model**
Full name	Open Systems Interconnection	Transmission Control Protocol / Internet Protocol
Number of layers	**7 layers**	**4 layers**
Type	Theoretical model	Practical (used in real networks)
Developed by	ISO (International Organization for Standardization)	DARPA (U.S. Department of Defense)
Usage	Used for learning and reference	Used in real-world Internet
Layer structure	Application, Presentation, Session, Transport, Network, Data Link, Physical	Application, Transport, Internet, Network Access
Flexibility	Strict layered structure	More flexible and simpler
Protocol dependency	Not protocol-specific	Based on TCP/IP protocols
Implementation	Rarely fully implemented	Fully implemented in all modern networks

Concept of Transmitter and Receiver

In data communication, a **transmitter** and a **receiver** are the two main devices that make communication possible between systems.

1. Transmitter





A **transmitter** is a device or component that **sends data from one system to another**.

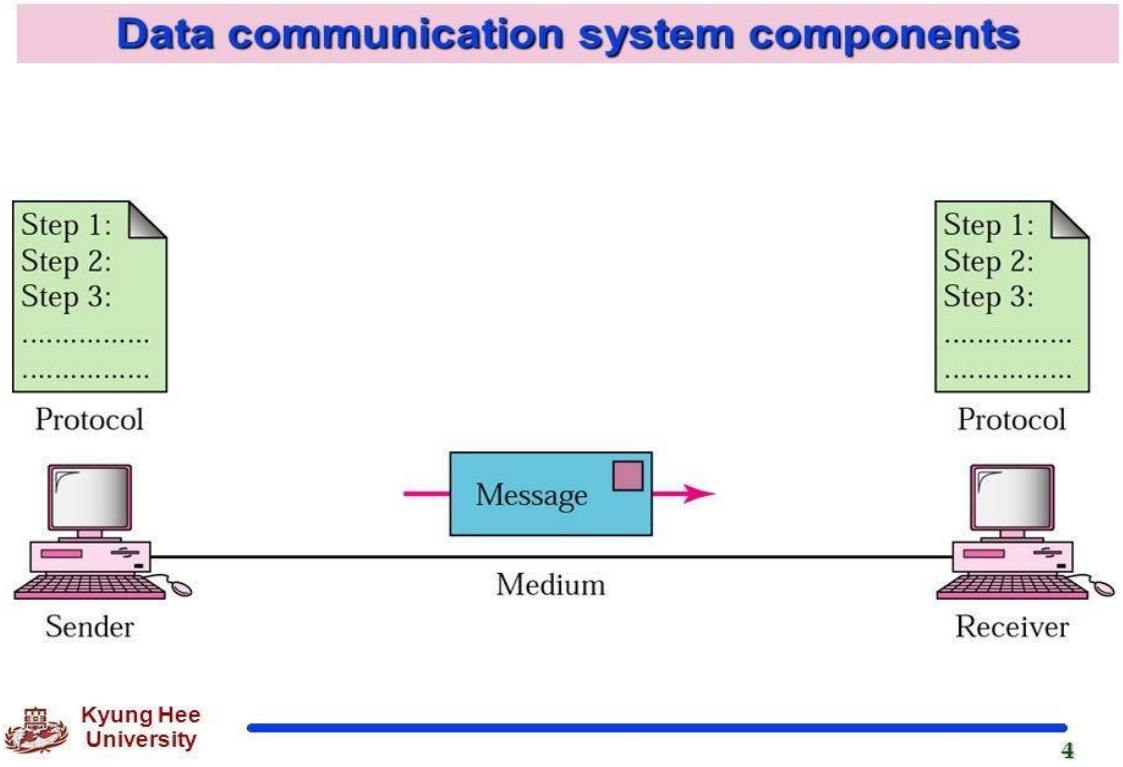
Functions of a transmitter:

- Converts data into signals (electrical, optical, or radio waves)
- Sends signals through a transmission medium (cable or wireless)
- Encodes data for safe transmission

Examples:

- Computer sending an email
- Mobile phone sending a message
- Wi-Fi router transmitting internet signals

2. Receiver



A **receiver** is a device or component that **accepts and interprets data sent by the transmitter**.

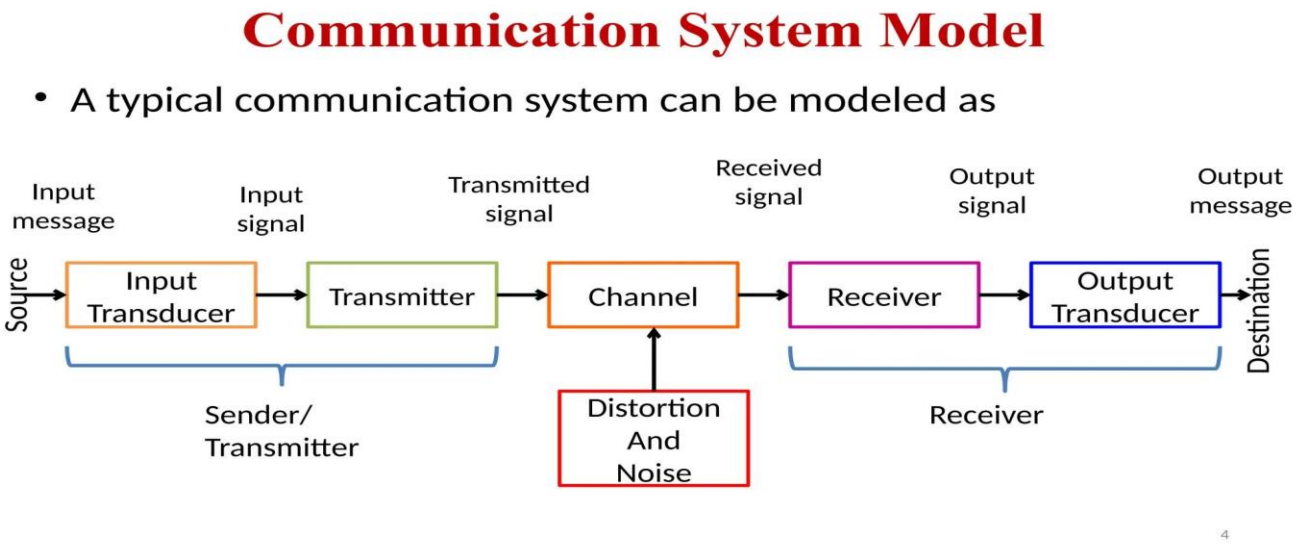
Functions of a receiver:

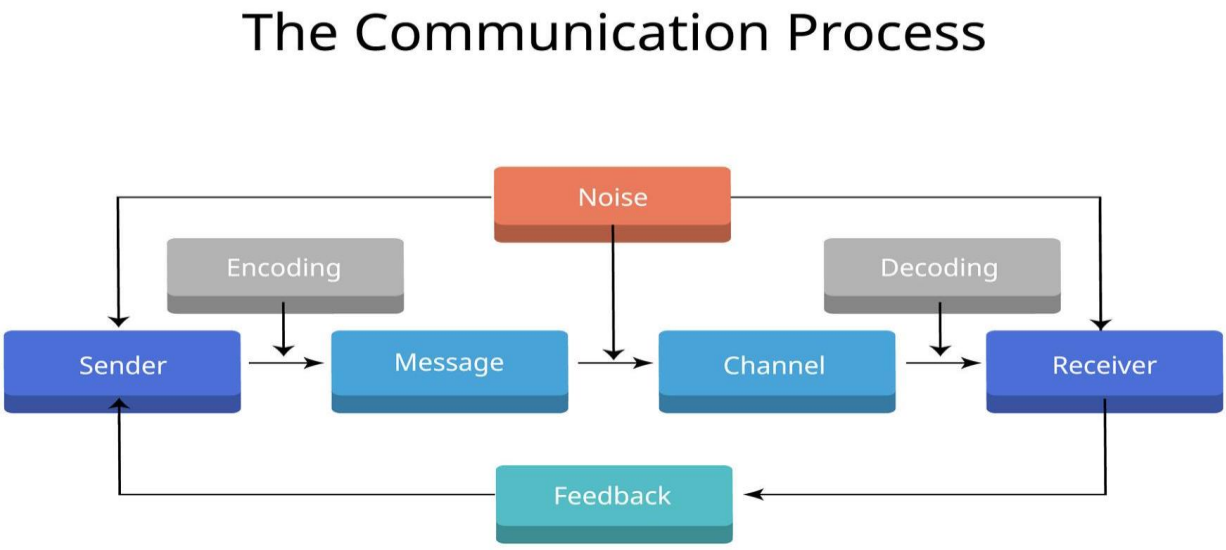
- Receives signals from the transmission medium
- Decodes signals back into usable data
- Displays or processes the received information

Examples:

- Computer receiving a file
- Smartphone receiving a message
- TV receiving broadcast signals

How they work together





1. Sender (Transmitter) sends data
2. Data travels through a medium (cable/wireless)
3. Receiver gets and decodes the data
4. Information is delivered to the user