



Marwadi
University

Department of CE

Unit No:1

Introduction to Computer Networks and Internet

Computer Networks
(01CE0410)

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Associate Professor

Course Objective & Outcome

Course Objective:

- Students are expected to learn basics of Computer Network which will help them to build LAN, MAN and WAN.
- The course is designed to let students demonstrate an understanding of the protocols, IP address and Routing algorithms.
- Additionally, to demonstrate a basic understanding of various internetworking devices.

Course Outcome:

After completion of this course, student will be able to

- Understand the basic terminologies used in networking, various networking topologies, switching techniques and layered architecture of computer network. (Understand)
- Understand various networking protocols of application layer. (Understand)
- Distinguish connection oriented and connection less protocols used for reliable data transfer and relate with flow control and congestion control. (Analyse)
- Apply the concept of IP addressing and subnetting for IP based networks also demonstrate routing protocols. (Apply)
- Demonstrate error correction and error detection techniques in data link layer, use of random access and CSMA protocol. (Apply)

Suggested Theory distribution:

Distribution of Theory for course delivery and evaluation

Remember	Understand	Apply	Analyse	Evaluate	Create
10 %	35 %	10 %	35 %	5 %	5 %

Teaching and Examination Scheme

Teaching and Examination Scheme

Teaching Scheme (Hours)			Credits	Theory Marks			Tutorial/ Practical Marks		Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	Viva (V)	Term work (TW)	
3	0	2	4	50	30	20	25	25	150

Credit: 04

Assignments
(20)

CCNA Two Course Certifications
 $(13 + 12 = 25)$

Syllabus

Contents:		Unit Number	Topics	Contact Hours
1	Introduction Internet today, Data communication, Categories of Network, Layered approach, Understanding of Delay and its types, TCP/IP Reference model, Transmission Mode, Transmission Media, Network Topologies: Star, Bus, Ring, Mesh, Hybrid, Types of Network: LAN, WAN, MAN, PAN, Switching Techniques: Circuit Switching, Packet Switching.			10
2	Application Layer Web and HTTP, File Transfer: FTP, Electronic mail in the internet, Domain name server, SMTP, SNMP, FTP, DHCP: Request and Response.			8
3	Transport Layer Introduction to Transport layer and its services, Transport layer Protocol: TCP and UDP, Principles of Reliable data transfer: Go-BACK-N and Selective Repeat, Flow Control, Congestion Control.			9
4	Network Layer Network Layer functionalities, Network Layer design Issues, Unicast routing, Multicast Routing, Inter domain and intra domain routing, Distance Vector Routing, Link State routing, OSPF, EIGRP.			9
5	Data Link Layer Data link layer services, Data link layer design issues, Error correction and Error Detection techniques, Parity, Checksum, Framing, Flow Control, Error Control, Multiple access protocols, Random Access Protocols, CSMA , CSMA/CD, CSMA/CA, VLAN.			9

Reference Books

Reference Standard Books:

1. Computer Networking- A Top-Down approach (6th edition), Kurose and Ross, Pearson
2. Computer Networks- A Top-Down approach, Behrouz Forouzan, McGraw Hill
3. Computer Networks (5th edition), Andrew Tanenbaum, Prentice Hall
4. Computer Networking and the Internet (5th edition), Fred Halsall, Addison Wesley
5. Data Communications and Networking (5th edition), Behrouz Forouzan, McGraw Hill
6. TCP/IP Protocol Suite (4th edition), Behrouz Forouzan, McGraw Hill

For Numerical:

1. J. S. Katre
2. Sanjay Sharma

Expectations

- Smiling Face
- Interactive Session
- Participation
- Enjoy the joy of learning



Methodology

- Why
 - ❖ Need to learn
- What
 - ❖ Definition, Meaning, is all about
- How
 - ❖ Performance, Implementation, Simulation, Development

Topics Unit-1

- Internet today
- Data communication
- Categories of Network
- Layered approach
- Understanding of Delay and its types
- TCP/IP Reference model
- Transmission Mode
- Transmission Media
- Network Topologies: Star, Bus, Ring, Mesh, Hybrid
- Types of Network: LAN, WAN, MAN, PAN
- Switching Techniques: Circuit Switching, Packet Switching.

How We Communicate ?



DATA COMMUNIC- -ATIONS

- The term **telecommunication** means communication at a distance.
- The word **data** refers to information presented in whatever form is agreed upon by the parties creating and using the data.
- **Data communications** are the exchange of data between two devices via some form of transmission medium such as a wire cable.

Network Model

Network models

Protocols and standards

Data communications

Components

Data representation

Data Flow

Networking

Internet

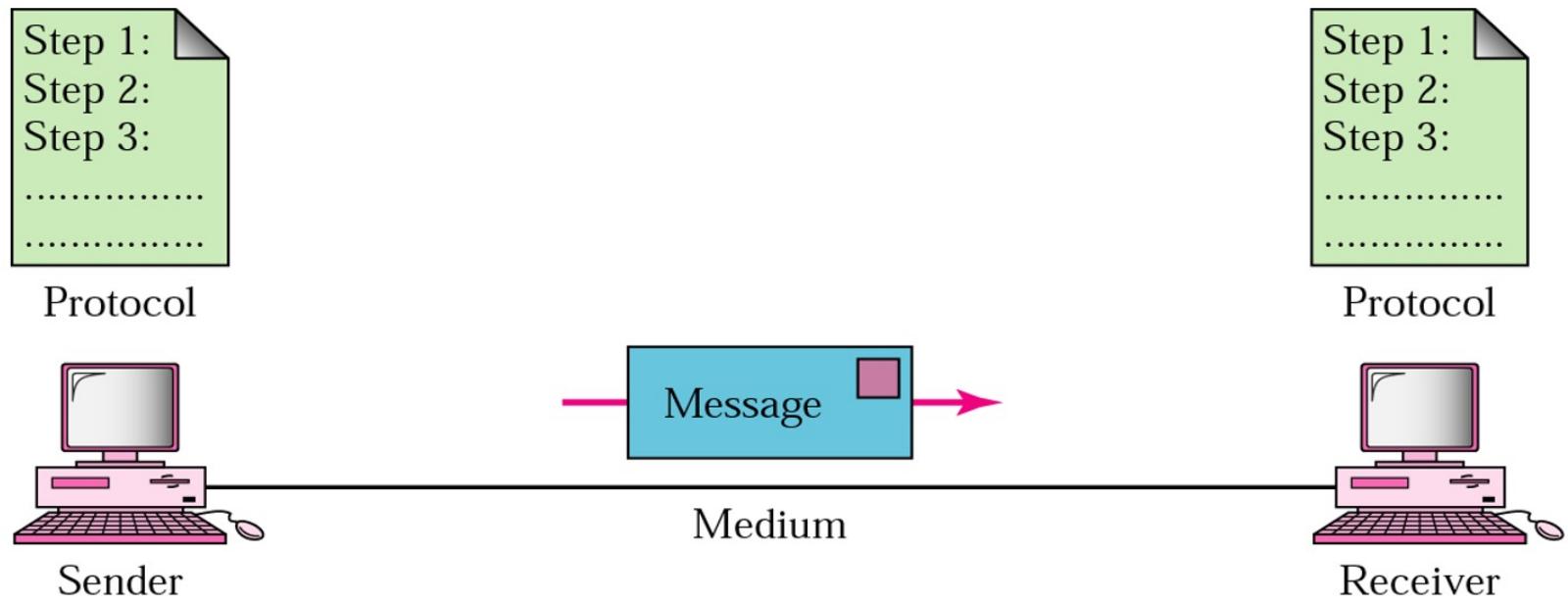
LANs and WANs

Distribution processing

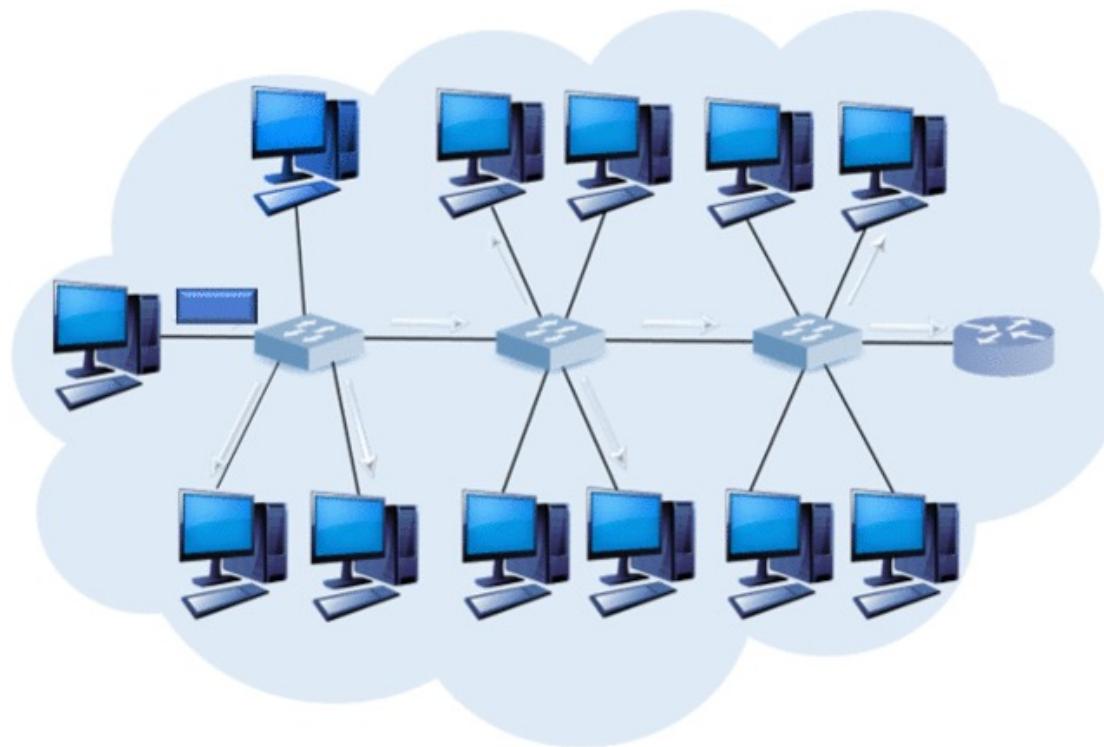
Criteria

Structure

Similar Way, Computer, Component of Data Communication



THE INTERNET

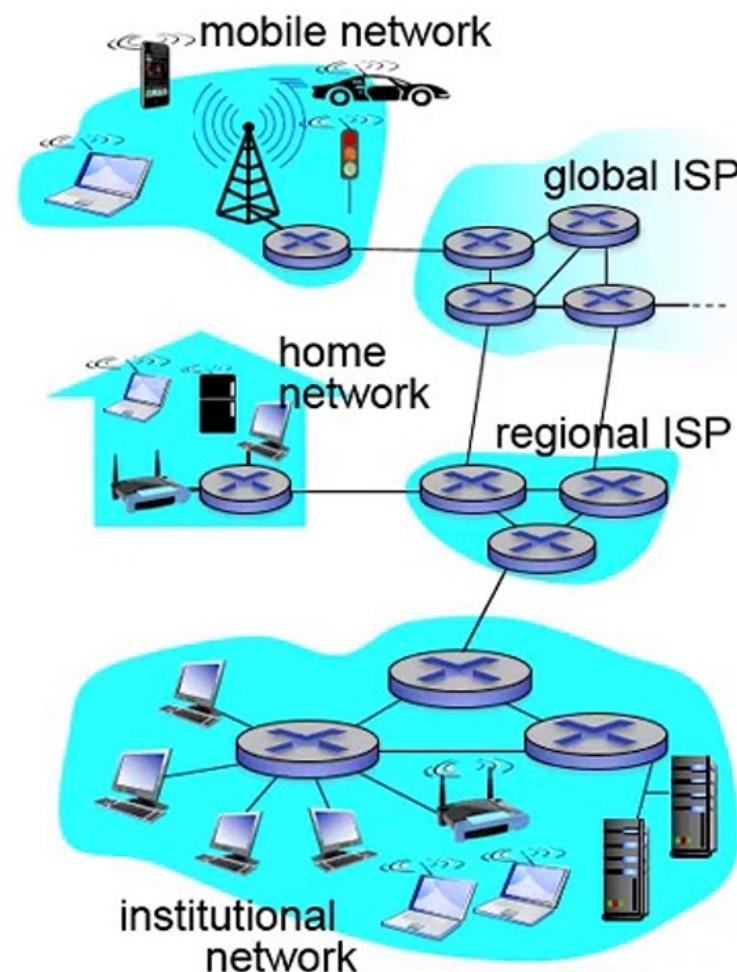


- *The Internet has revolutionized many aspects of our daily lives. It has affected the way we do business as well as the way we spend our leisure time.*
- *The Internet is a communication system that has brought a wealth of information to our fingertips and organized it for our use.*

What is the Internet?

What's the Internet: “nuts and bolts” view

- *Internet: “network of networks”*
 - Interconnected ISPs
- *protocols* control sending, receiving of messages
 - e.g., TCP, IP, HTTP, Skype, 802.11
- *Internet standards*
 - A group of people working on a topic, say TCP
 - IETF: Internet Engineering Task Force, group of people
 - <https://www.ietf.org/>
 - Draft of streamline the TCP work, RFC
 - For TCP
<https://tools.ietf.org/html/rfc7414>
 - Window, Gmail, Linux, Yahoo, etc, implement TCP using RFC
 - What is the advantage???

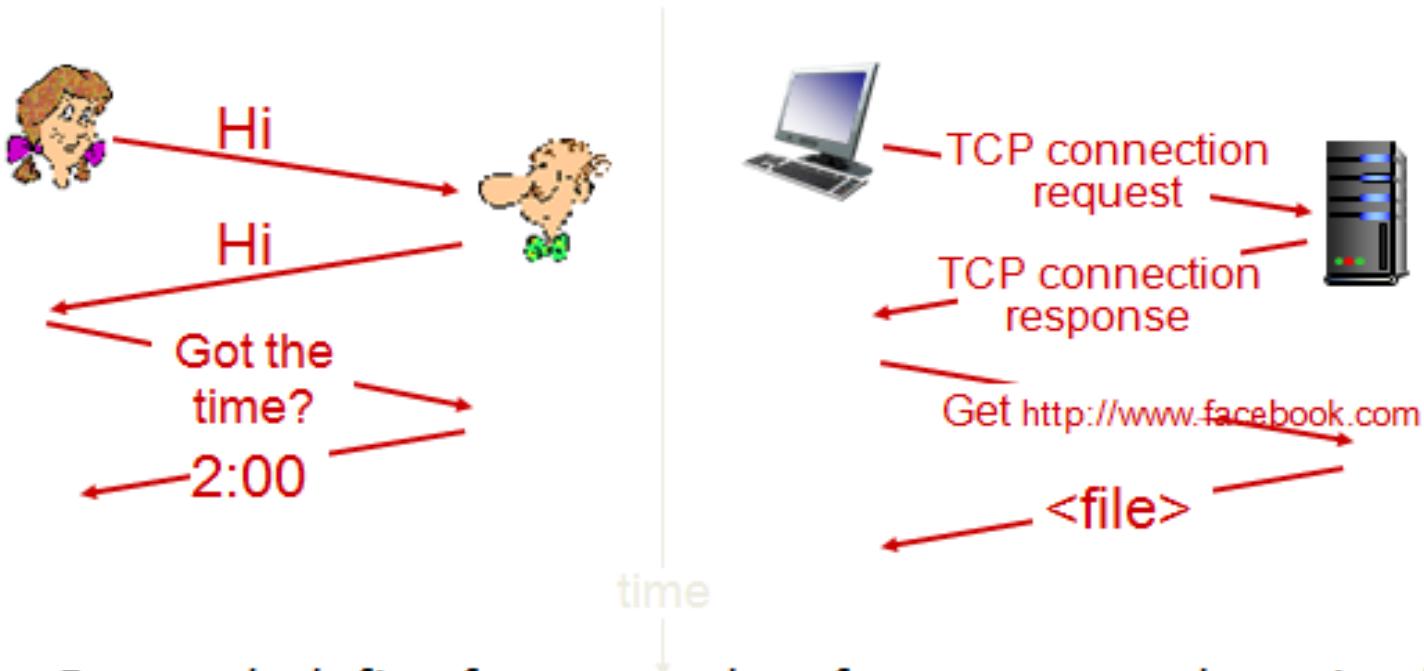


Protocols

Syntax, Semantics, Timing

Protocols

a human protocol and a computer network protocol:



Protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt

Data Transmission Modes or Data flow

- Data Transmission mode defines **the direction of the flow of information** between two communication devices. It is also called Data Communication or Directional Mode.
- It specifies the direction of the flow of information from one place to another in a computer network.
- Data transmission modes based on **the direction of exchange, synchronization between the transmitter and receiver, and the number of bits sent simultaneously** in a computer network.

Data Transmission Modes or Data flow

The data transmission modes can be characterized in the following three types **based on the direction of exchange of information:**

1. Simplex
2. Half-Duplex
3. Full Duplex

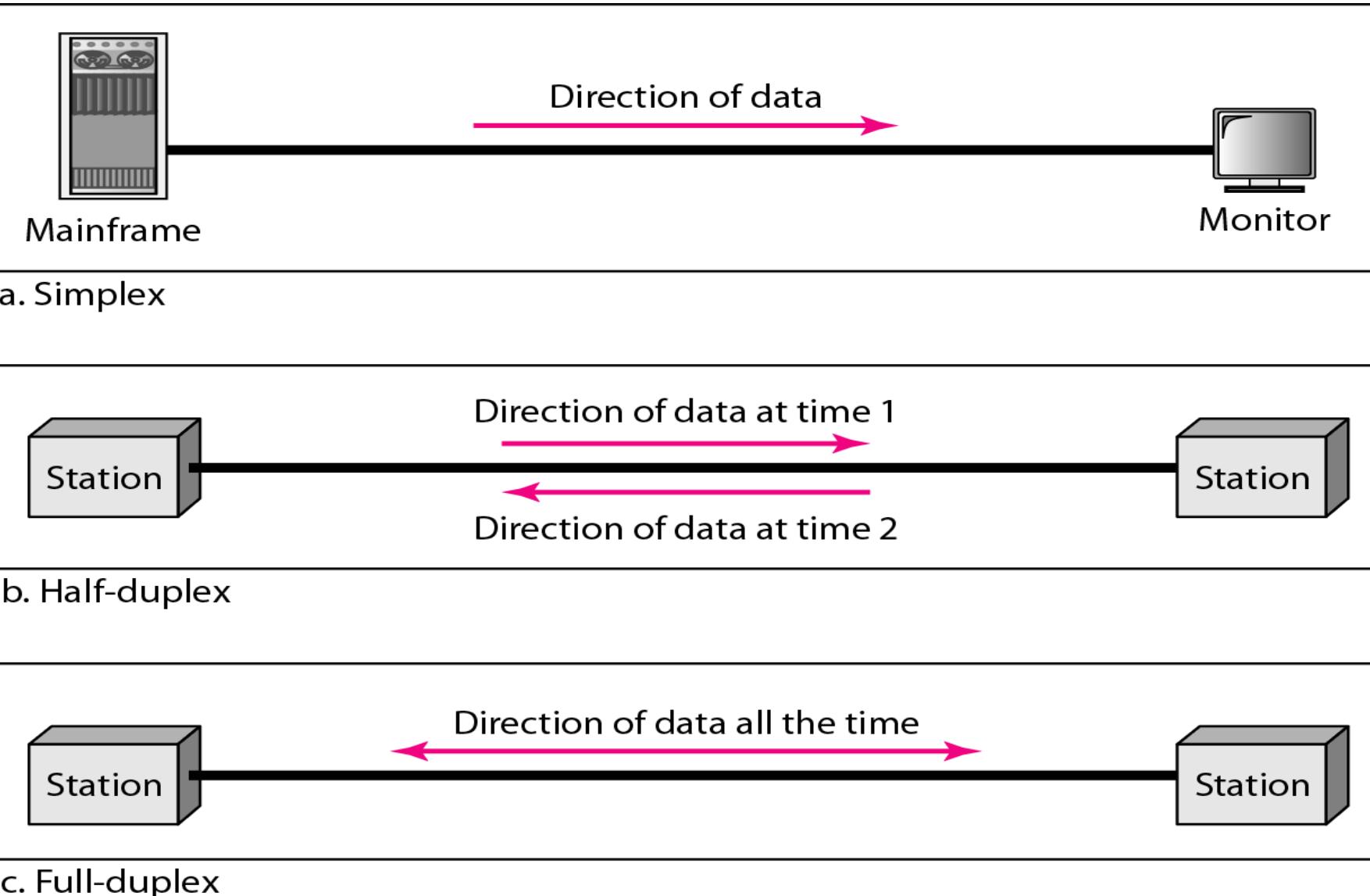
The data transmission modes can be characterized in the following two types **based on the synchronization between the transmitter and the receiver:**

1. Synchronous
2. Asynchronous

The data transmission modes can be characterized in the following two types **based on the number of bits sent simultaneously in the network:**

1. Serial (RS 232 protocol)
2. Parallel (IEEE 488 protocol)

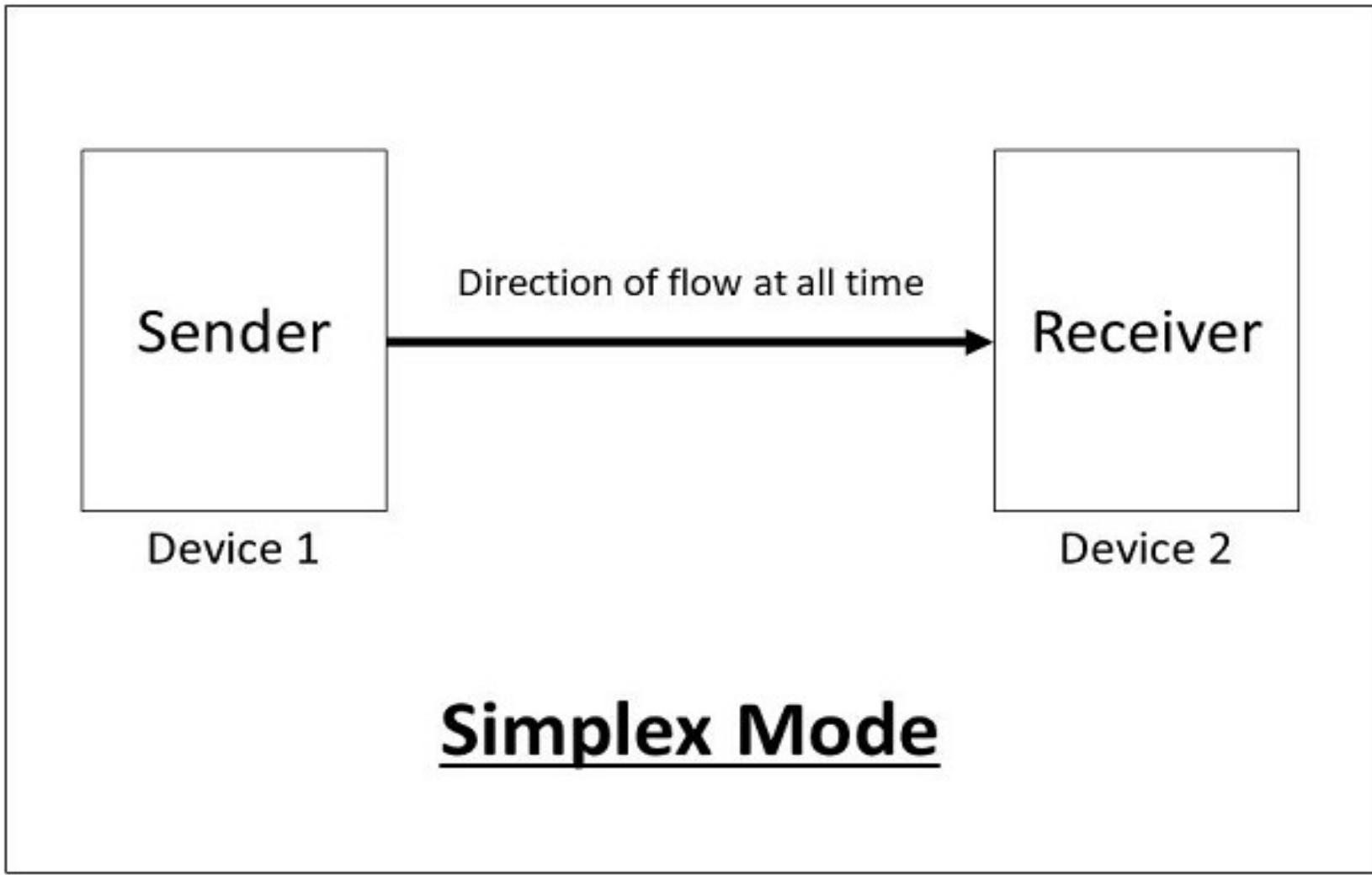
Data Transmission Modes or Data flow



Simplex

- In simplex mode, **the communication is unidirectional**, as on a one-way street.
- Only one of the two devices on a link can transmit; the other can only receive.
- **Keyboards and traditional monitors** are examples of simplex devices. The keyboard can only introduce input; the monitor can only accept output.
- **The simplex mode can use the entire capacity of the channel to send data in one direction.**

Simplex



Advantages and Disadvantages

Advantage:

Following are the **advantages** of using a Simplex transmission mode:

- It utilizes the full capacity of the communication channel during data transmission.
- It has the least or no data traffic issues as data flows only in one direction.

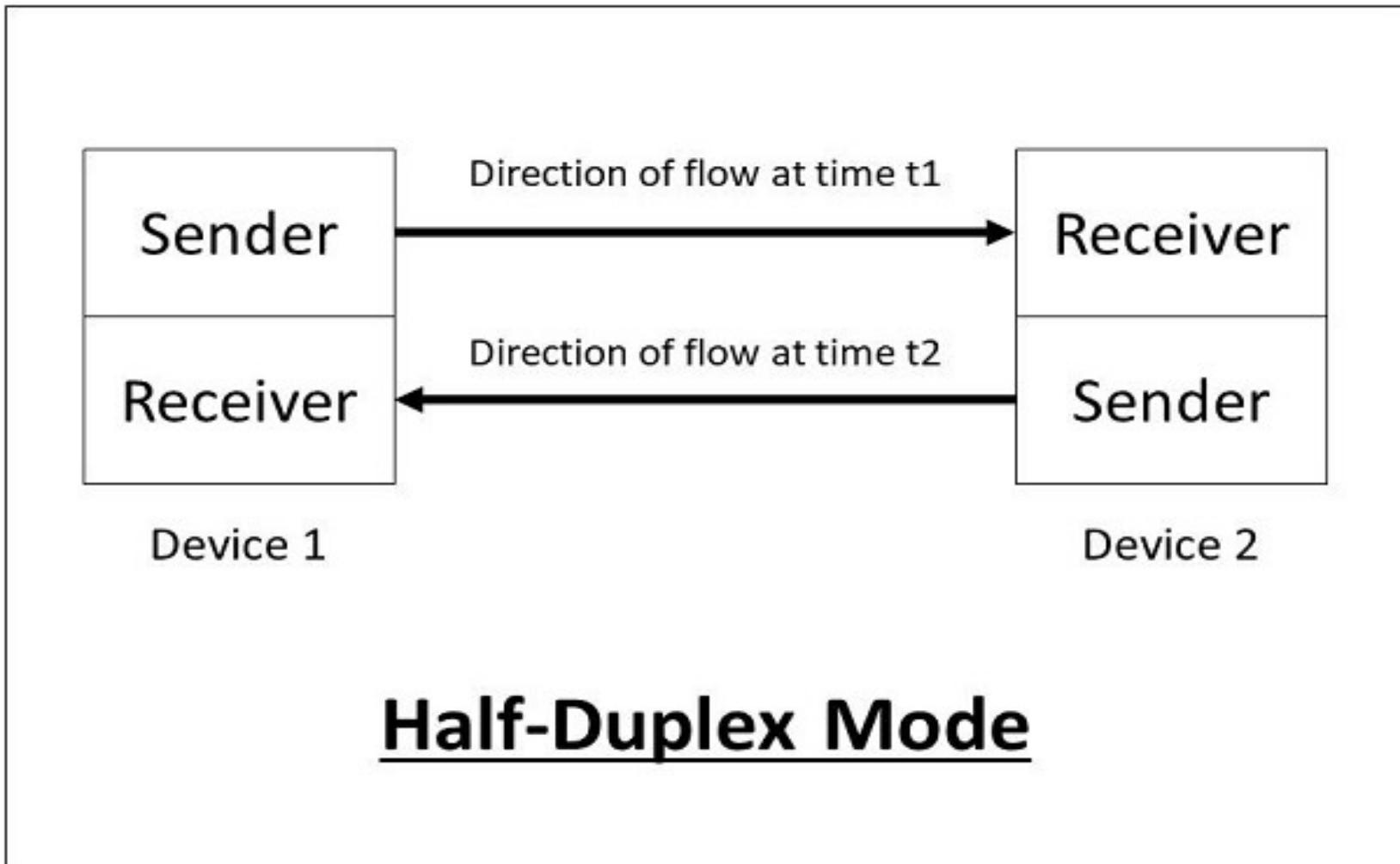
Disadvantage:

- Following are the **disadvantages** of using a Simplex transmission mode:
- It is unidirectional in nature having no inter-communication between devices.
- There is no mechanism for information to be transmitted back to the sender (**No mechanism for acknowledgement**).

Half-Duplex

- In half-duplex mode, each station can both transmit and receive, but not at the same time.
- When one device is sending, the other can only receive, and vice versa.
- The half-duplex mode is like a one-lane road with traffic allowed in both directions.
- When cars are traveling in one direction, cars going the other way must wait.
- In a half-duplex transmission, the entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time.
- Walkie-talkies are half-duplex system.

Half Duplex



Advantages and Disadvantages

Advantage:

Following are the **advantages** of using a half-duplex transmission mode:

- It facilitates the optimum use of the communication channel.
- It provides two-way communication.

Disadvantage:

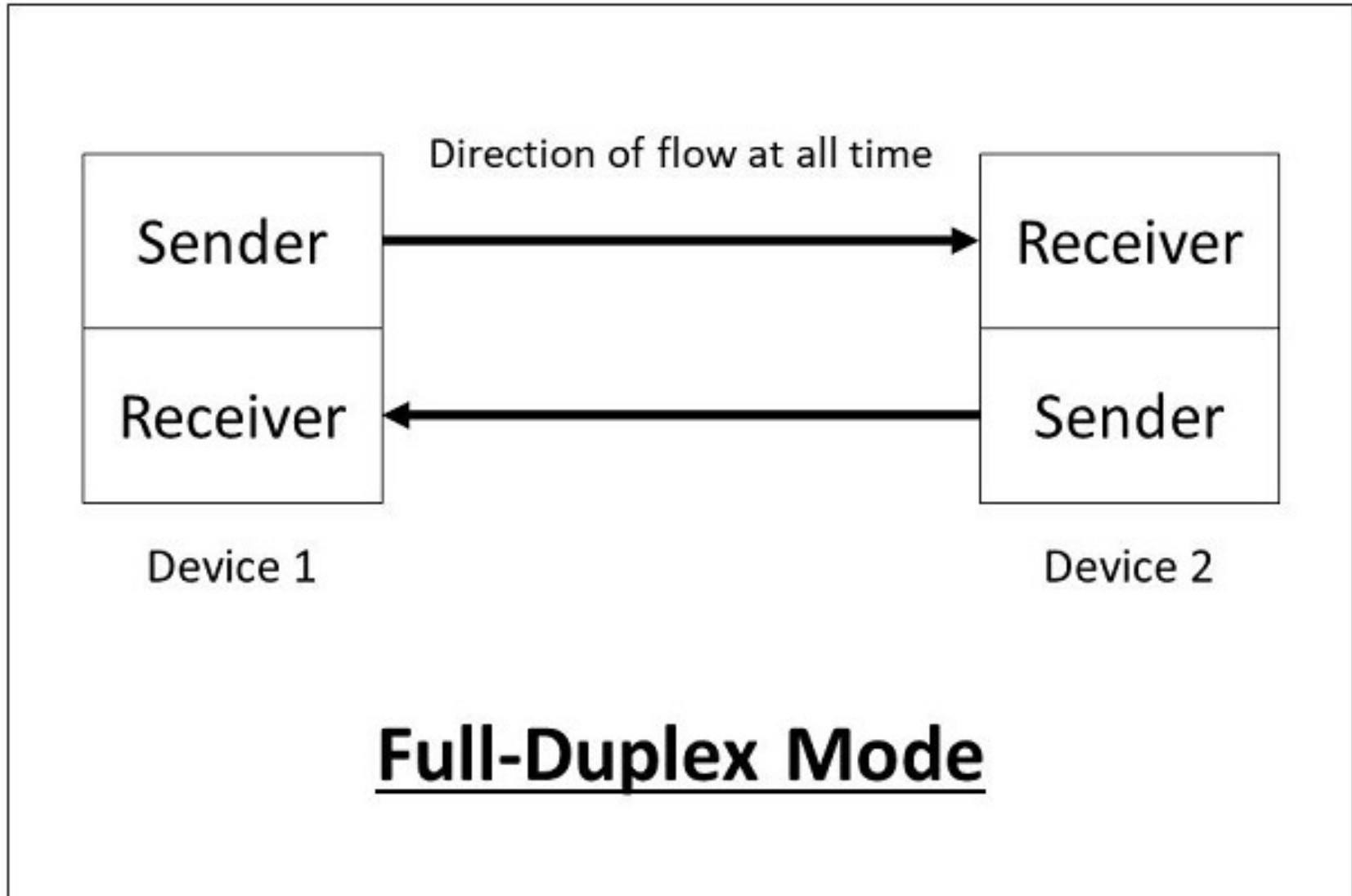
Following are the **disadvantages** of using a half-duplex transmission mode:

- The two-way communication can not be established simultaneously at the same time.
- Delay in transmission may occur as only one way communication can be possible at a time.

Full-Duplex

- In full-duplex mode (also called **duplex**), both stations can transmit and receive simultaneously.
- The full-duplex mode is like a **two-way street** with traffic flowing in both directions at the same time.
- In full-duplex mode, **signals going in one direction share the capacity of the link**: with signals going in the other direction.
- This sharing can occur in two ways:
Either the link must contain two physically separate transmission paths, one for sending and the other for receiving; or the capacity of the channel is divided between signals traveling in both directions.

Full Duplex



Advantages and Disadvantages

Advantage:

Following are the advantages of using a full-duplex transmission mode:

- The **two-way communication can be carried out simultaneously in both directions.**
- It is the **fastest mode** of communication between devices.

Disadvantage:

Following are the disadvantages of using a half-duplex transmission mode:

- The **capacity of the communication channel is divided into two parts.** Also, no dedicated path exists for data transfer.
- It has **improper channel bandwidth utilization** as there exist two separate paths for two communicating devices.

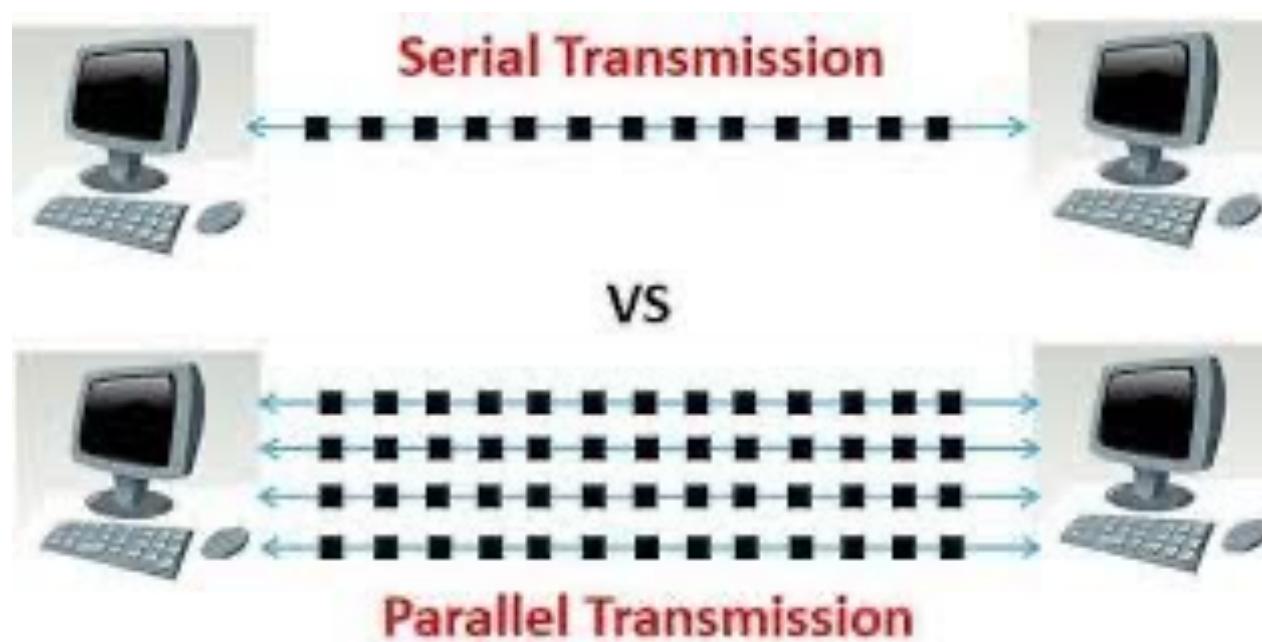
Serial and Parallel Data Flow

Serial Transmission:

In Serial Transmission, **data-bit flows from one computer to another computer in bi-direction**. In this transmission, one-bit flows at one clock pulse. In Serial Transmission, 8 bits are transferred at a time having a start and stop bit.

Parallel Transmission:

In Parallel Transmission, **many bits are flow together simultaneously from one computer to another computer**. Parallel Transmission is faster than serial transmission to transmit the bits. Parallel transmission is used for short distance.



Data Representation

Information today comes in different forms such as:

- Text
- Numbers
- Images
- Audio
- Video
- Graphics

Quiz

Which of the following 'pieces' of the Internet is a host (or end system)?

1. A modem
2. A router
3. An ISP
4. A Smartphone
5. All of the Above

Network Metrics

- Metrics are a **quantitative and qualitative** way to verify a desired behaviour.
- For instance, many operators like to measure their “**uptime**”, a count of how often services are available for users.
- Network metrics are similar and are related to desired outcomes.
- **Network capacity** can be described as “how much” traffic can cross a given link, segment, or aggregated path.
- **Network utilization** measures how much of the capacity is currently in use.

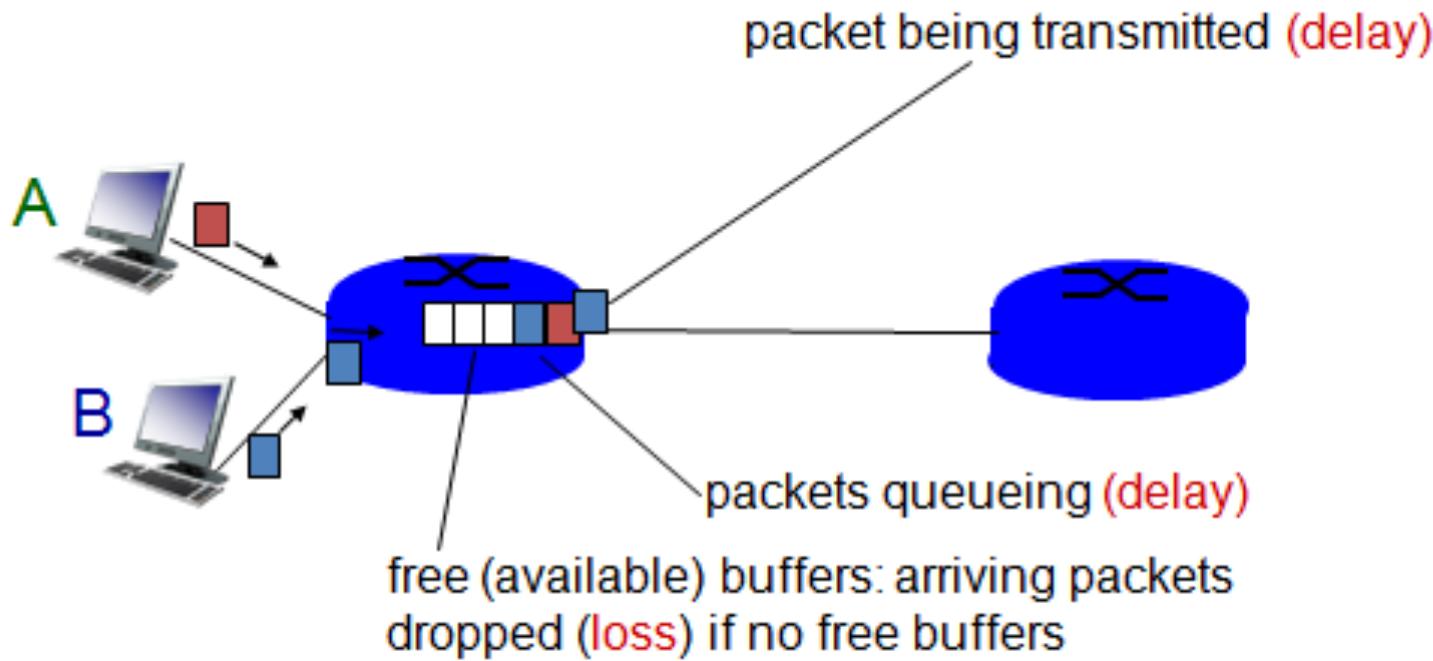
Network Metrics

- Computer networks necessarily constrain **Throughput** (the amount of data per second that can be transferred) between end systems.
- Introduce delays between end systems and can actually lose packets.
- Delay
- Loss
- Throughput

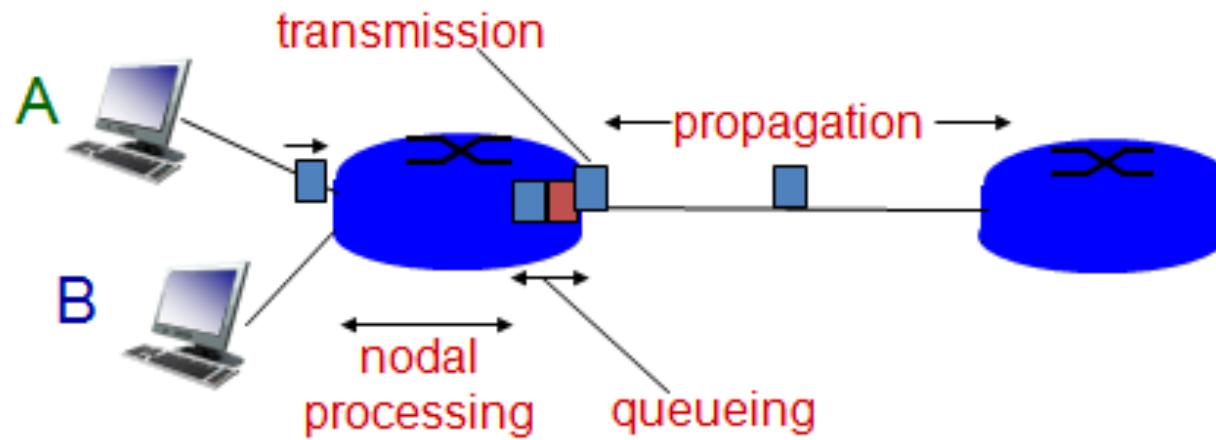
How do loss and delay occur ?

Packets queue in router buffers

- packet arrival rate to link (temporarily) exceeds output link capacity
- packets queue, wait for turn



Sources of Packet Delay



$$d_{\text{nodal}} = d_{\text{proc}} + d_{\text{queue}} + d_{\text{trans}} + d_{\text{prop}}$$

d_{proc} : nodal processing

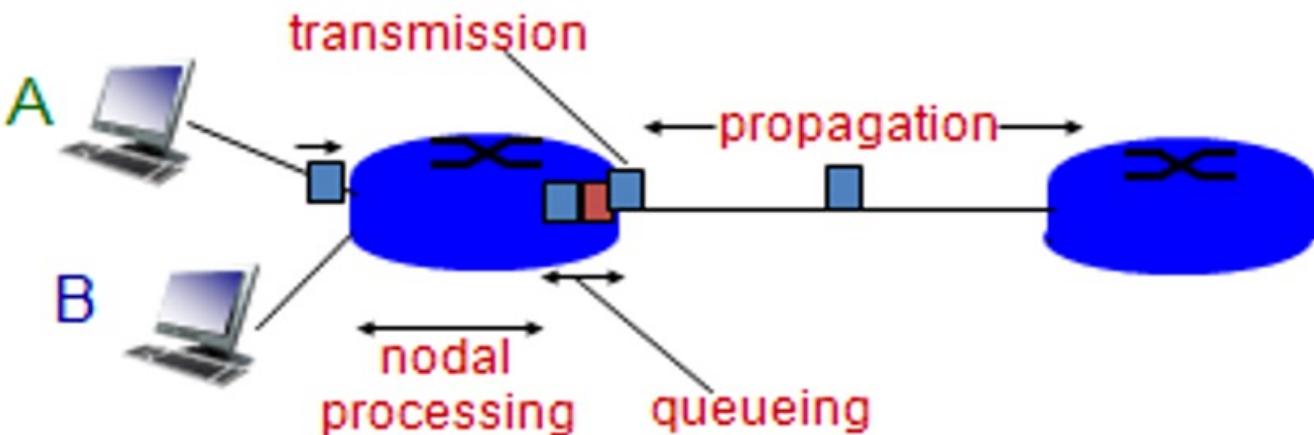
- check bit errors
- determine output link
- typically < msec

d_{queue} : queueing delay

- time waiting at output link for transmission
- depends on congestion level of router

Sources of Packet Delay

Sources of Packet Delay



$$d_{\text{nodal}} = d_{\text{proc}} + d_{\text{queue}} + d_{\text{trans}} + d_{\text{prop}}$$

d_{trans} : transmission delay:

- L : packet length (bits)
- R : link bandwidth (bps)
- $d_{\text{trans}} = L/R$

d_{prop} : propagation delay:

- d : length of physical link
- s : propagation speed in medium ($\sim 2 \times 10^8$ m/sec)
- $d_{\text{prop}} = d/s$

Quiz

- How long does it take a packet of length 1,000 bytes to propagate over a link of distance 2,500 km, propagation speed $2.5 * 10^8$ m/s, and transmission rate 2 Mbps?

Answer

- 10msec; d/s;

Step-by-step-solution

Step 1 of 5

Consider the given data:

$$\begin{aligned}\text{Length of the packet} &= 1000 \text{bytes} \\ &= 1000 \times 8 \text{ bits} \\ &= 8000 \text{ bits}\end{aligned}$$

$$\begin{aligned}\text{Distance of the link} &= 2500 \text{ km} \\ &= 2500 \times 1000 \text{ m} \\ &= 2500000 \text{ m}\end{aligned}$$

$$\text{Propagation speed} = 2.5 \times 10^8 \text{m/s}$$

$$\text{Transmission rate} = 2 \text{Mbps}$$

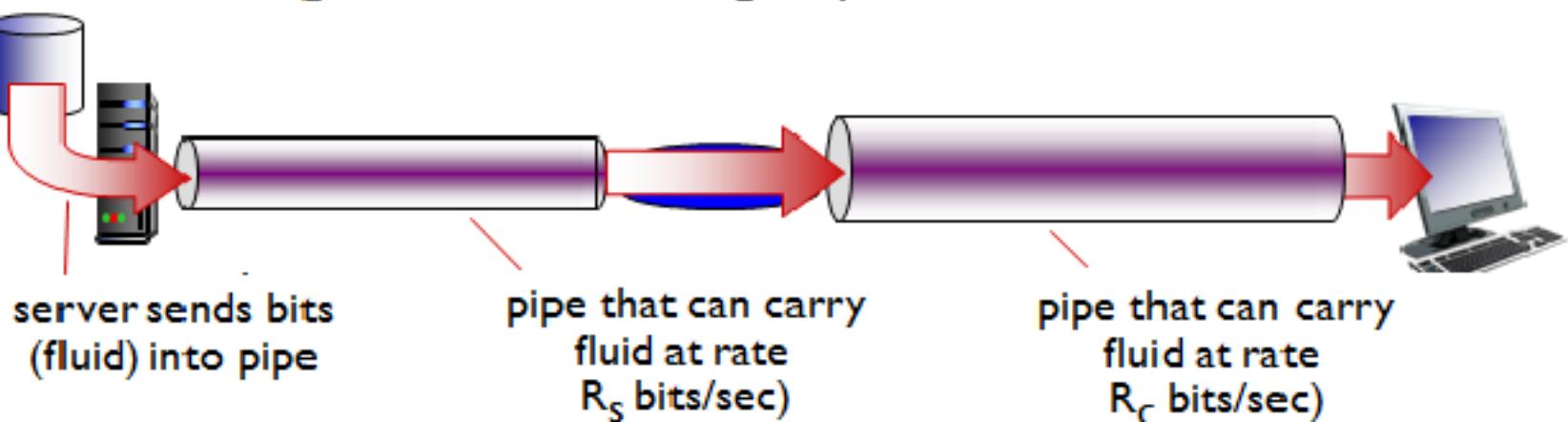
Calculate the time taken by a packet to propagate by using propagation time formula.

$$\begin{aligned}\text{Propagation time} &= \frac{\text{Distance of the link}}{\text{Propagation speed}} \\&= \frac{2500000 \text{ m}}{2.5 \times 10^8 \text{ m/sec}} \\&= \frac{2500000 \text{ sec}}{250000000} \\&= 0.01 \text{ sec} \\&= 10 \text{ msec}\end{aligned}$$

Therefore, the time taken for a packet of length 1,000 bytes to propagate over a link of distance 2,500 km with propagation speed of 2.5×10^8 and transmission rate of 2 Mbps is **10 msec**.

Throughput

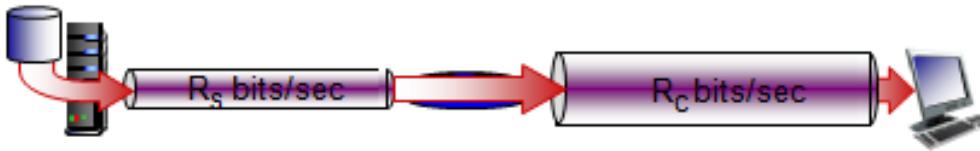
- Throughput: rate (bits/time unit) at which bits transferred between sender/receiver
 - instantaneous: rate at given point in time
 - average: rate over longer period of time



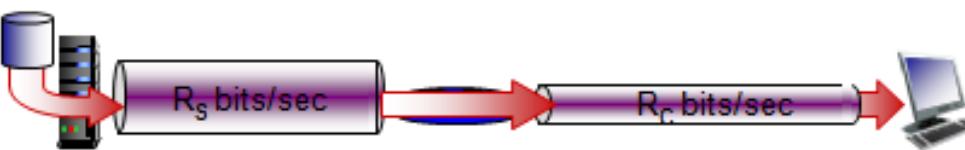
Throughput

Throughput

- $R_s < R_c$ What is average end-end throughput?



- ❖ $R_s > R_c$ What is average end-end throughput?



bottleneck link

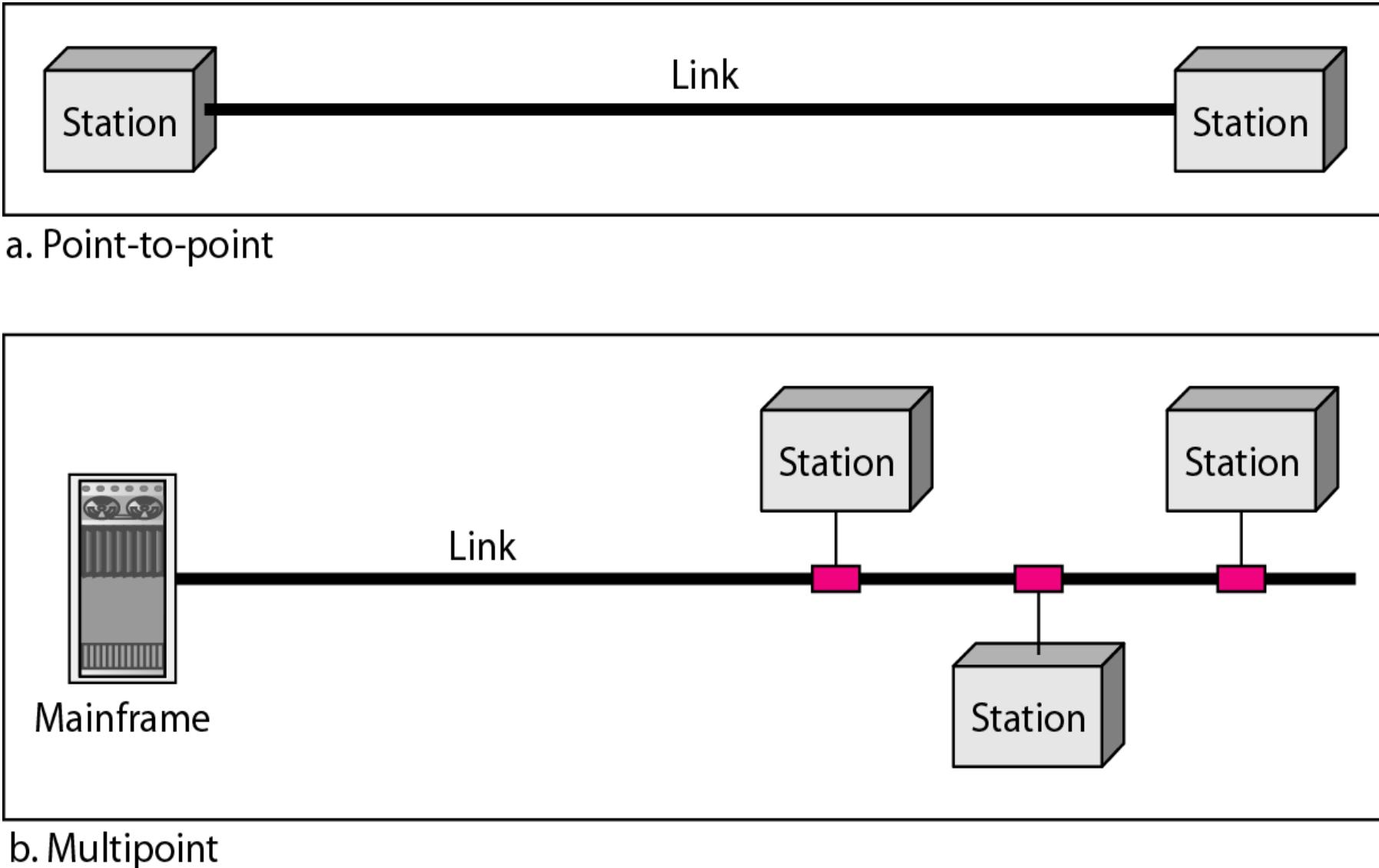
link on end-end path that constrains end-end throughput

- The number of messages transferred successfully per unit of time is referred to as **throughput**. Throughput value depends upon many factors such as hardware capabilities, available signal-to-noise ratio, available bandwidth, etc.
- The maximal throughput of a computer network may be greater than the **throughput achieved regularly**. When various protocol costs are considered, the use rate of the transmitted data can be quite smaller than the maximum throughput achievable.

NETWORKS

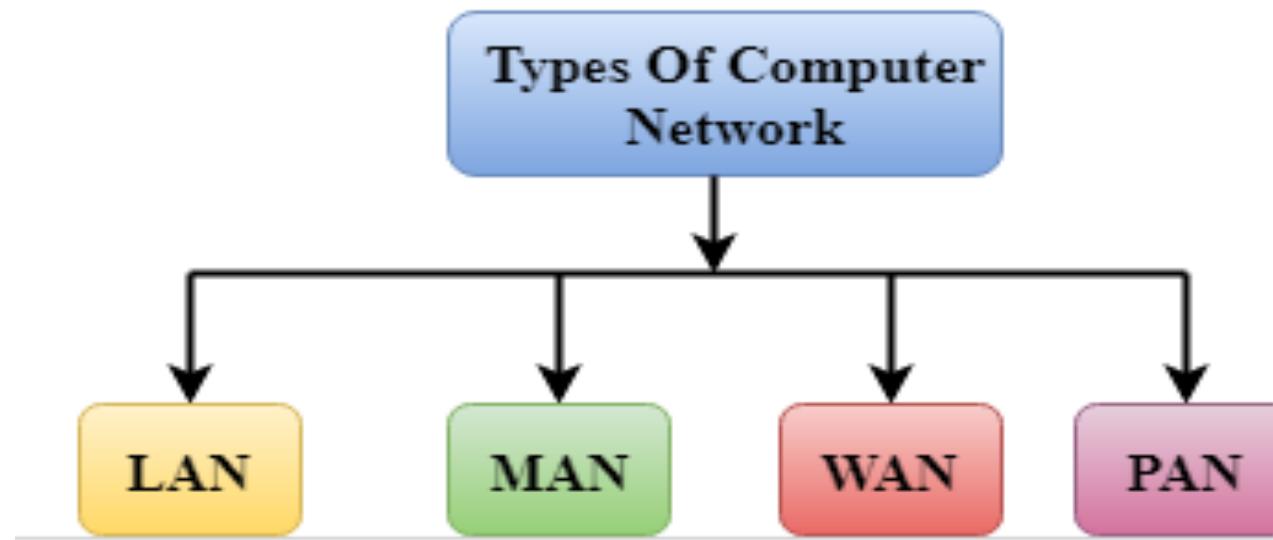
- A **network** is a set of devices (often referred to as nodes) connected by communication links.
- A node can be a **computer, printer, or any other device** capable of sending and/or receiving data generated by other nodes on the network.

Types of connections: point-to-point and multipoint



Types of Computer Network

A computer network can be categorized by their size.



LAN (LOCAL AREA NETWORK)

- Small Area network such as **building**, **office**
- Connecting two or more personal computers
- Less costly
- Data transfer is extremely faster.
- Provides **high security**.

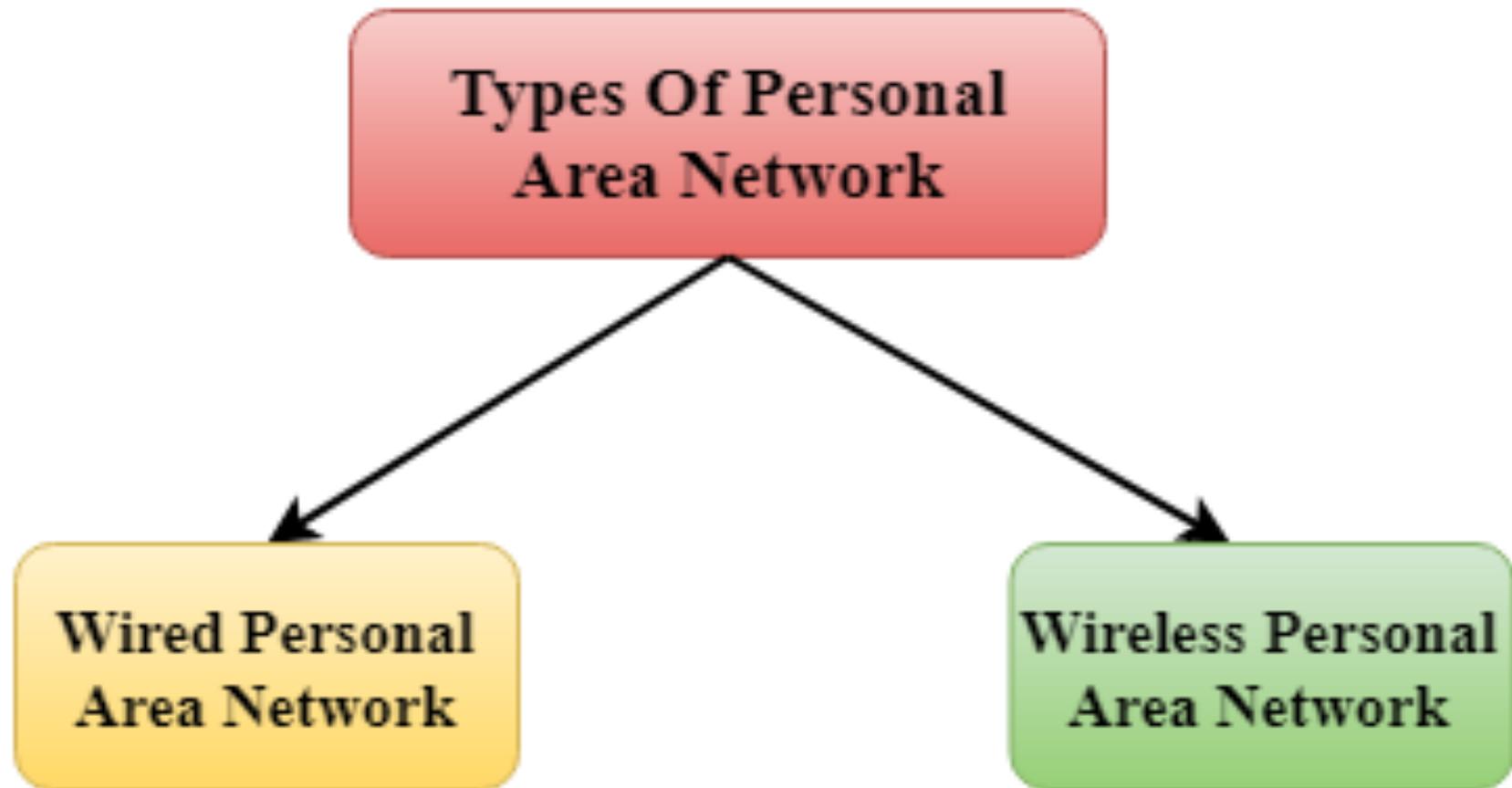


PAN (Personal Area Network)

- Network arranged within an individual person.
- covers an area of **30 feet**.
- Personal computer devices that are used to develop the personal area network are the laptop, mobile phones, media player and play stations.

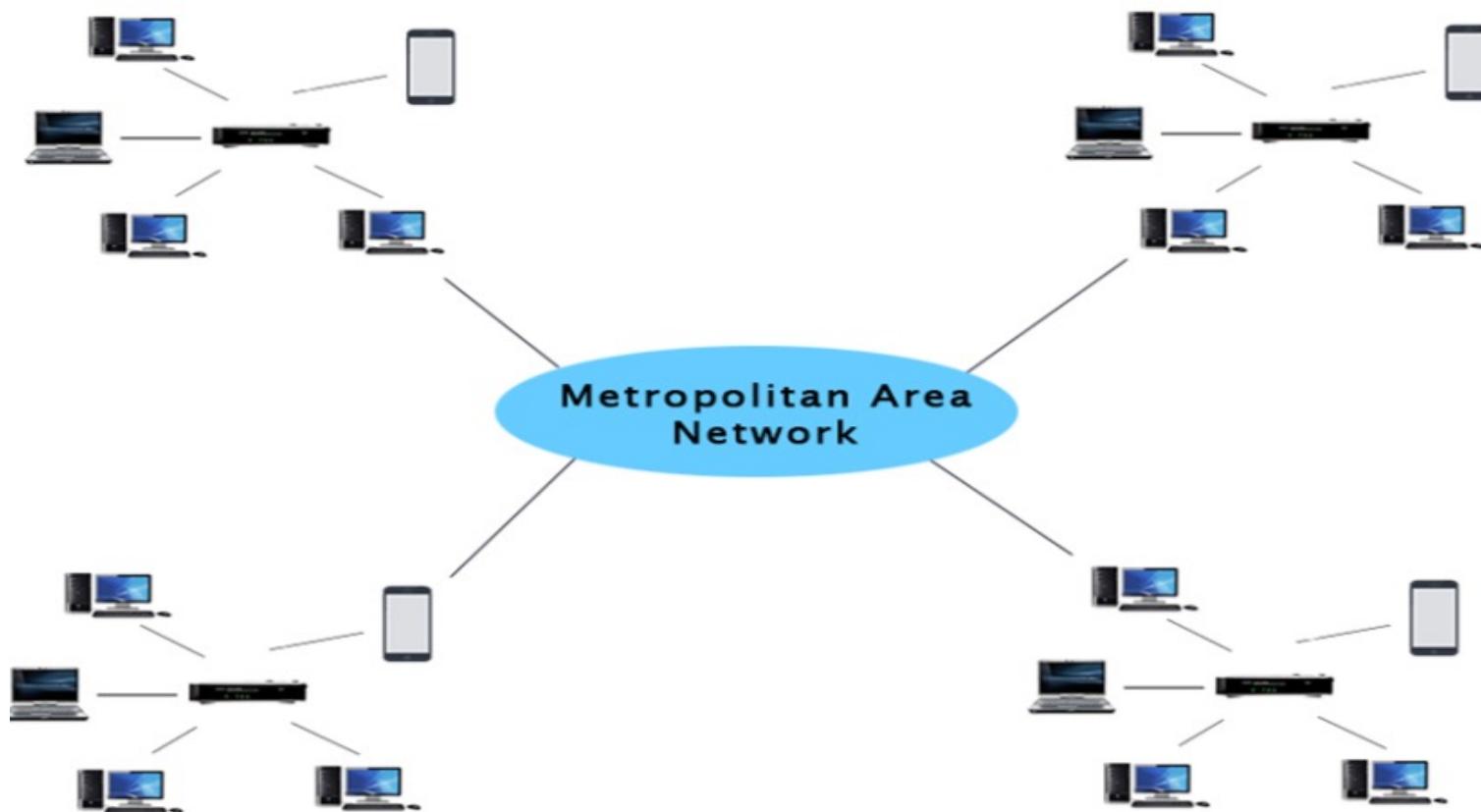


Types of Personal Area Network



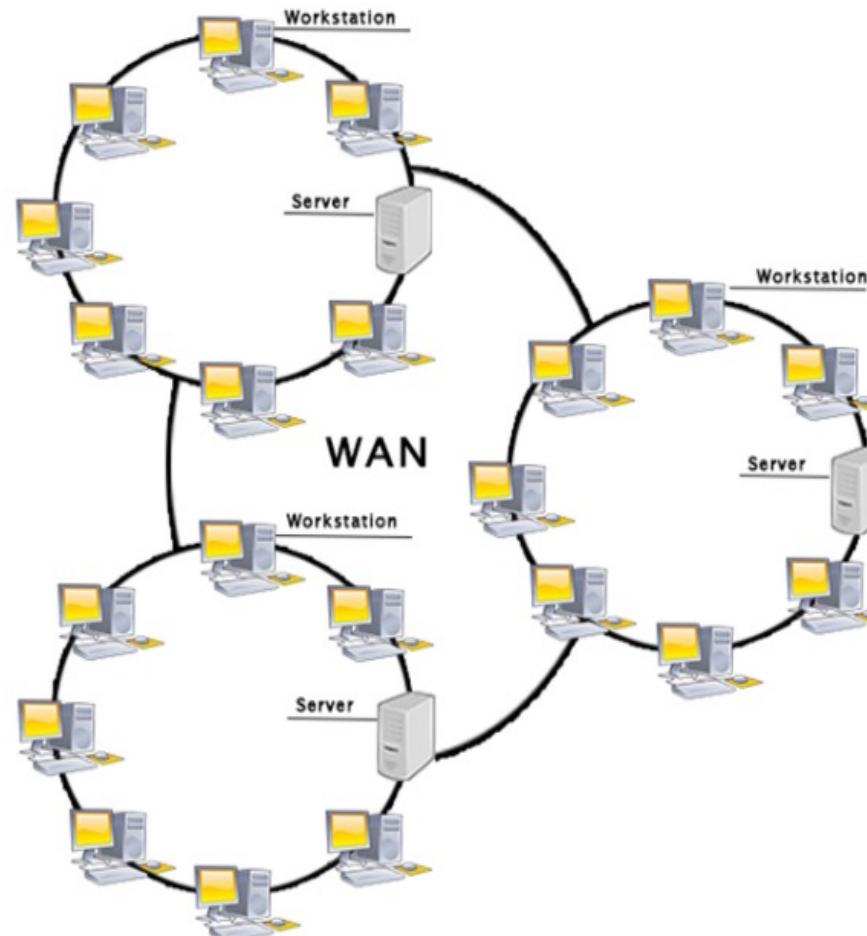
MAN (Metropolitan Area Network)

- Covers a larger geographic area by interconnecting a **different LAN** to form a **larger network**.
- Government agencies use MAN.
- It has a **higher range than Local Area Network(LAN)**.



WAN (Wide Area Network)

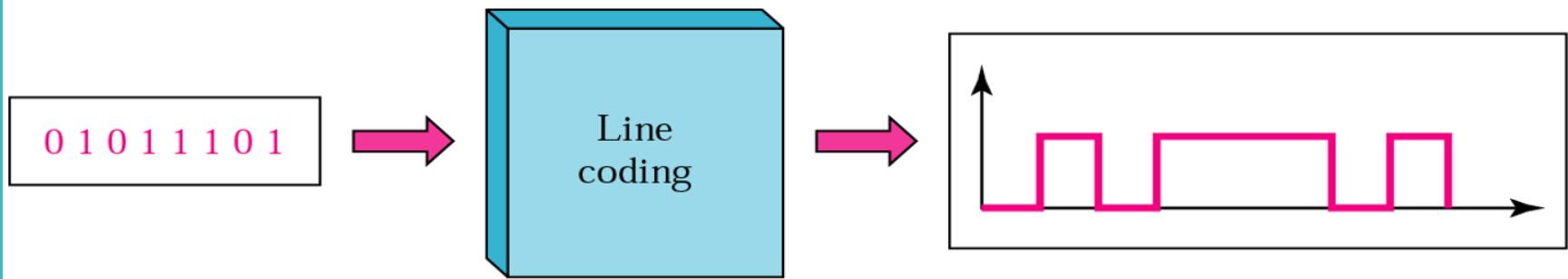
- Extends over a large geographical area such as states or countries.
- Quite bigger network than the LAN.
- Used in the field of Business, government, and education.



Digital Transmission

Line Coding

Digital Transmission



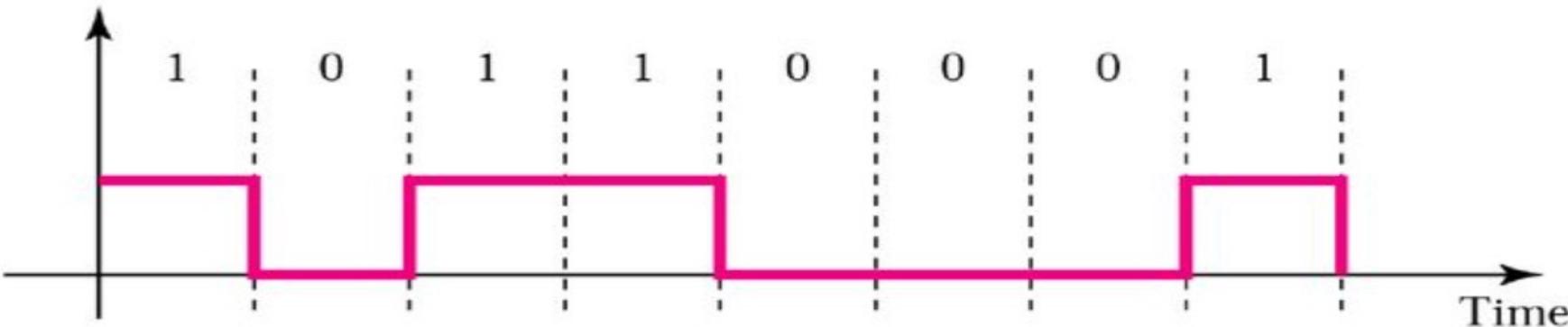
Convert of Sequence of bits in Digital Signal

Digital Transmission

Signal Level Vs Data Level

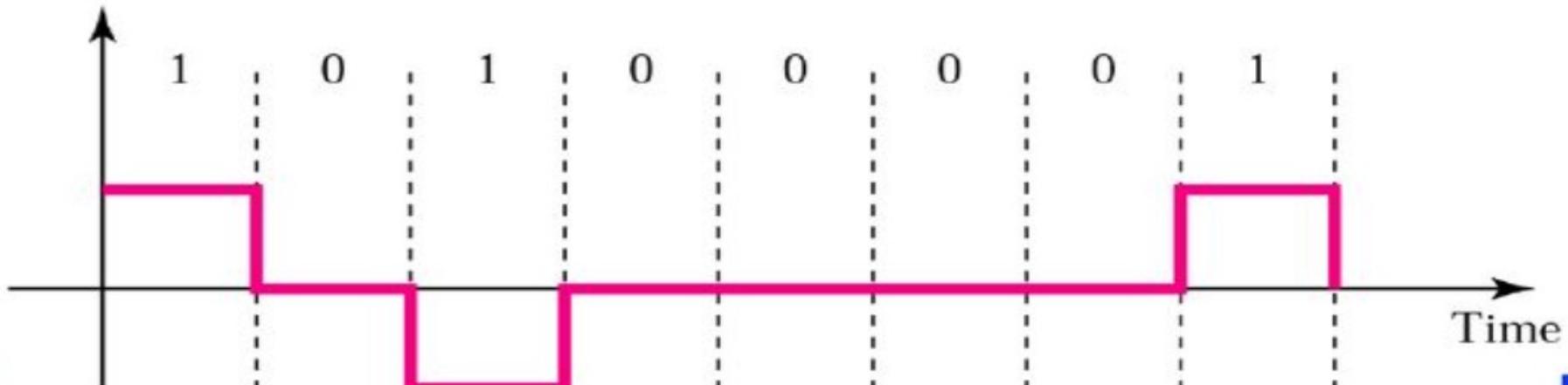
- Signal level – number of values allowed in a signal
- Data level – number of values used to represent data

Amplitude



a. Two signal levels, two data levels

Amplitude



Three signal levels, two data levels

Numerical

A signal has two data levels with a pulse duration of 1 ms. We calculate the pulse rate and bit rate as follows:

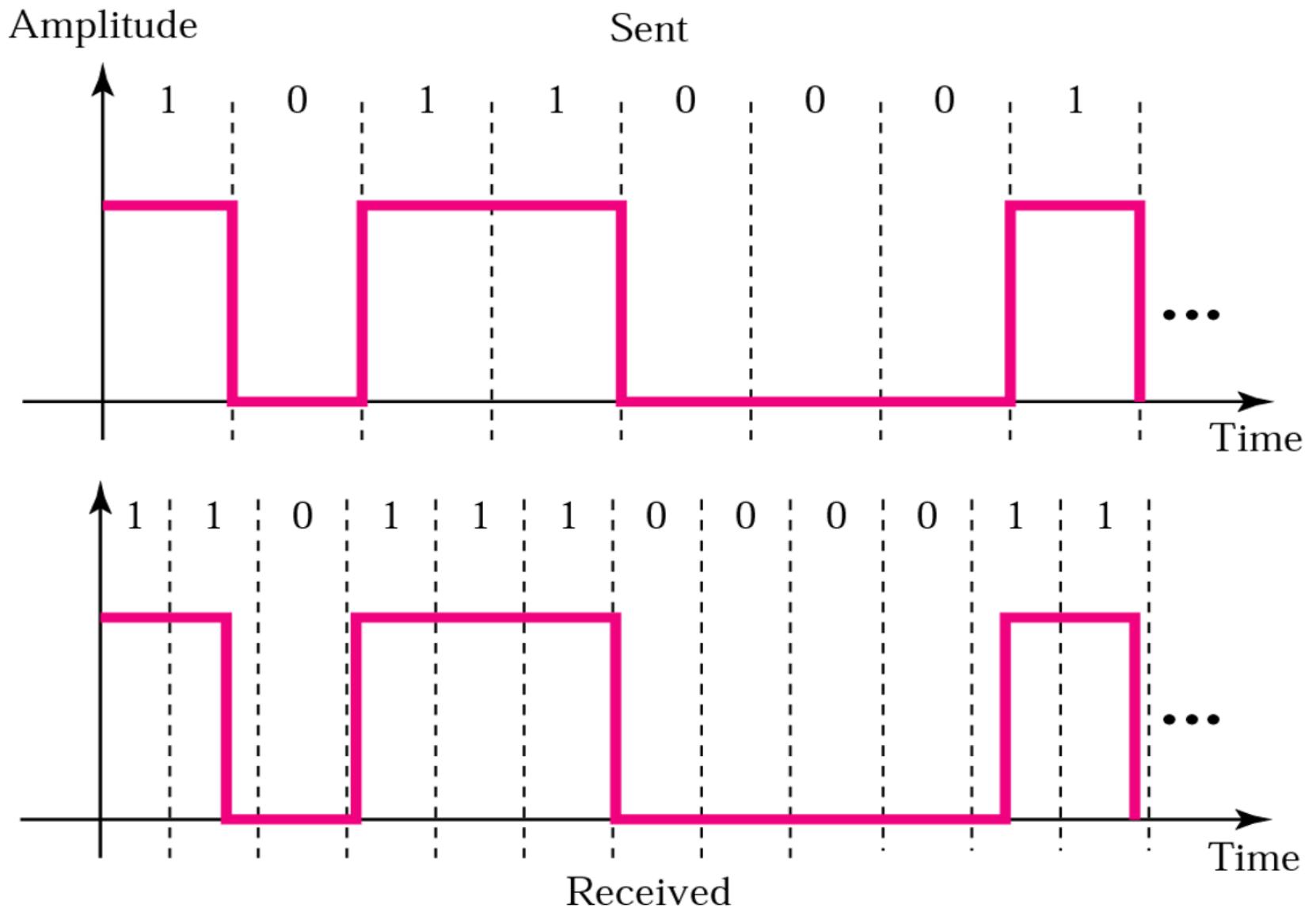
$$\text{Pulse Rate} = 1/10^{-3} = 1000 \text{ pulses/s}$$

$$\text{Bit Rate} = \text{Pulse Rate} \times \log_2 L = 1000 \times \log_2 2 = 1000 \text{ bps}$$

A signal has four data levels with a pulse duration of 1 ms. We calculate the pulse rate and bit rate as follows:

?????????

Lack of Synchronization



Numerical

In a digital transmission, the receiver clock is 0.1 percent faster than the sender clock. How many extra bits per second does the receiver receive if the data rate is 1 Kbps? How many if the data rate is 1 Mbps?

Solution

At 1 Kbps:

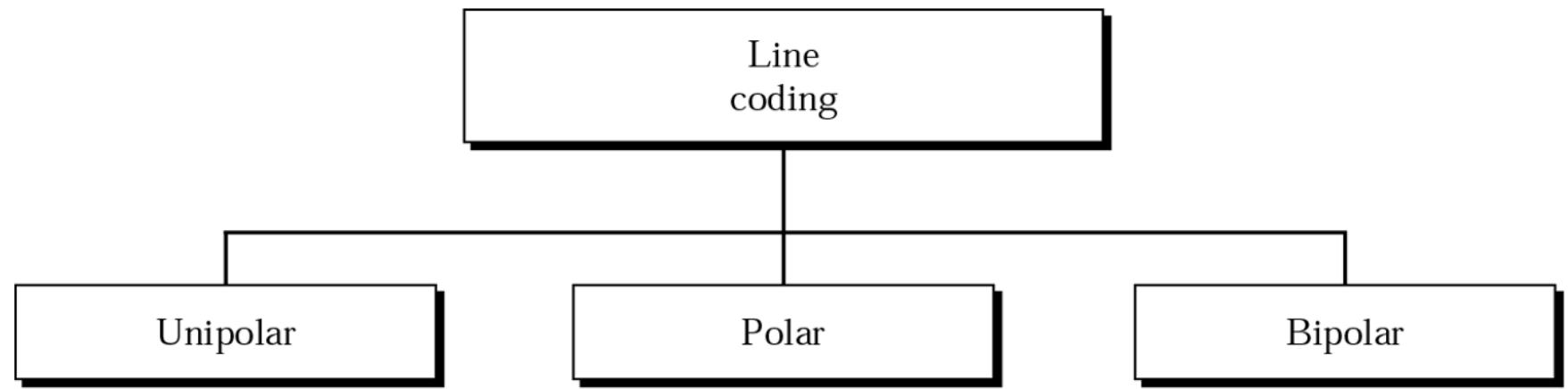
1000 bits sent → 1001 bits received → 1 extra bps

At 1 Mbps:

1,000,000 bits sent → 1,001,000 bits received → 1000 extra bps

Line Coding Scheme

Line Coding Scheme

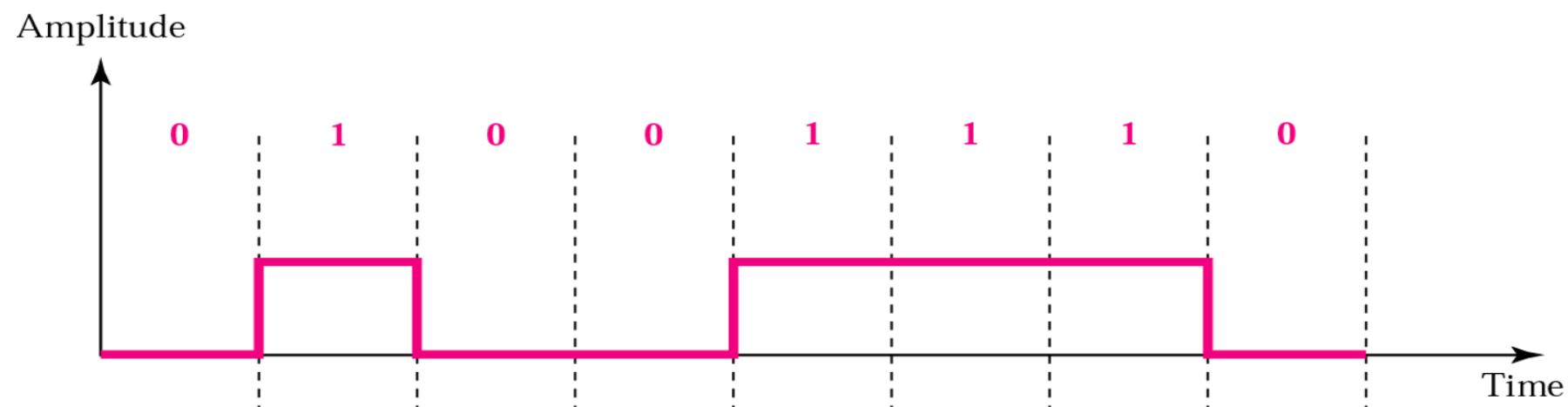


Unipolar



Note:

Unipolar encoding uses only one voltage level.

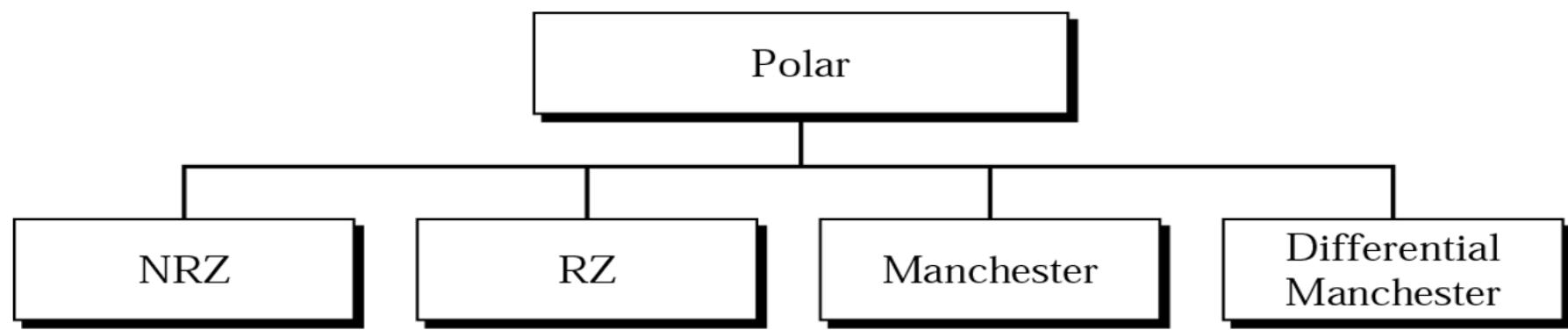


Polar Encoding



Note:

Polar encoding uses two voltage levels (positive and negative).



NRZ-L, NRZ-I



Note:

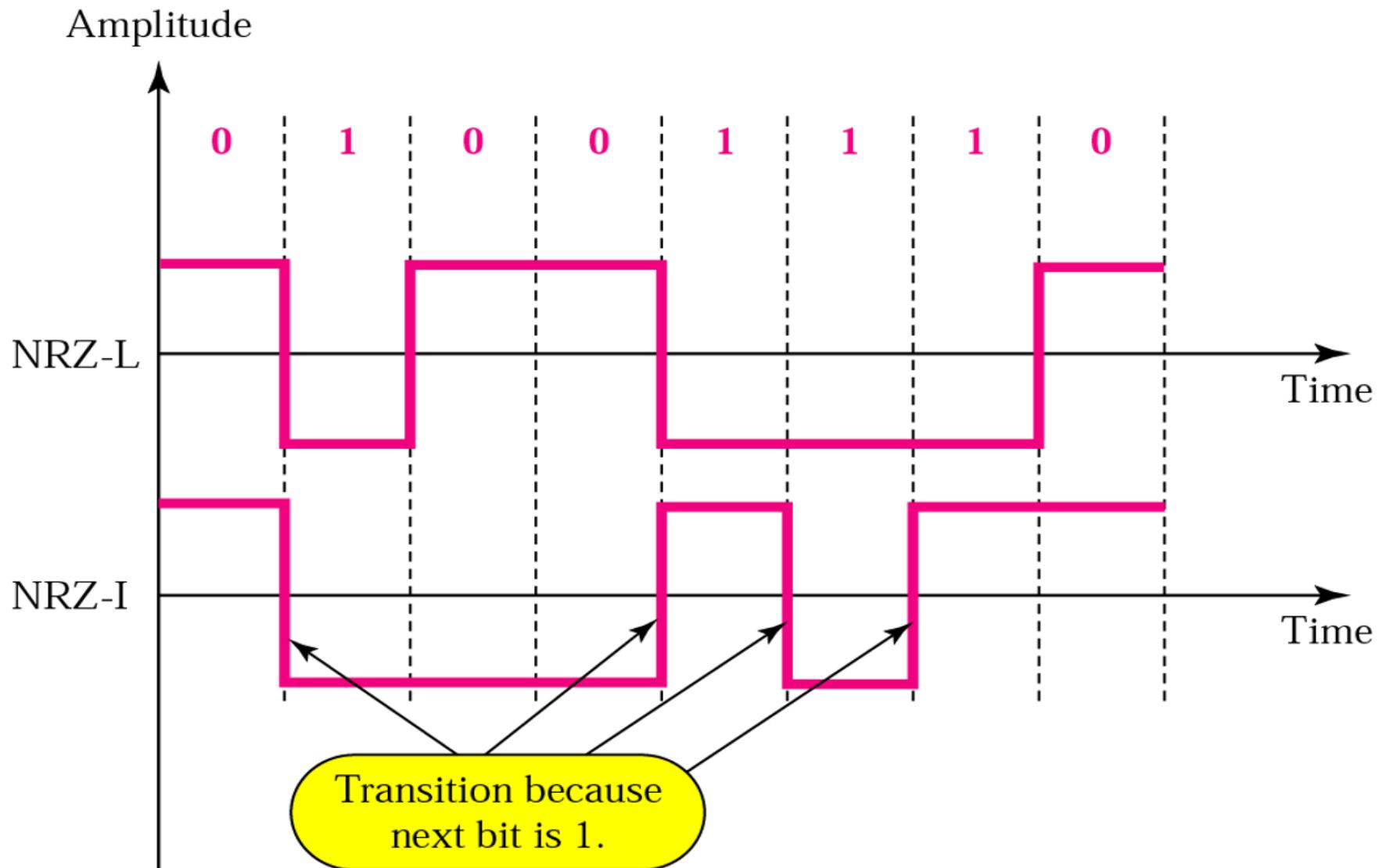
In NRZ-L the level of the signal is dependent upon the state of the bit.



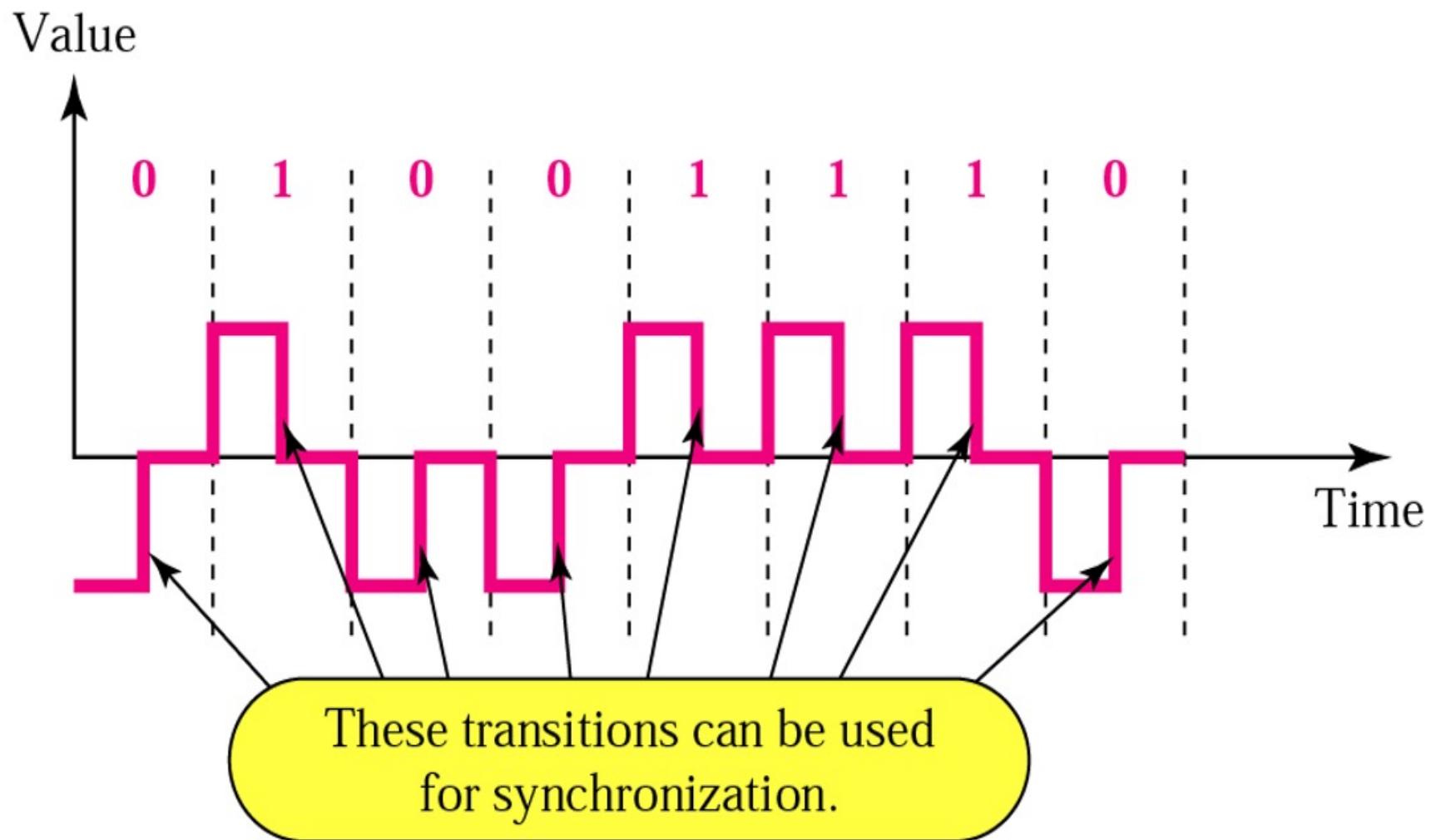
Note:

In NRZ-I the signal is inverted if a 1 is encountered.

NRZ-L, NRZ-I



RZ Encoding

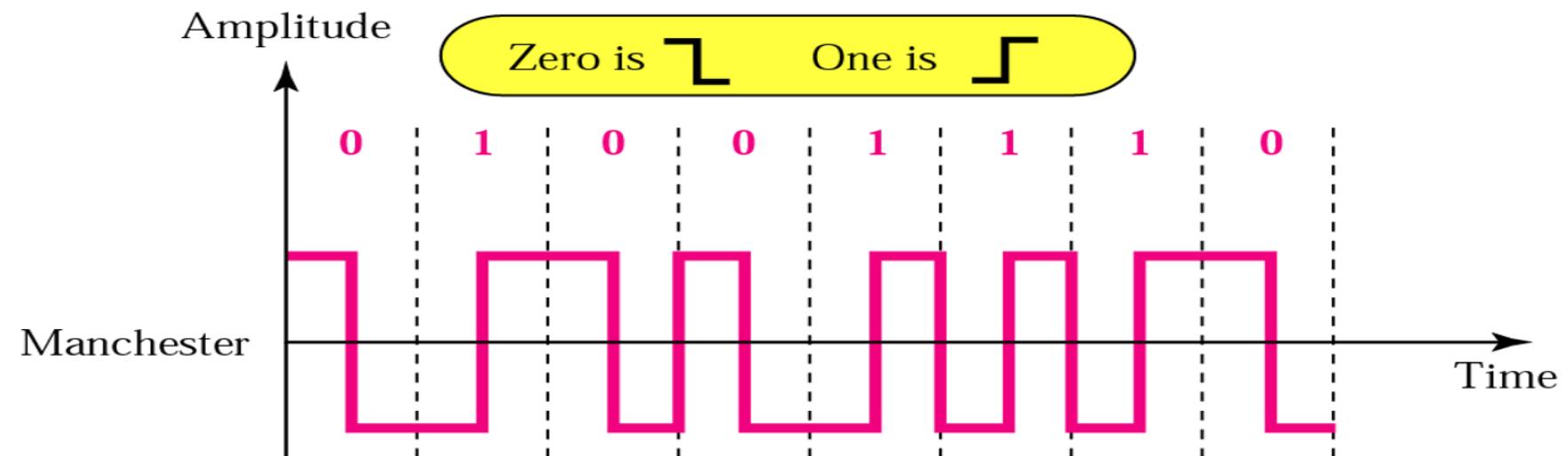


Manchester Encoding



Note:

In Manchester encoding, the transition at the middle of the bit is used for both synchronization and bit representation.

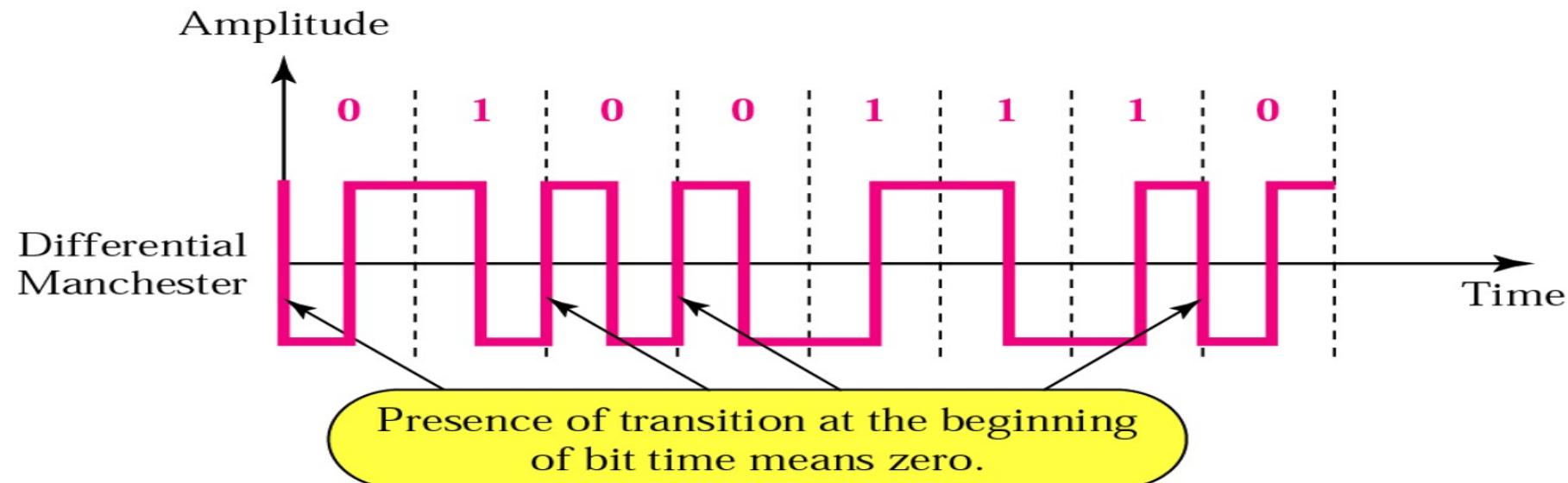


Differential Manchester Encoding



Note:

In differential Manchester encoding, the transition at the middle of the bit is used only for synchronization. The bit representation is defined by the inversion or noninversion at the beginning of the bit.



Numerical

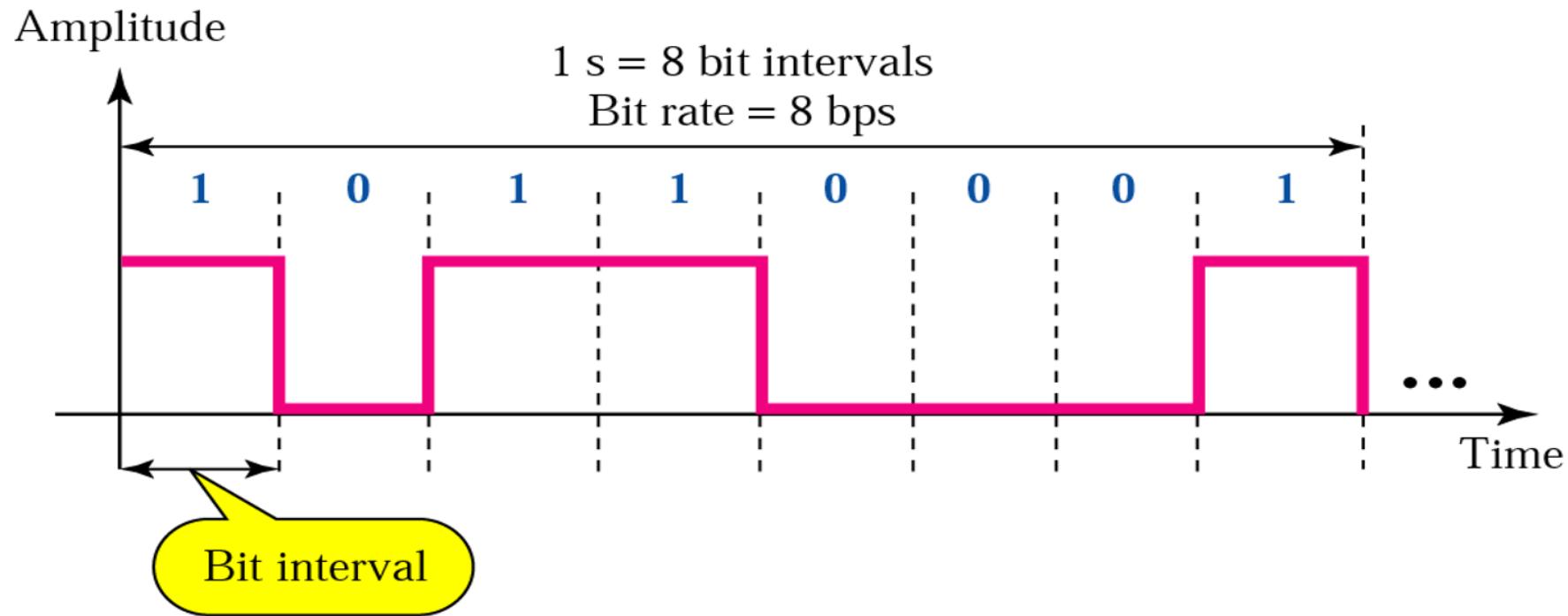
A digital signal has a bit rate of 2000 bps. What is the duration of each bit (bit interval)

Solution

The bit interval is the inverse of the bit rate.

$$\begin{aligned}\text{Bit interval} &= 1 / 2000 \text{ s} = 0.000500 \text{ s} \\ &= 0.000500 \times 10^6 \mu\text{s} = 500 \mu\text{s}\end{aligned}$$

Bit Rate and Bit Interval



Numerical

Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with two signal levels. The maximum bit rate can be calculated as

$$\text{Bit Rate} = 2 \times 3000 \times \log_2 2 = 6000 \text{ bps}$$

Consider the same noiseless channel, transmitting a signal with four signal levels (for each level, we send two bits). The maximum bit rate can be calculated as:

$$\text{Bit Rate} = 2 \times 3000 \times \log_2 4 = 12,000 \text{ bps}$$

Numerical

Consider an extremely noisy channel in which the value of the signal-to-noise ratio is almost zero. In other words, the noise is so strong that the signal is faint. For this channel the capacity is calculated as

$$\begin{aligned}C &= B \log_2 (1 + \text{SNR}) = B \log_2 (1 + 0) \\&= B \log_2 (1) = B \times 0 = 0\end{aligned}$$

We can calculate the theoretical highest bit rate of a regular telephone line. A telephone line normally has a bandwidth of 3000 Hz (300 Hz to 3300 Hz). The signal-to-noise ratio is usually 3162. For this channel the capacity is calculated as

$$\begin{aligned}C &= B \log_2 (1 + \text{SNR}) = 3000 \log_2 (1 + 3162) \\&= 3000 \log_2 (3163) \\C &= 3000 \times 11.62 = 34,860 \text{ bps}\end{aligned}$$

Numerical

We have a channel with a 1 MHz bandwidth. The SNR for this channel is 63; what is the appropriate bit rate and signal level?

Solution

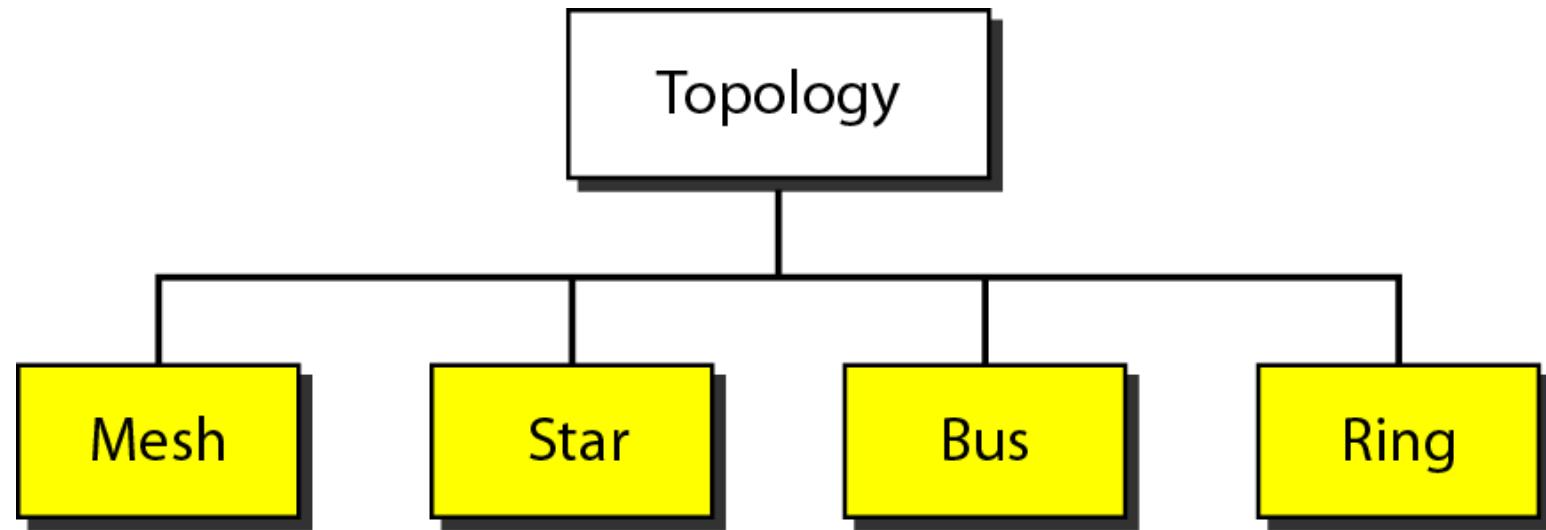
First, we use the Shannon formula to find our upper limit.

$$C = B \log_2 (1 + \text{SNR}) = 10^6 \log_2 (1 + 63) = 10^6 \log_2 (64) = 6 \text{ Mbps}$$

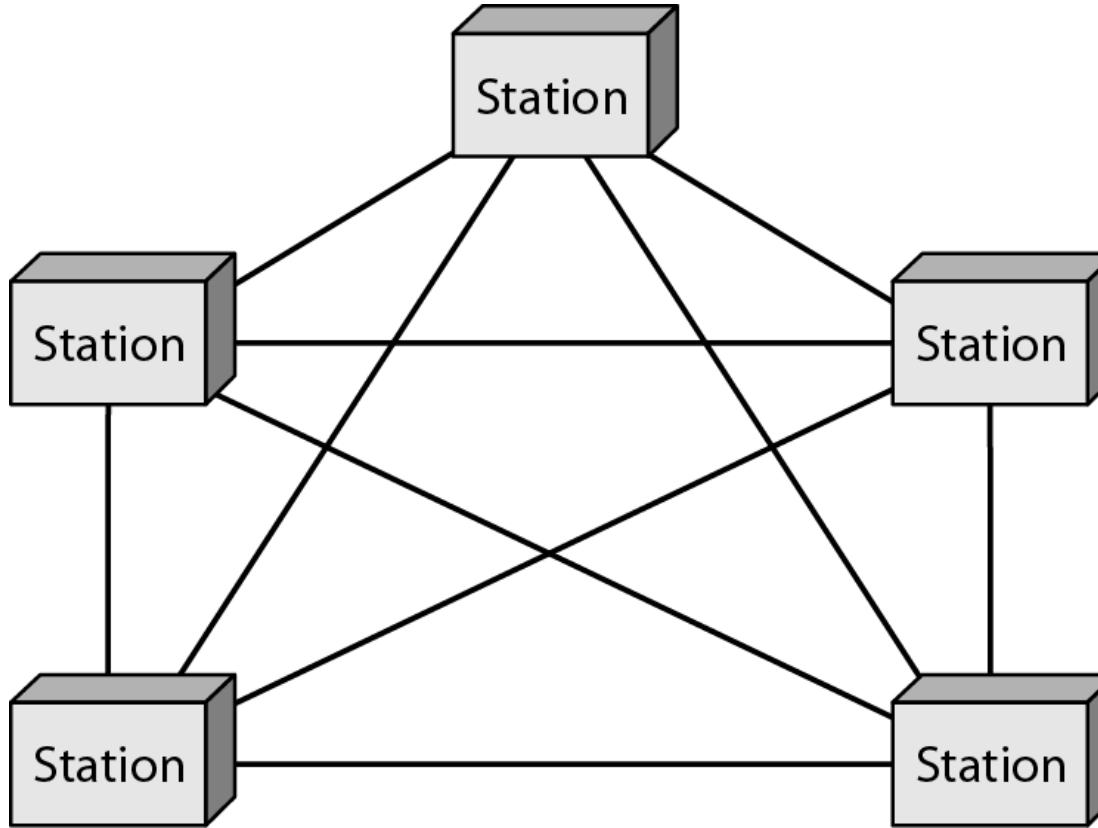
Then we use the Nyquist formula to find the number of signal levels.

$$4 \text{ Mbps} = 2 \times 1 \text{ MHz} \times \log_2 L \rightarrow L = 4$$

Categories of Topology



A fully connected mesh topology (five devices)



- Every device has a dedicated point to point link to every other device.
- Node 1 must be connected to $(n-1)$ nodes.
- Need $n(n-1)/2$ physical links.....No. of wires.

A fully connected mesh topology (five devices)

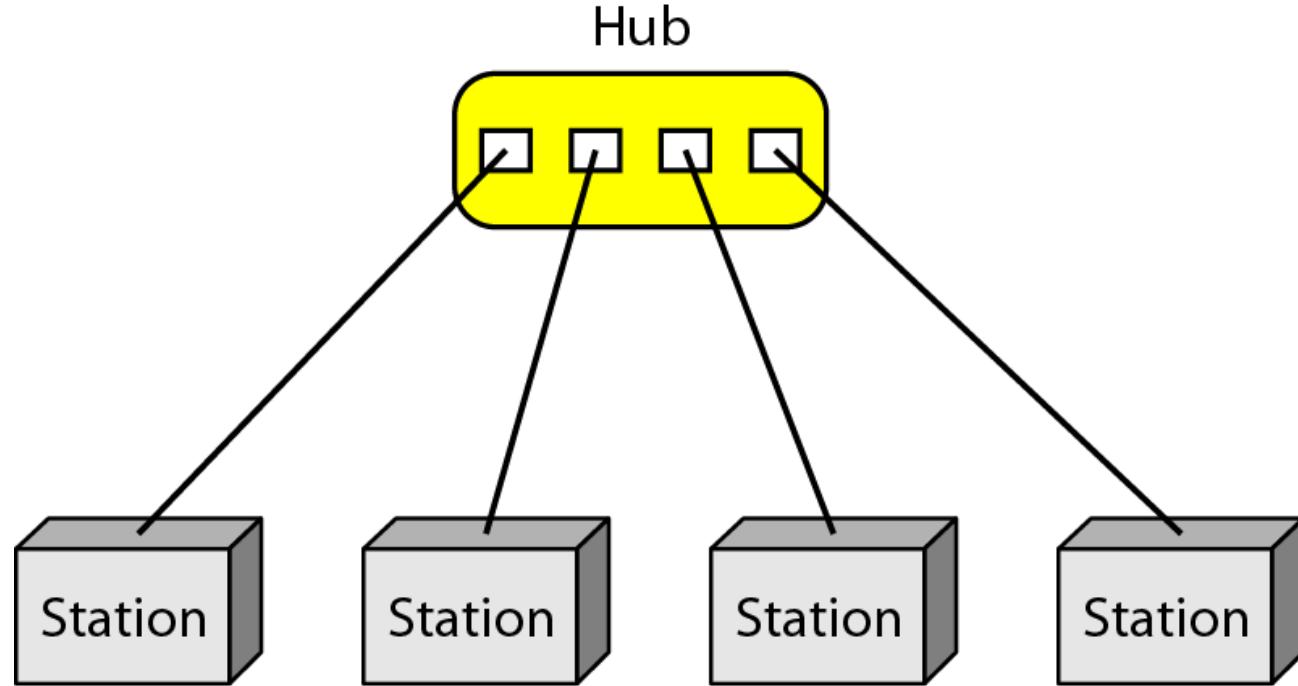
Advantages

- Eliminating the traffic problem.
- Robust
- Privacy and Security
- Fault Identification and Isolation easy

Disadvantage

- More Space
- More Wire
- Installation and Reconfiguration tough
- Expensive

A star topology connecting four stations



- Every device has a **dedicated point to point link to the Hub (Central Controller)** .
- Works in LANs

A star topology connecting four stations

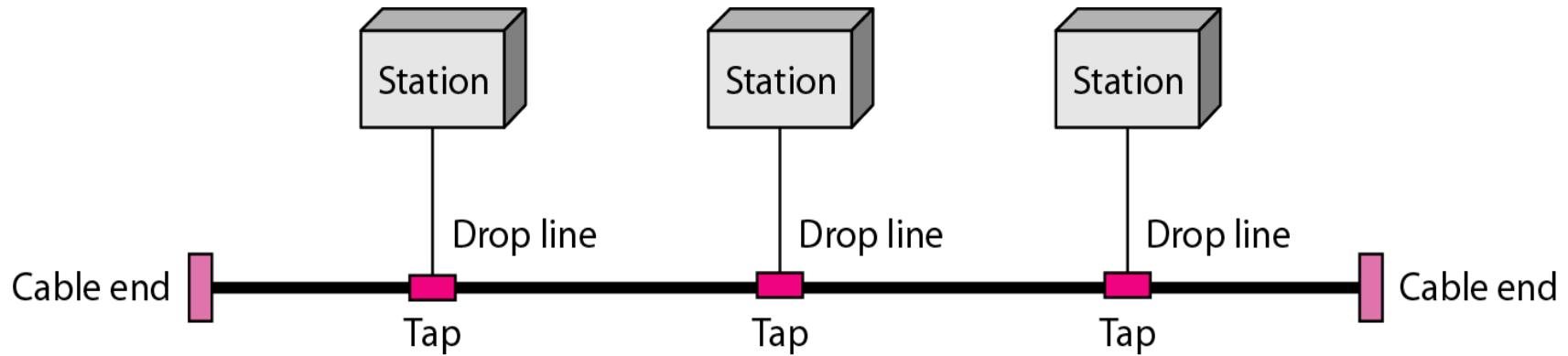
Advantages

- Less expensive than Mesh Topology.
- Installation and Reconfiguration Easy
- Robust
- Less cable than Mesh Topology.
- Fault Identification and Isolation easy

Disadvantage

- Hub is damage, then work is stop.

A bus topology connecting three stations



- Use Multipoint Connection.
- Use long cable acts as a backbone.
- Ethernet LANs use this topology.

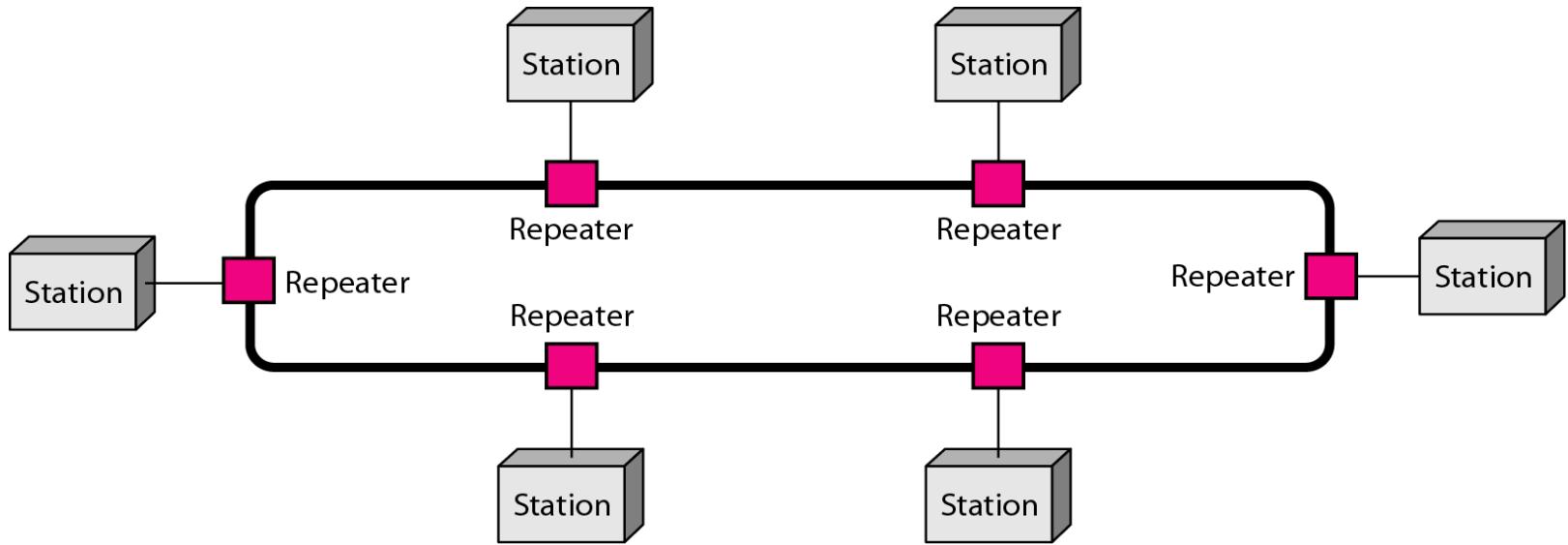
Advantages

- Easy Installation.
- Use less cable compare than Mesh and Star.
- No Redundance Issue.

Disadvantage

- Difficult to add or delete the devices
- Installation and Reconfiguration difficult

A ring topology connecting six stations



- Each device has dedicated **point to point link** to other next and previous devices.

A ring topology connecting six stations

Advantages

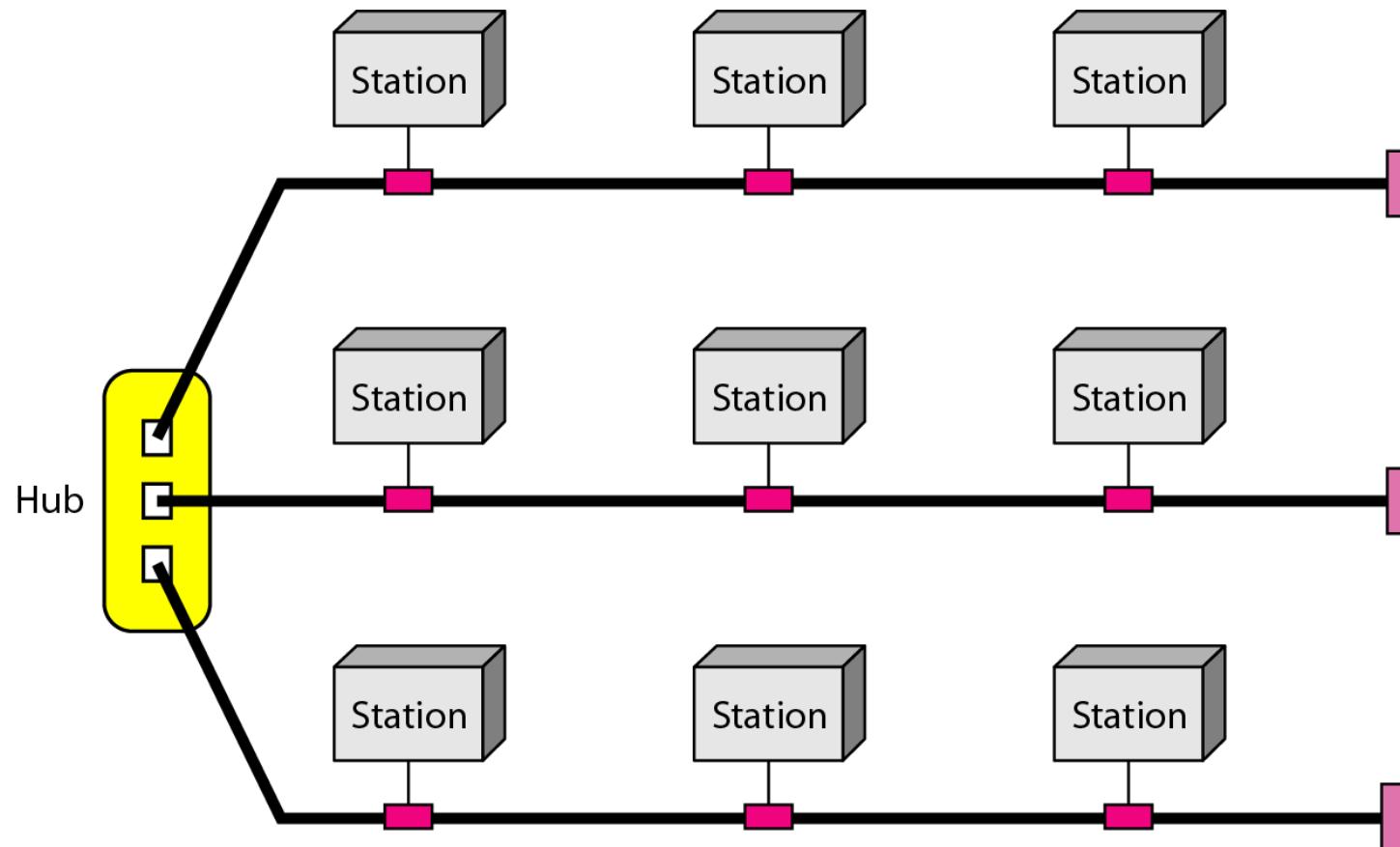
- Easy Installation and reconfiguration.
- Addition and deletion of device easy. (Two Connection needs)
- Fault Isolation is simplified.

Disadvantage

- Unidirectional traffic is main problem
- If connection is cut, then processing stop. (No Robust)

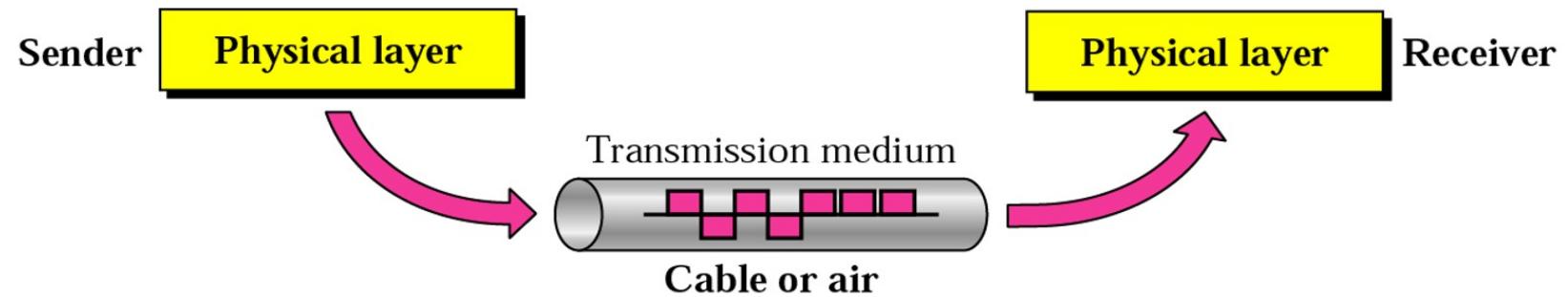
Hybrid Topology

A hybrid topology: a star backbone with three bus networks



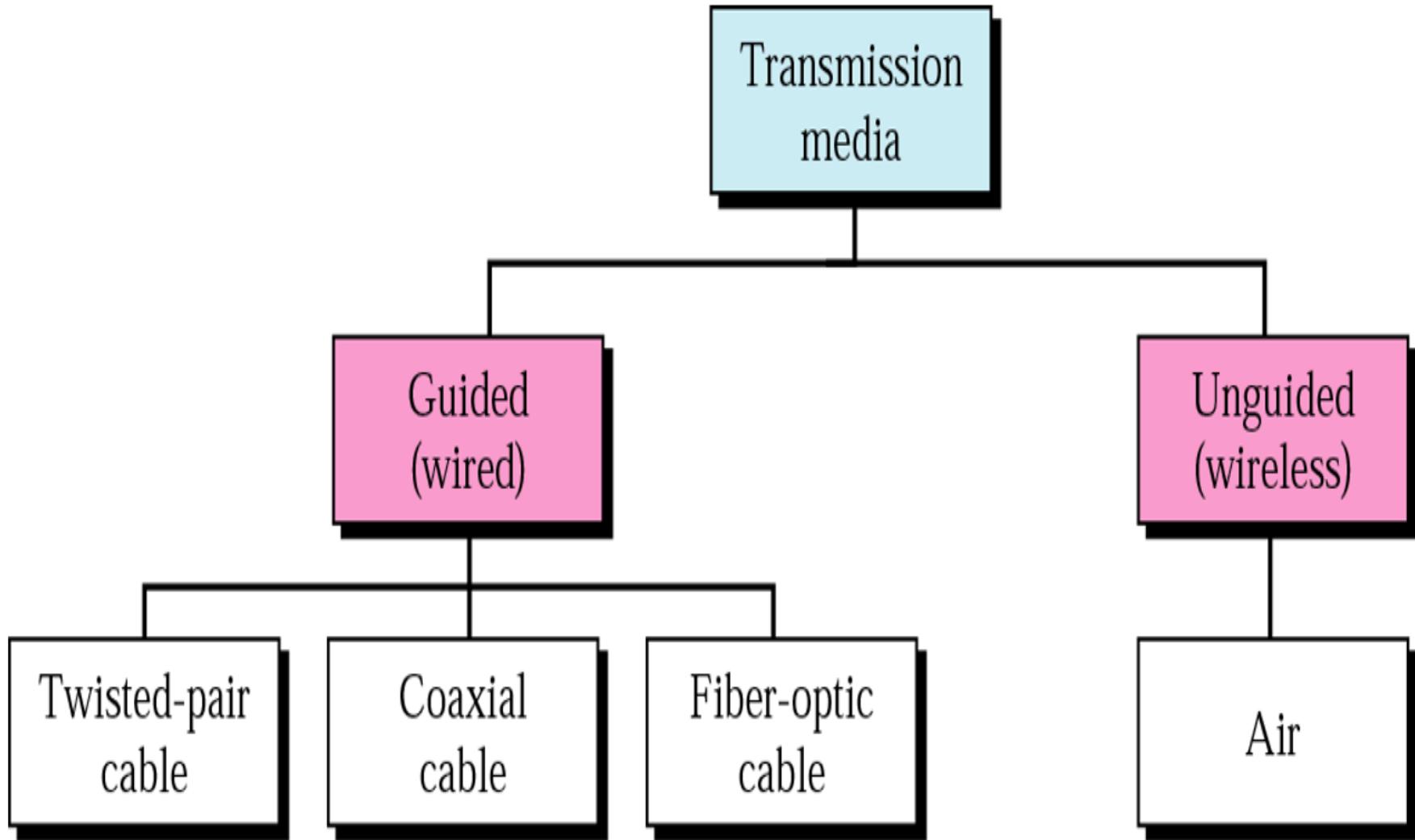
Transmission Media

Transmission Media



Transmission media means share the information from one place to other via some medium (**Wire or Wireless**).

Classification Of Transmission Media



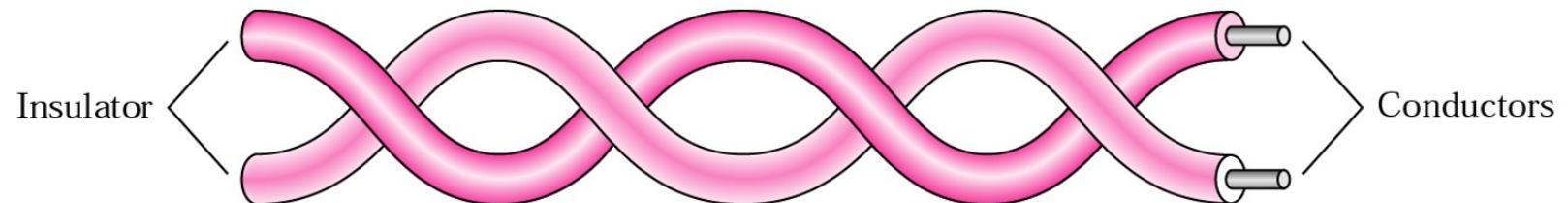
Guided Media

Twisted Pair Cable

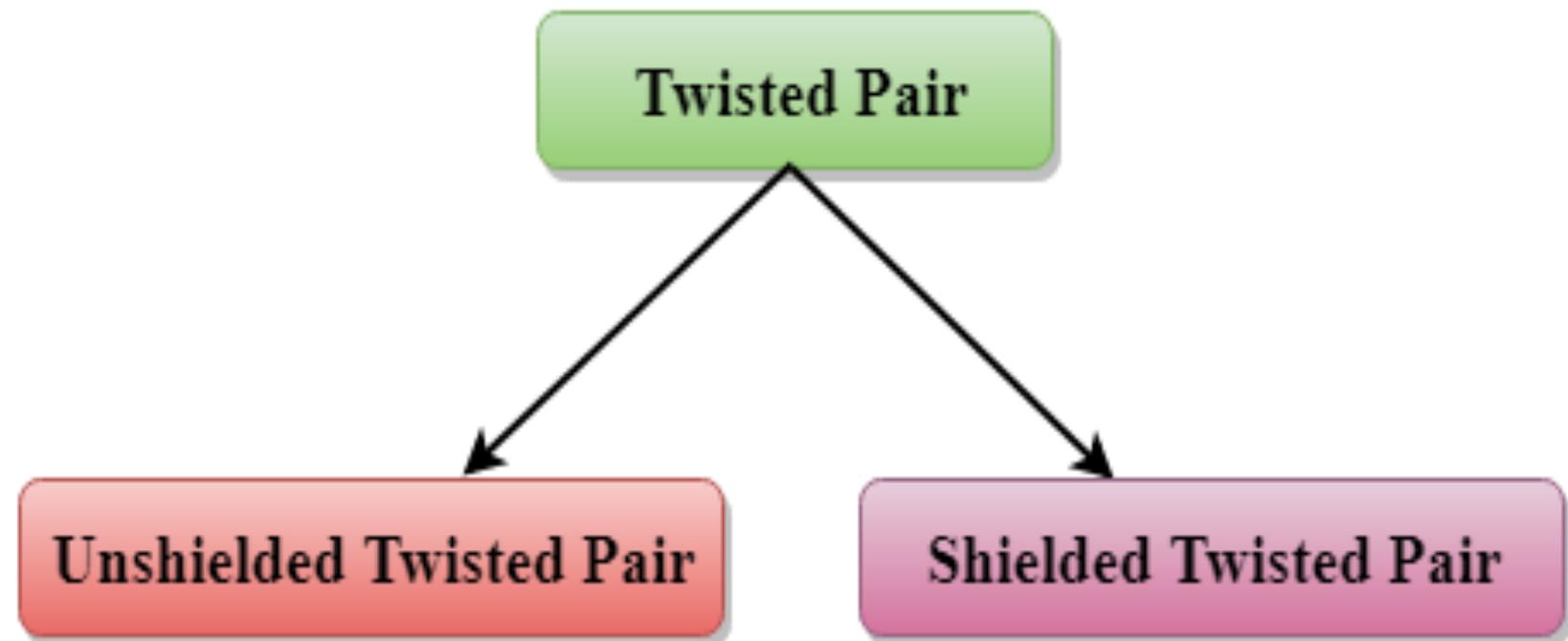
- It is defined as the **physical medium** through which the signals are transmitted. It is also known as **Bounded media**.

Twisted Pair:

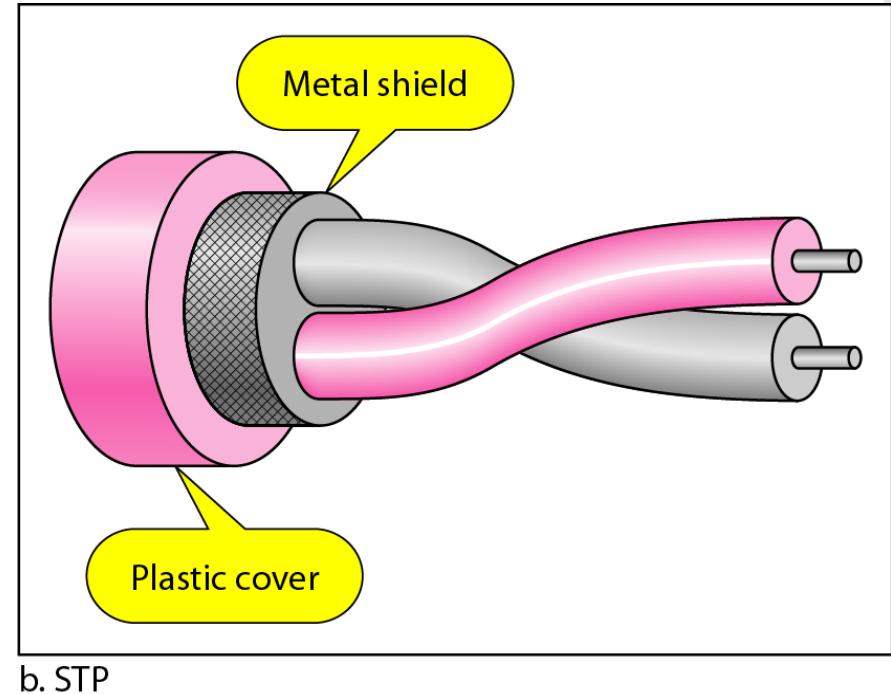
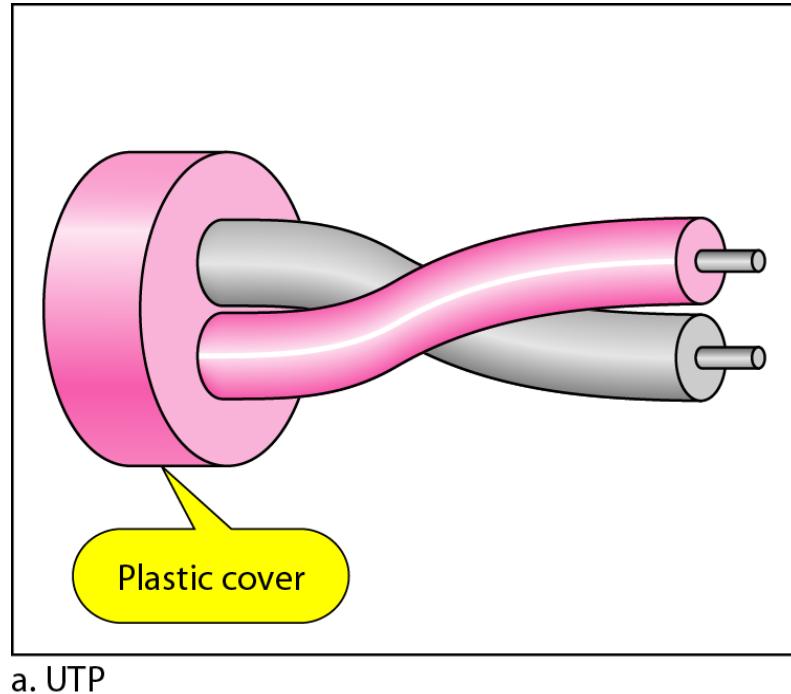
- Twisted pair is a **physical media** made up of a pair of cables twisted with each other.
- A twisted pair cable is cheap as compared to other transmission media.
- The frequency range for twisted pair cable is from **100Hz to 5MHz**.
- Reduce the noise.



Types of Twisted pair



Difference between UTP and STP.



Unshielded Twisted Pair

Advantages

- It is **cheap**.
- Installation of the unshielded twisted pair is **easy**.
- It can be used for **high-speed LAN**.

Disadvantage:

- This cable can only be used for **shorter distances** because of attenuation.

Shielded Twisted Pair

Advantages

- An installation of STP is **easy**.
- It is shielded that provides the **higher data transmission rate**.

Disadvantages

- It is more expensive as compared to UTP and coaxial cable.
- It has a **higher attenuation rate**.

Unshielded Twisted Pair

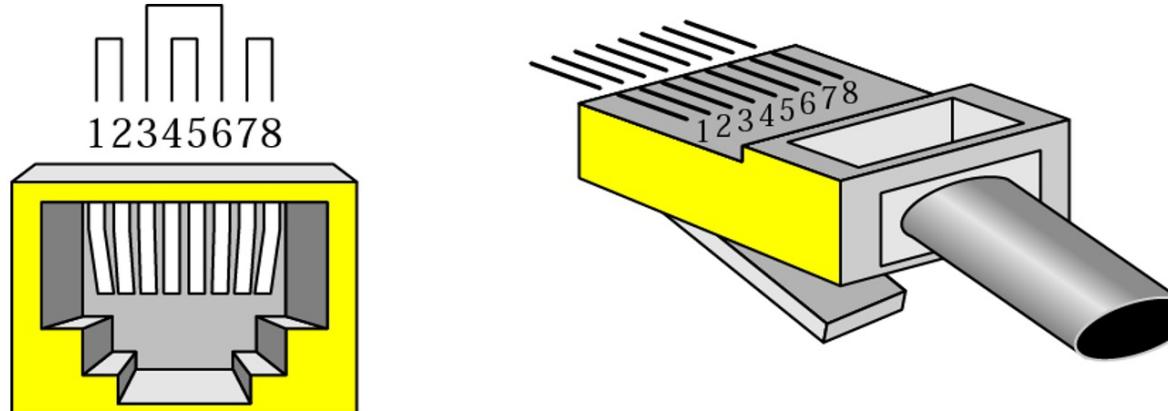
Table 7.1 Categories of unshielded twisted-pair cables

Category	Bandwidth	Data Rate	Digital/Analog	Use
1	very low	< 100 kbps	Analog	Telephone
2	< 2 MHz	2 Mbps	Analog/digital	T-1 lines
3	16 MHz	10 Mbps	Digital	LANs
4	20 MHz	20 Mbps	Digital	LANs
5	100 MHz	100 Mbps	Digital	LANs
6 (draft)	200 MHz	200 Mbps	Digital	LANs
7 (draft)	600 MHz	600 Mbps	Digital	LANs

Unshielded Twisted Pair

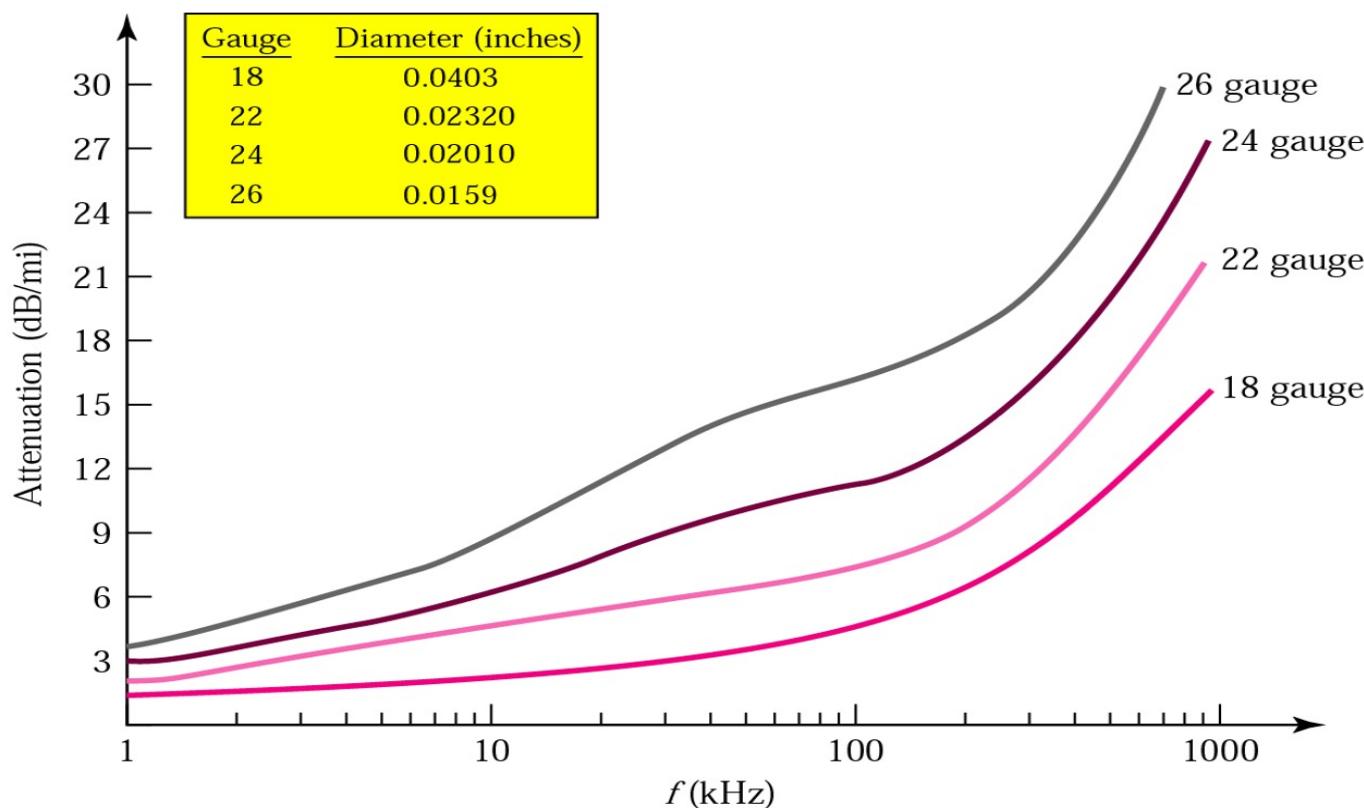
Connectors and Performance

RJ--- Registered Jack



RJ-45 Female

RJ-45 Male

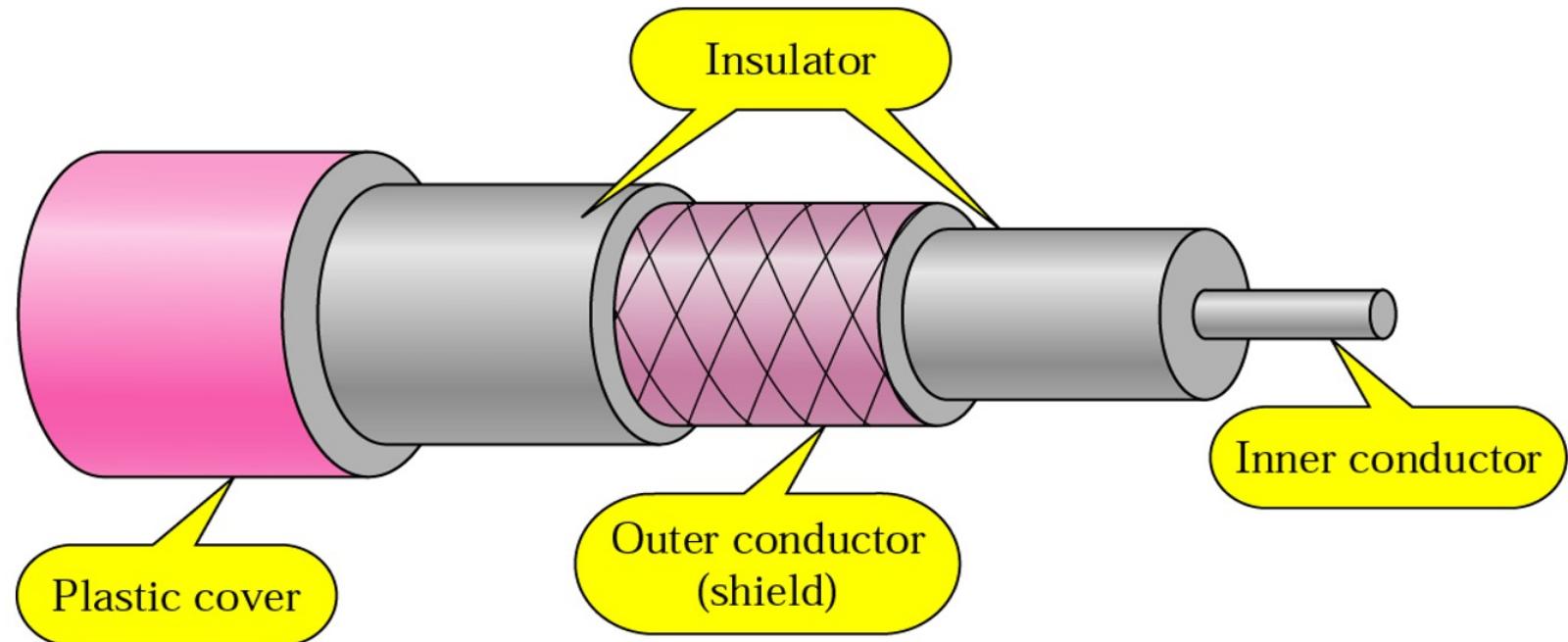


Coaxial Cable

- Coaxial cable is very **commonly used in TV**.
- Two conductors parallel to each other.
- High frequency as compared to Twisted pair cable (**100KHz-500MHz**).

Coaxial Cable

- The inner conductor is made up of **copper**, and the outer conductor is made up of **copper mesh**. The middle core is made up of **non-conductive cover**.
- The middle core is responsible for the **data transferring** whereas the copper mesh prevents from the **EMI(Electromagnetic interference)**.



Coaxial Cable

Advantages

- The data can be transmitted at **high speed**.
- It has better shielding as compared to twisted pair cable.
- It provides **higher bandwidth**.

Disadvantages

- It is **more expensive** as compared to twisted pair cable.
- If any fault occurs in the cable causes the failure in the entire network.

Coaxial Cable

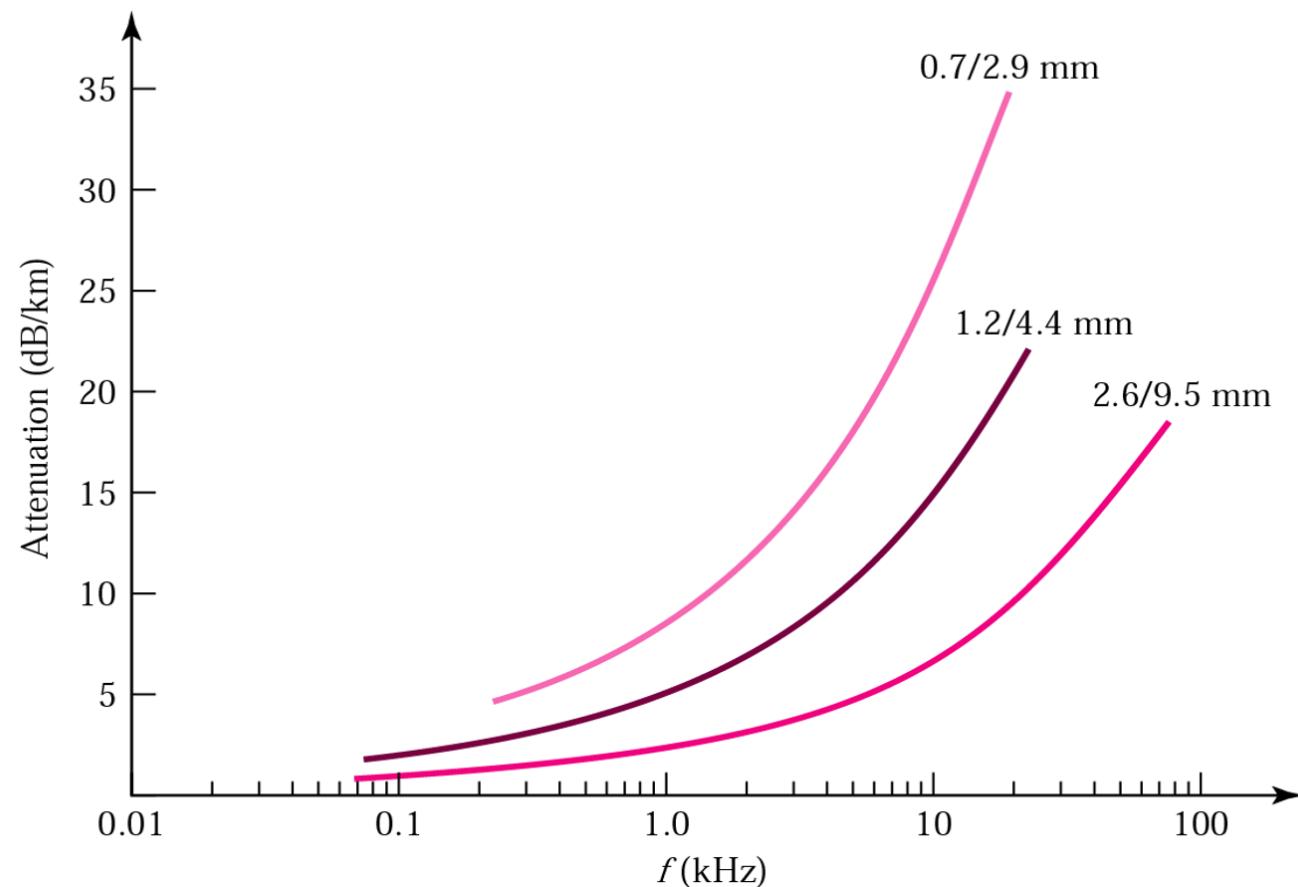
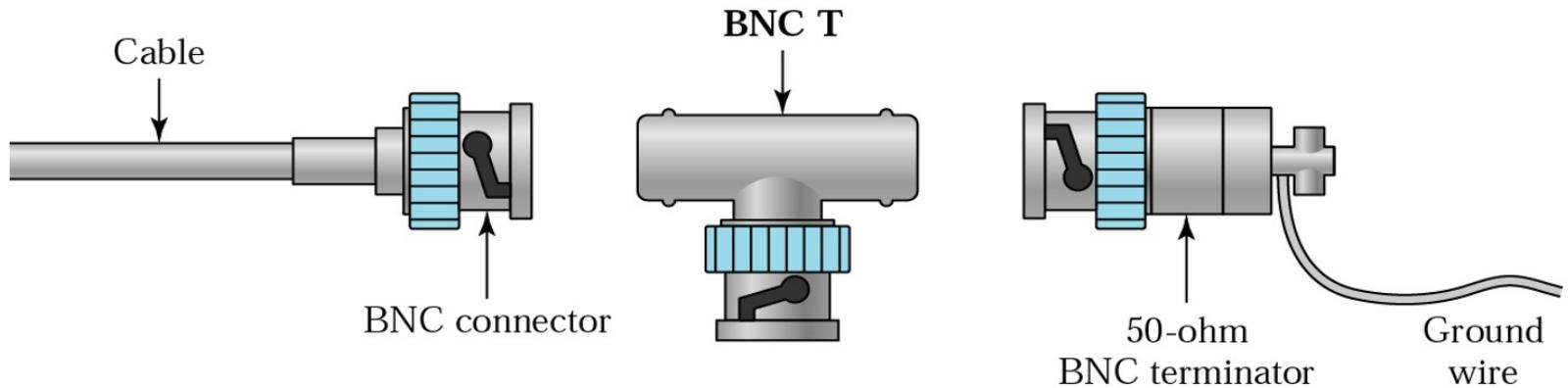
Table 7.2 Categories of coaxial cables

Category	Impedance	Use
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

Coaxial Cable

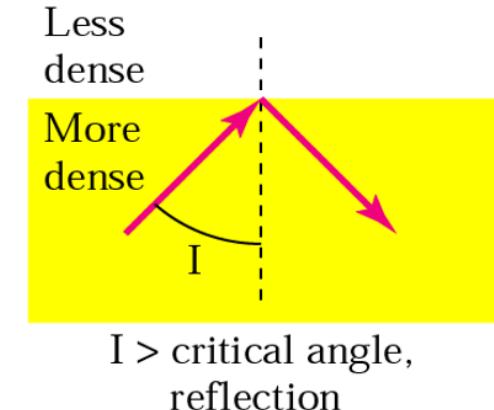
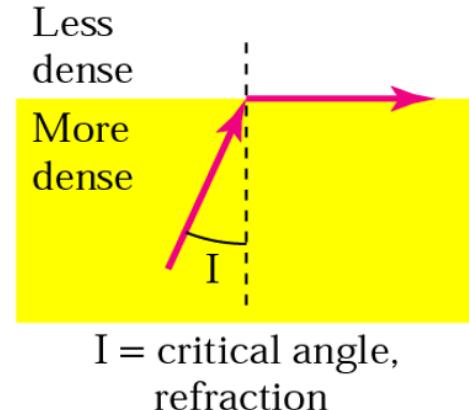
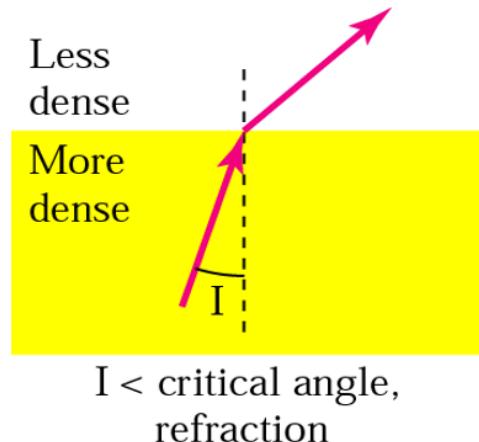
Connectors and Performance

BNC----- Bayone-Neil-
Concelman



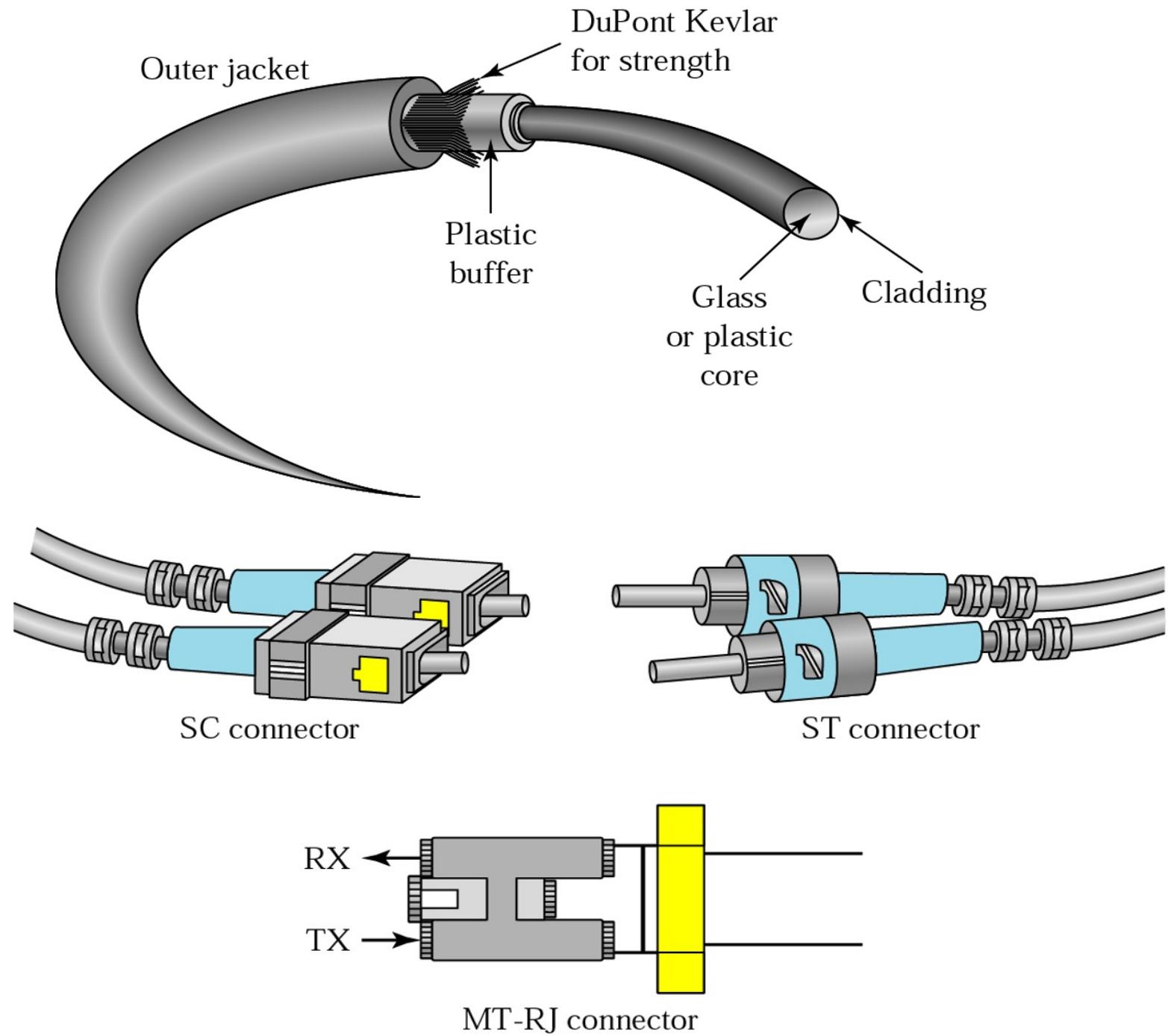
Fibre Optic

- Fibre optic is a cable that holds the optical fibres coated in plastic that are used to **send the data by pulses of light.**
- The plastic coating protects the optical fibres from heat, cold, electromagnetic interference from other types of wiring.
- Fibre optics **provide faster data transmission than copper wires.**

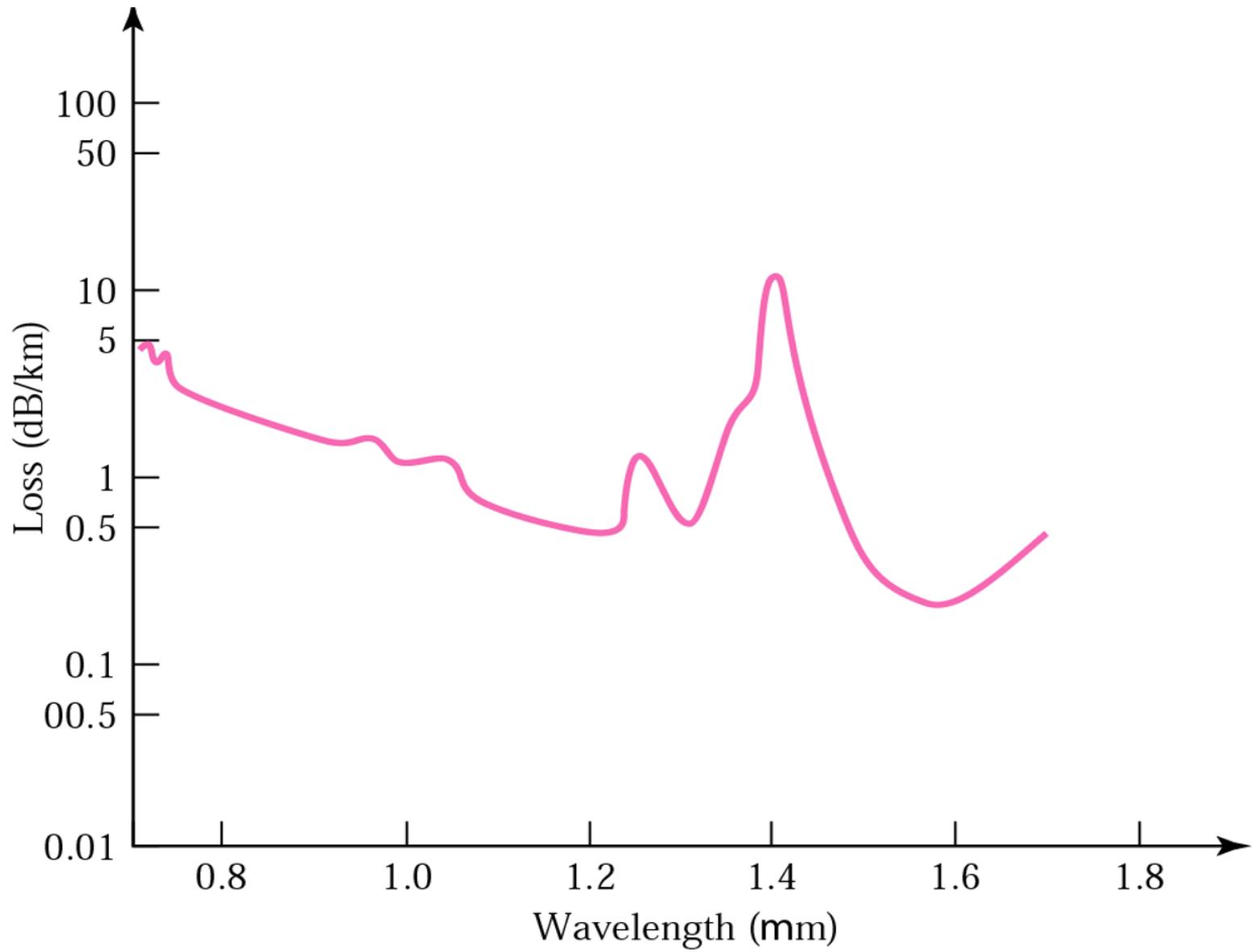


Fibre Optic Connectors

SC—Subscriber Channel,
ST—Straight Tip



Fibre Optic Performance

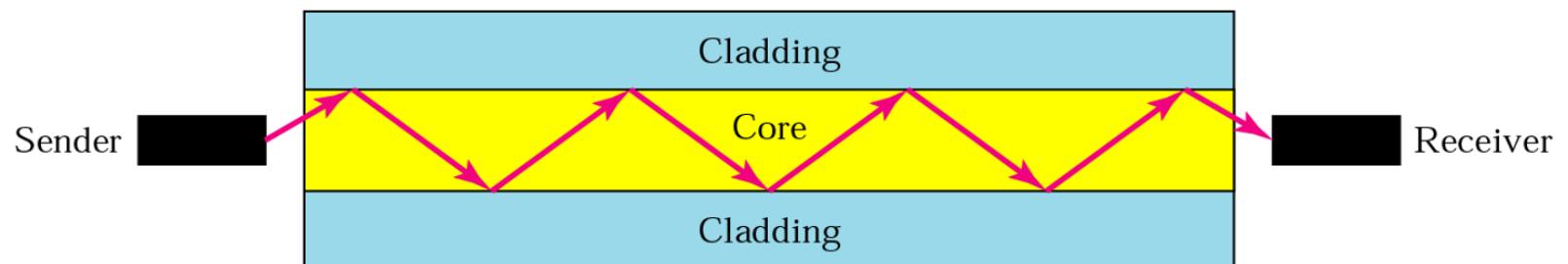


Basic elements of Fibre optic cable

- **Basic Elements of Fibre optic cable:**

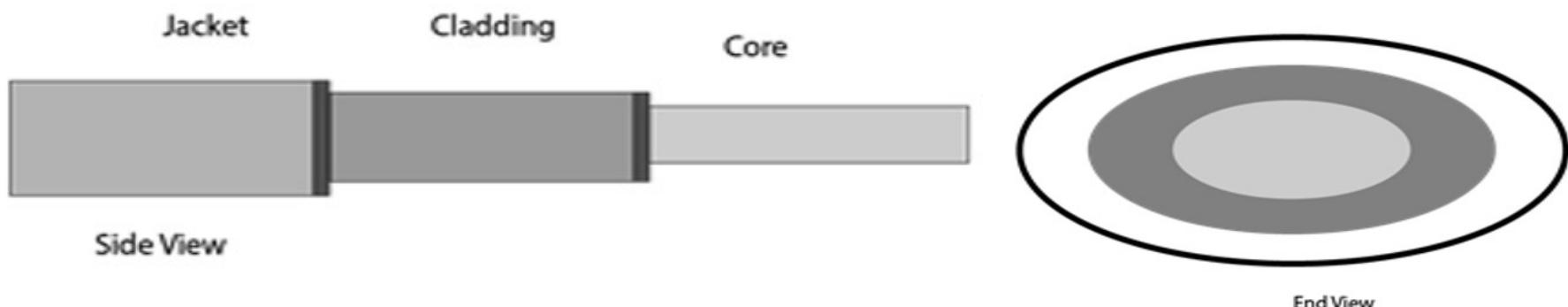
1. Core
2. Cladding
3. Jacket

- **Core:** The optical fibre consists of a **narrow strand of glass or plastic known as a core**. A core is a light transmission area of the fibre. The more the area of the core, the more-light will be transmitted into the fibre.



Fibre Optics

- **Cladding:** The concentric layer of glass is known as cladding. The main functionality of the cladding is to provide the lower refractive index at the core interface as to cause the reflection within the core so that the light waves are transmitted through the fibre.
- **Jacket:** The protective coating consisting of plastic is known as a jacket. The main purpose of a jacket is to preserve the fibre strength, absorb shock and extra fibre protection.



Advantages of fibre optic cable over copper

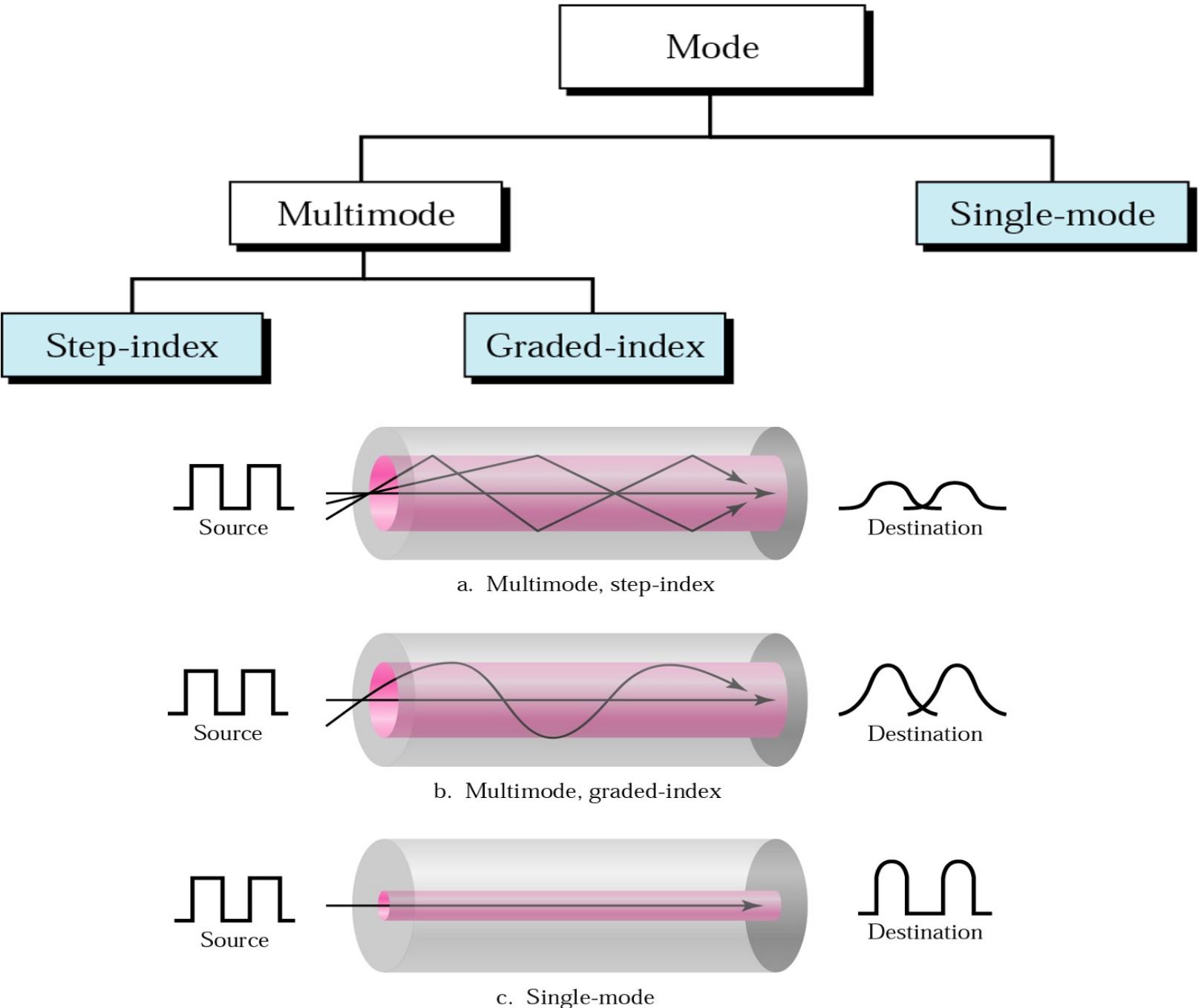
Advantages

- Greater Bandwidth
- Faster speed
- Longer distances
- Better reliability
- Thinner and Sturdier

Disadvantages

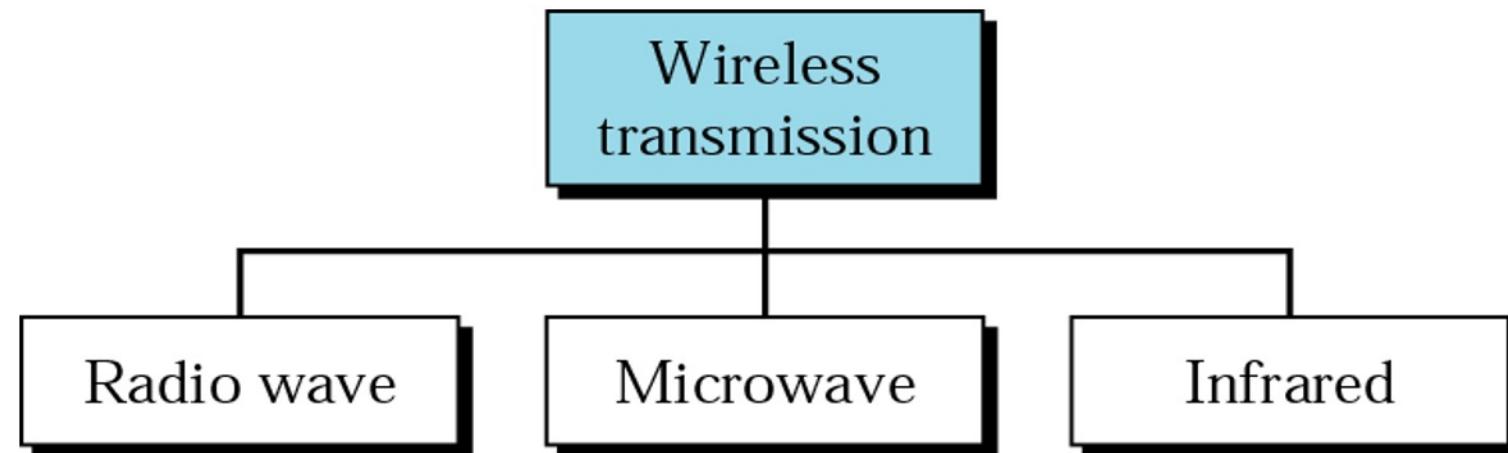
- Fragility
- Production & Installation Cost
- Installation & Construction Risk
- Splicing Difficulties

Propagation Modes

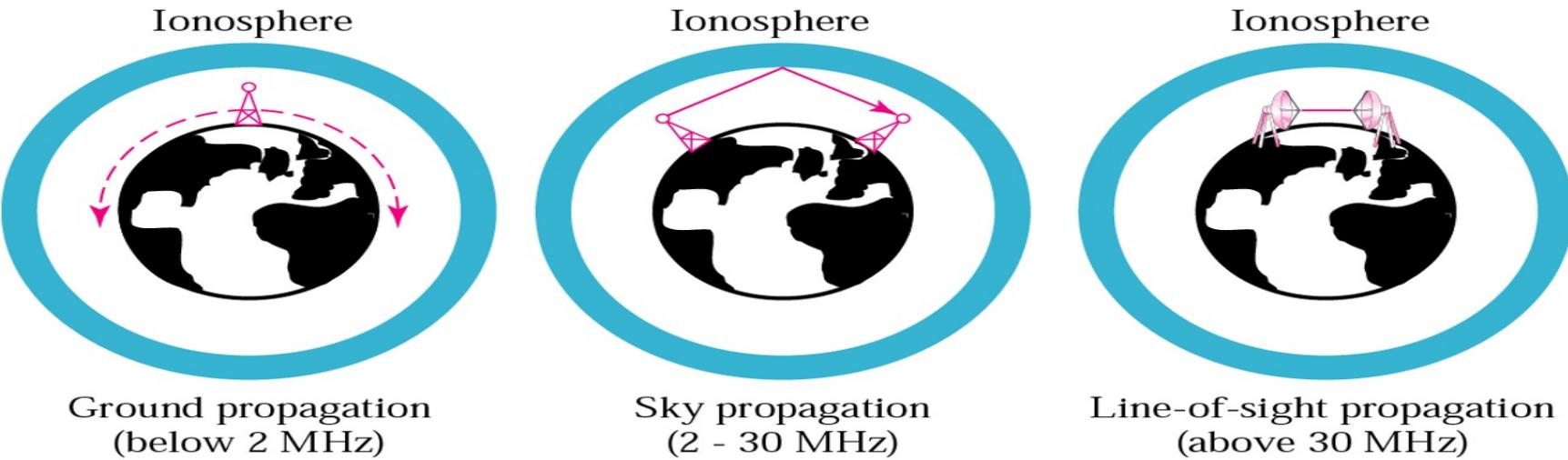


Unguided Transmission

- An unguided transmission transmits the **electromagnetic waves without using any physical medium**. Therefore, it is also known as **wireless transmission**.
- In unguided media, **air is the media** through which the electromagnetic energy can flow easily.
- Unguided transmission is broadly classified into three categories:



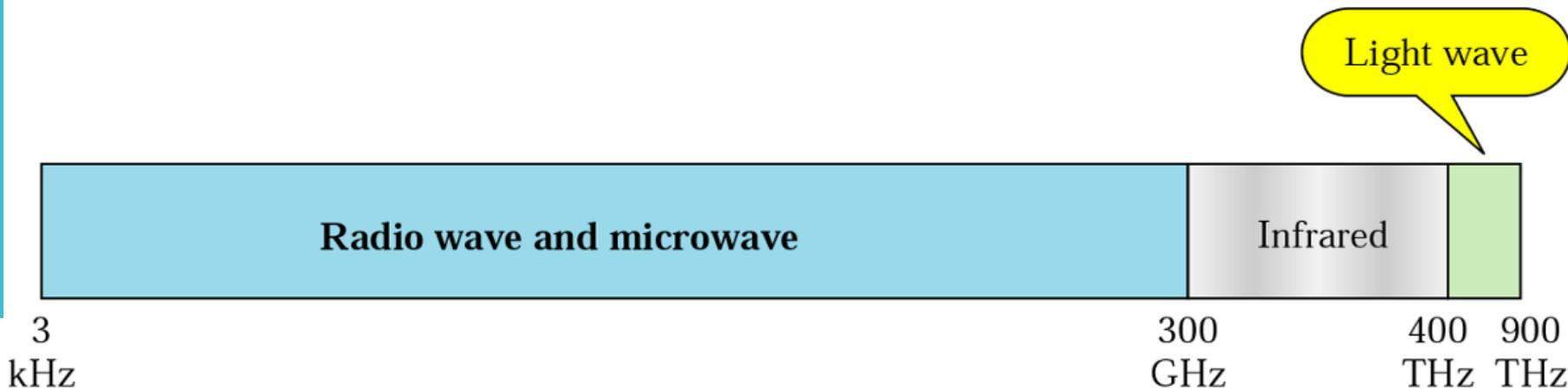
Propagation Methods



Band	Range	Propagation	Application
VLF	3–30 KHz	Ground	Long-range radio navigation
LF	30–300 KHz	Ground	Radio beacons and navigational locators
MF	300 KHz–3 MHz	Sky	AM radio
HF	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF	3–30 GHz	Line-of-sight	Satellite communication
EHF	30–300 GHz	Line-of-sight	Long-range radio navigation

Radio waves

- Radio waves are **electromagnetic waves** that are transmitted in all directions of free space.
- Radio waves are **omnidirectional**, i.e., the signals are propagated in all directions.
- In the case of radio waves, **the sending and receiving antenna are not aligned**, i.e., the wave sent by the sending antenna can be received by any receiving antenna.
- An example of the radio wave is **FM radio**.

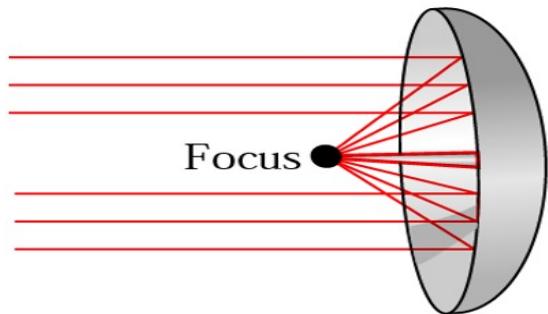


Radio waves

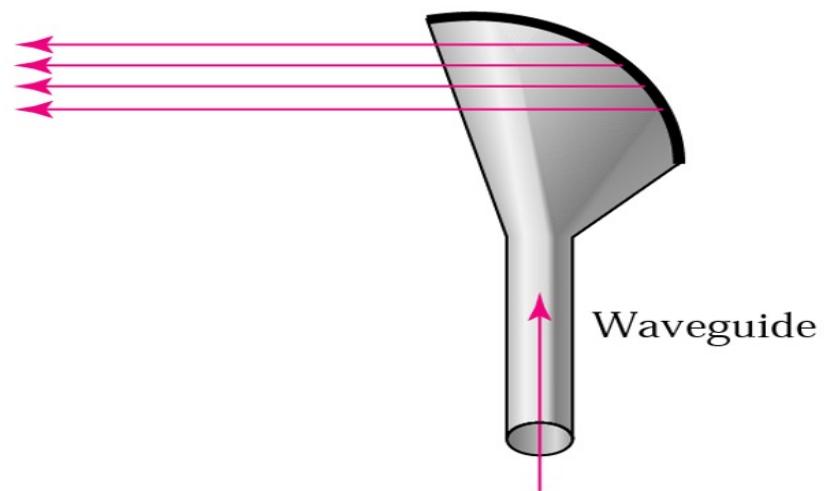


Note:

Radio waves are used for multicast communications, such as radio and television, and paging systems.



a. Dish antenna



b. Horn antenna

Application and Advantage

Applications and Advantages

- A Radio wave is **useful for multicasting** when there is one sender and many receivers.
- An **FM radio, television, cordless phones** are examples of a radio wave.
- Radio transmission is mainly used for **wide area networks and mobile cellular phones**.
- Radio waves cover a large area, and they can penetrate the walls.
- Radio transmission provides a **higher transmission rate**.

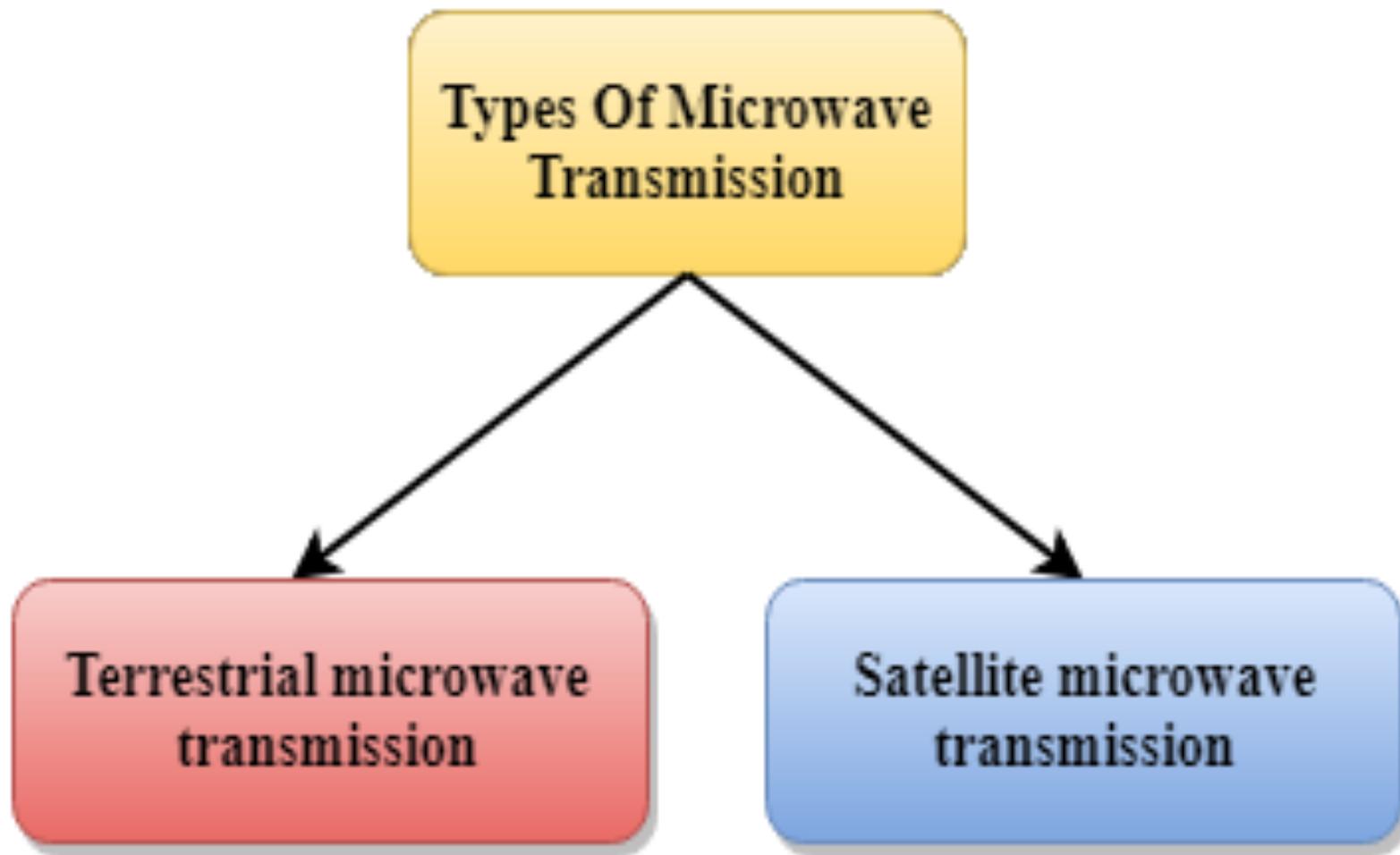
Microwaves



Note:

Microwaves are used for unicast communication such as cellular telephones, satellite networks, and wireless LANs.

Microwaves



Terrestrial Microwave Transmission

- Terrestrial Microwave transmission is a technology that transmits the **focused beam of a radio signal** from one ground-based microwave transmission antenna to another.
- Microwaves are **electromagnetic waves** with a frequency ranging from **1GHz to 1000 GHz**.
- Microwaves are **unidirectional** as the sending and receiving antenna is to be aligned, i.e., the waves sent by the sending antenna are narrowly focussed.

Advantages and disadvantages

Advantages

- Microwave transmission is cheaper than using cables.
- It is free from land acquisition as it does not require any land for the installation of cables.
- Microwave transmission provides an easy communication in terrains as the installation of cable in terrain is quite a difficult task.
- Communication over oceans can be achieved by using microwave transmission.

Disadvantages

- Eavesdropping
- Out-of-phase signal
- Susceptible to weather conditions
- Bandwidth limited

Satellite Microwave Communication

- A satellite is a **physical object** that revolves around the earth at a **known height**.
- Satellite communication is **more reliable** nowadays as it offers more flexibility than cable and fibre optic systems.
- We can communicate with **any point on the globe** by using satellite communication.

How Does Satellite work?

- The satellite **accepts the signal** that is transmitted from the earth station, and it **amplifies the signal**. The amplified signal is retransmitted to another earth station.

Advantages Of Satellite Microwave Communication

- The coverage area of a satellite microwave is more than the terrestrial microwave.
- It is easy to install.
- It is used in a wide variety of applications such as weather forecasting, radio/TV signal broadcasting, mobile communication, etc.

Disadvantages Of Satellite Microwave Communication

- Satellite designing and development requires more time and higher cost.
- The Satellite needs to be monitored and controlled on regular periods so that it remains in orbit.
- The life of the satellite is about 12-15 years. Due to this reason, another launch of the satellite has to be planned before it becomes non-functional.

Infrared



Note:

Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation.

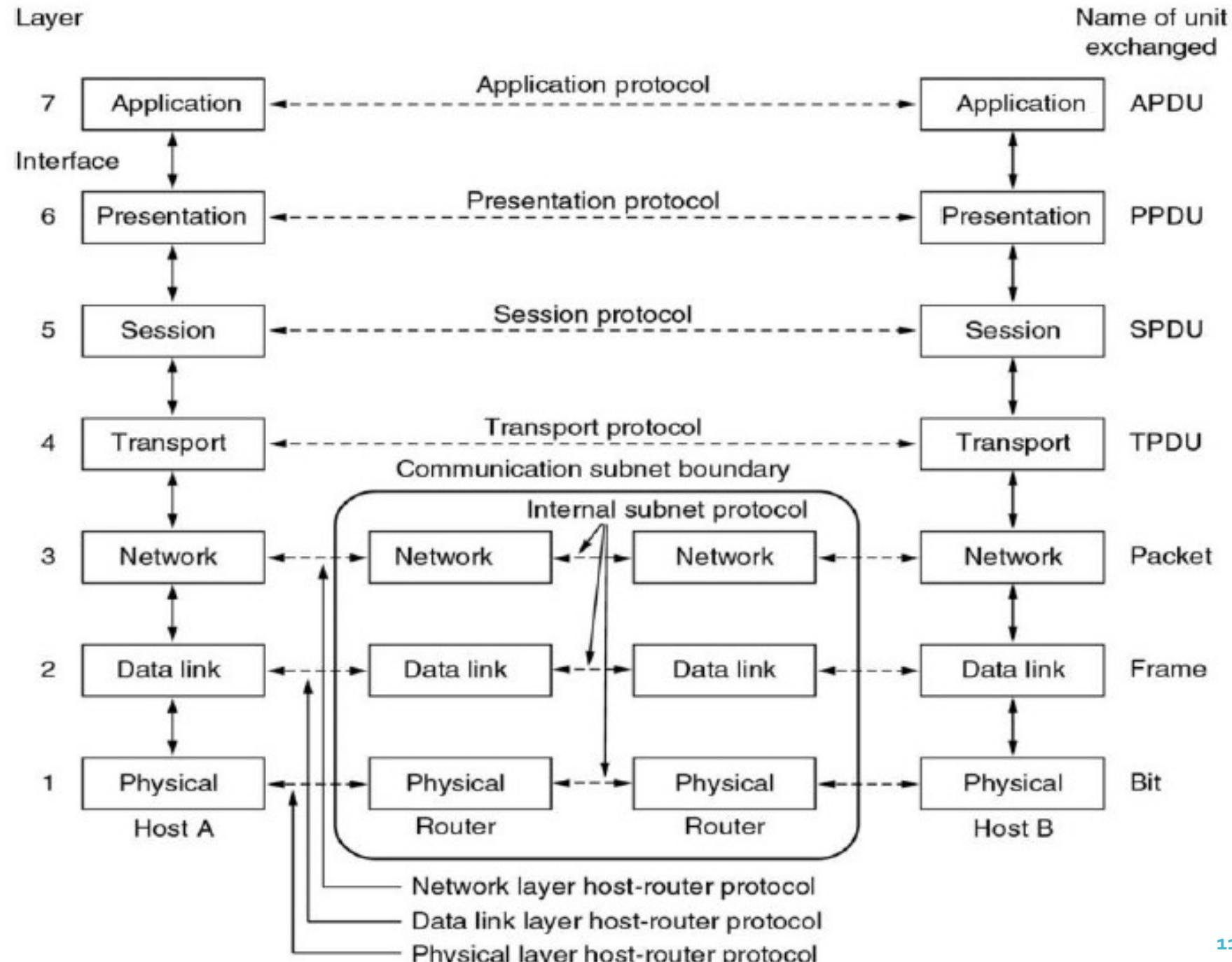
Infrared

- An infrared transmission is a wireless technology used for communication over short ranges.
- The frequency of the infrared is in the range from 300 GHz to 400 THz.
- It is used for short-range communication such as data transfer between two cell phones, TV remote operation, data transfer between a computer and cell phone resides in the same closed area.

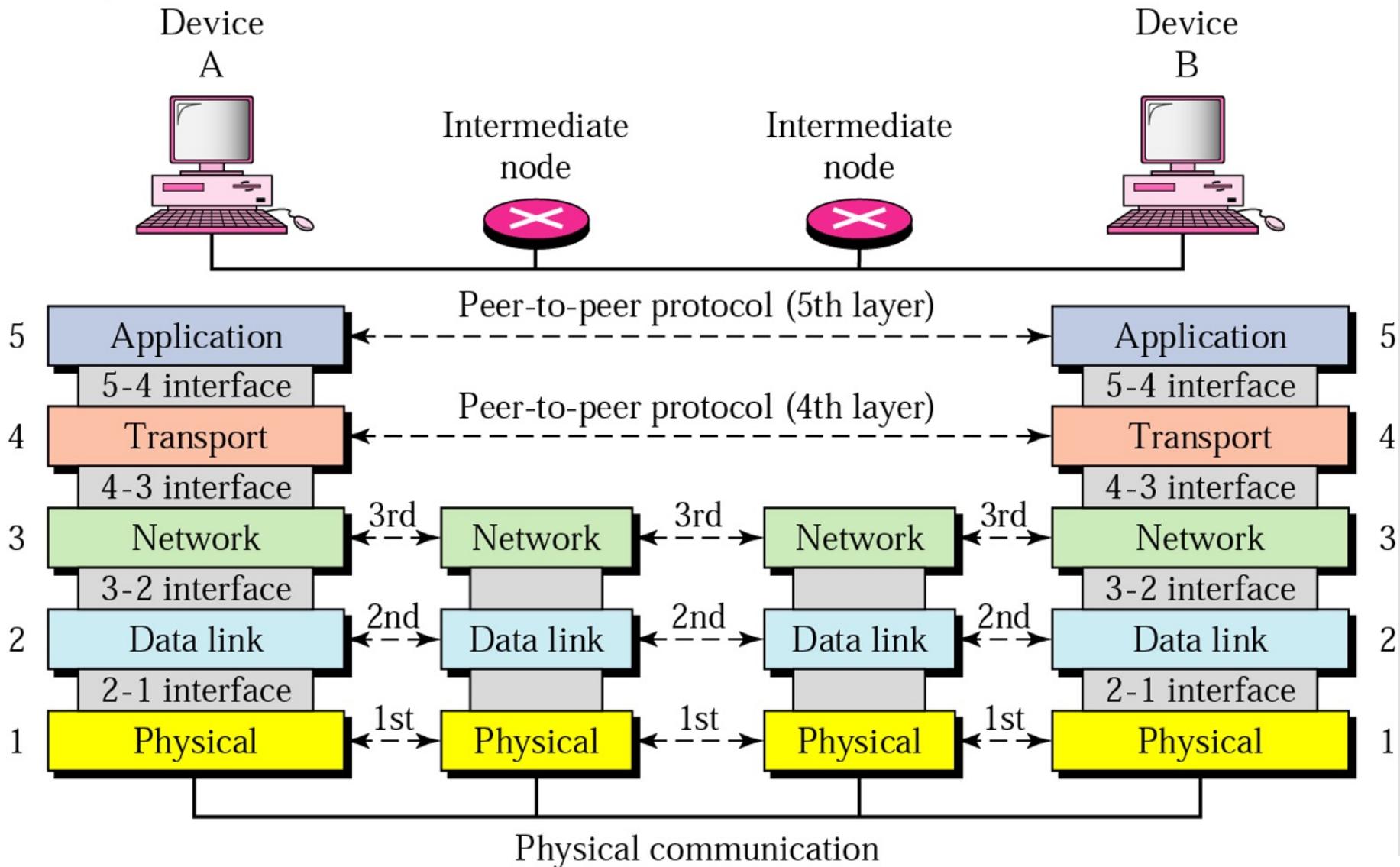
Characteristics Of Infrared

- It supports **high bandwidth**, and hence the **data rate will be very high.**
- Infrared waves cannot penetrate the walls. Therefore, the infrared communication in one room cannot be interrupted by the nearby rooms.
- An infrared communication provides **better security with minimum interference.**
- Infrared communication is unreliable outside the building because the sun rays will interfere with the infrared waves.

ISO/OSI Reference Model

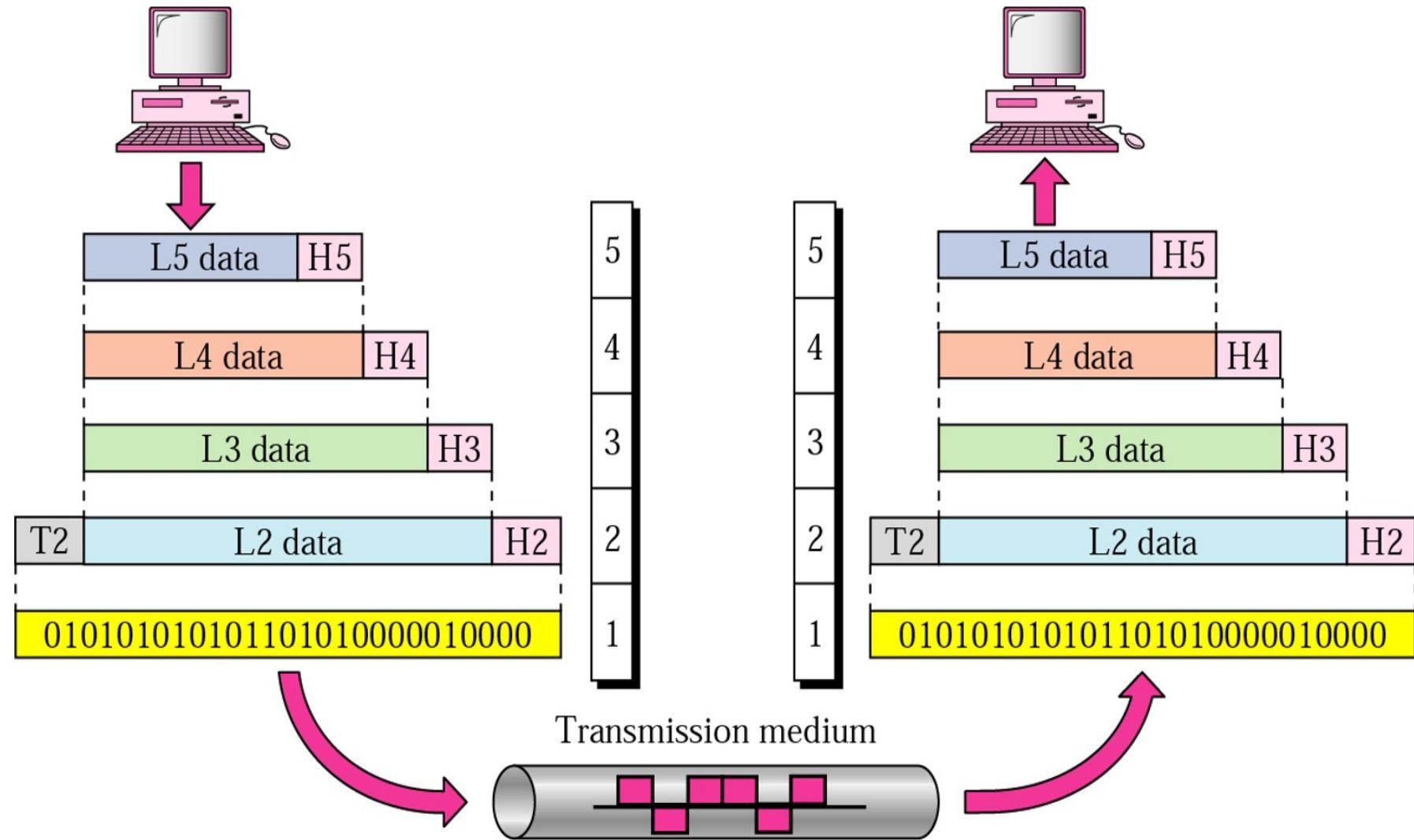


Internet Model, TCP/IP Model



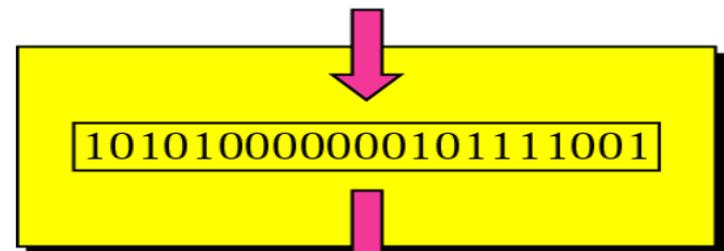
Host to Network, Internet, Transport, Application

Internet Model, TCP/IP Model

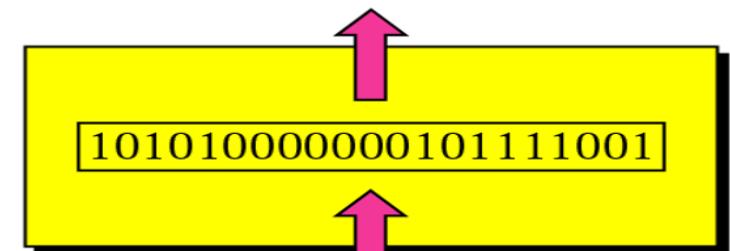


Physical Layer

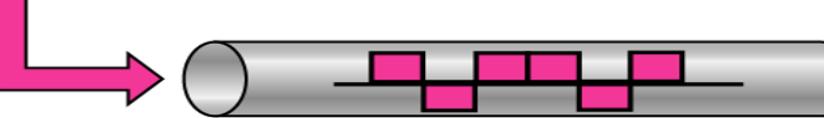
From data link layer



To data link layer



Physical
layer



Transmission medium



Note:

The physical layer is responsible for transmitting individual bits from one node to the next.

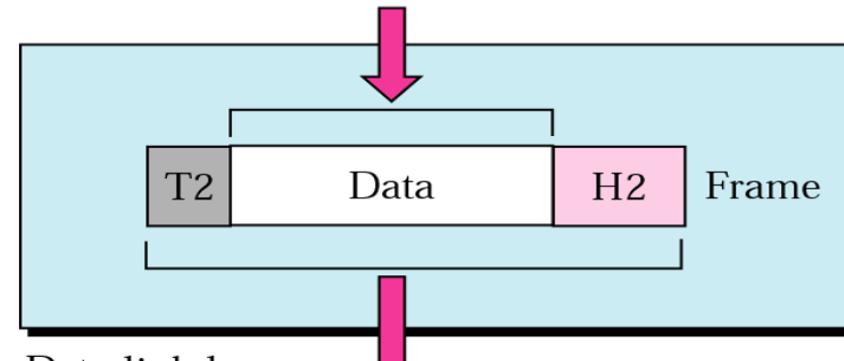
Physical Layer

Functions

1. Representation of bits
2. Data Rate
3. Synchronization of bits
4. Line Configuration
5. Transmission Mode
6. Physical Topology
7. Physical Characteristics of Interfaces and Medium
 - Number of pins and functions of each pin of the network connector (Mechanical)
 - Signal Level, Data rate (Electrical)
 - Whether simultaneous transmission in both directions
 - Establishing and breaking of connection
 - Deals with physical transmission.

Data Link Layer

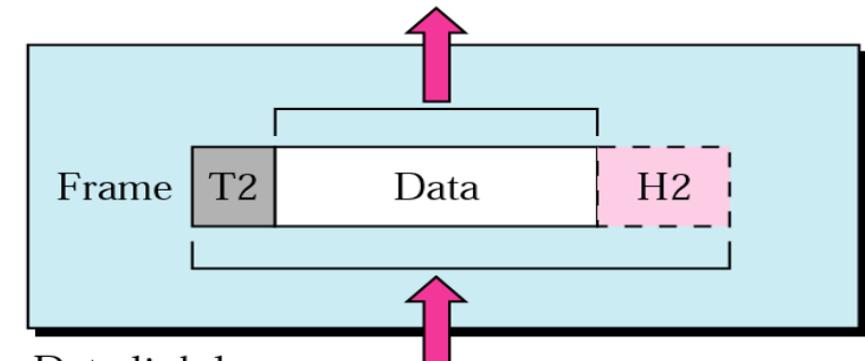
From network layer



Data link layer

To physical layer

To network layer



Data link layer

From physical layer



Note:

The data link layer is responsible for transmitting frames from one node to the next.

Data Link Layer

Functions

1. **Framing:** Group the physical layer bit stream into units called **frames**. Note that **frames are nothing more than "packets" or "messages"**. By convention, we shall use the term **"frames"** when discussing DLL packets.
2. Sender calculates the **checksum** and sends **checksum together with data**. The **checksum** allows the receiver to determine when a frame has been damaged in transit or received correctly. This is called **error detection and correction**.

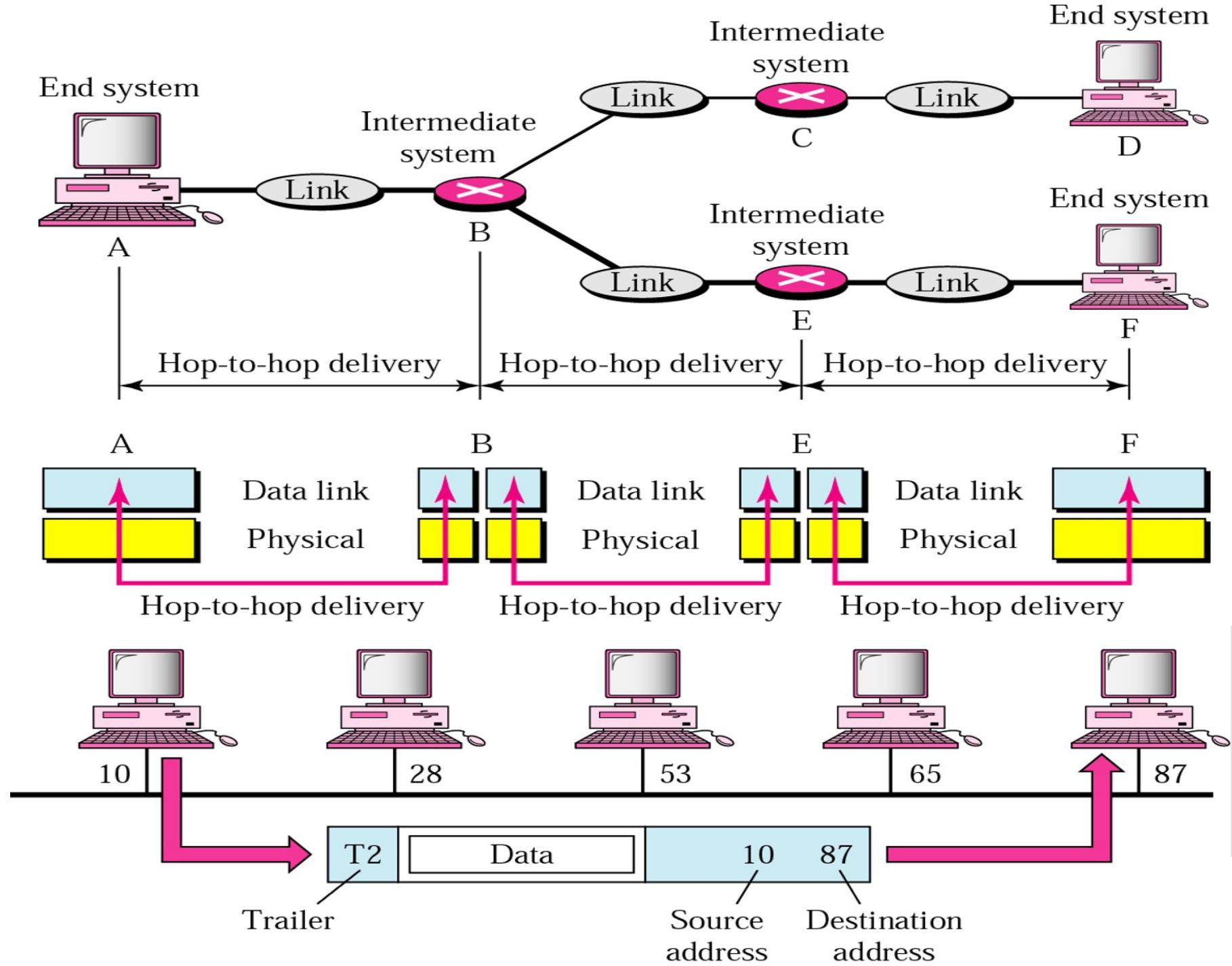
Data Link Layer

Functions

3. **Error control** protocol returns a positive or negative acknowledgment to the sender. A positive acknowledgment indicates the frame was received without errors, while a negative acknowledgment indicates the opposite.
4. **Flow control** prevents a fast sender from overwhelming a slower receiver. For example, a supercomputer can easily generate data faster than a PC can consume it.
5. **Access Control**
6. **Physical Addressing (MAC Address)**

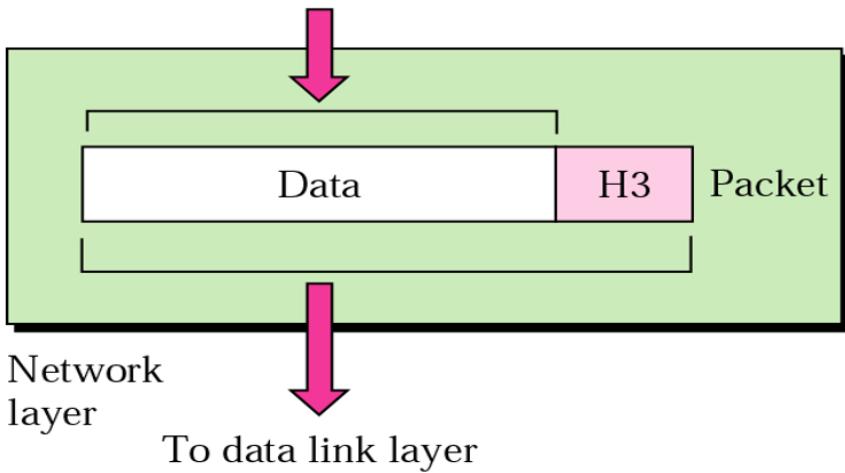
Data Link Layer

Node to Node Delivery

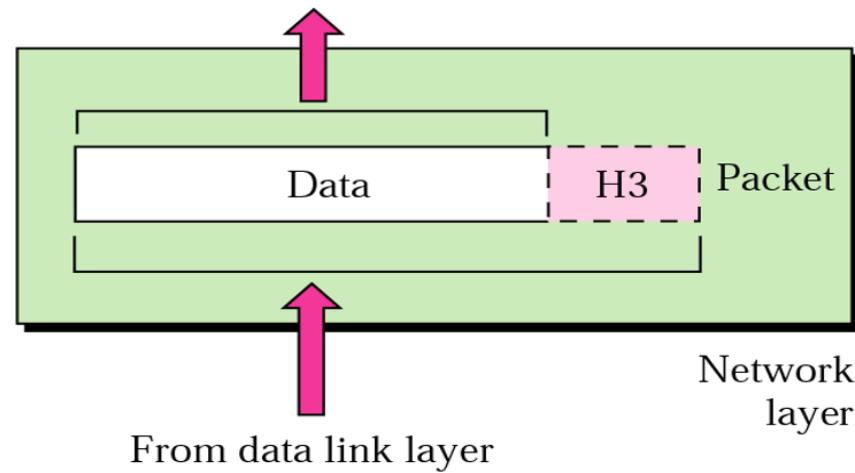


Network Layer

From transport layer



To transport layer



Note:

The network layer is responsible for the delivery of packets from the original source to the final destination.

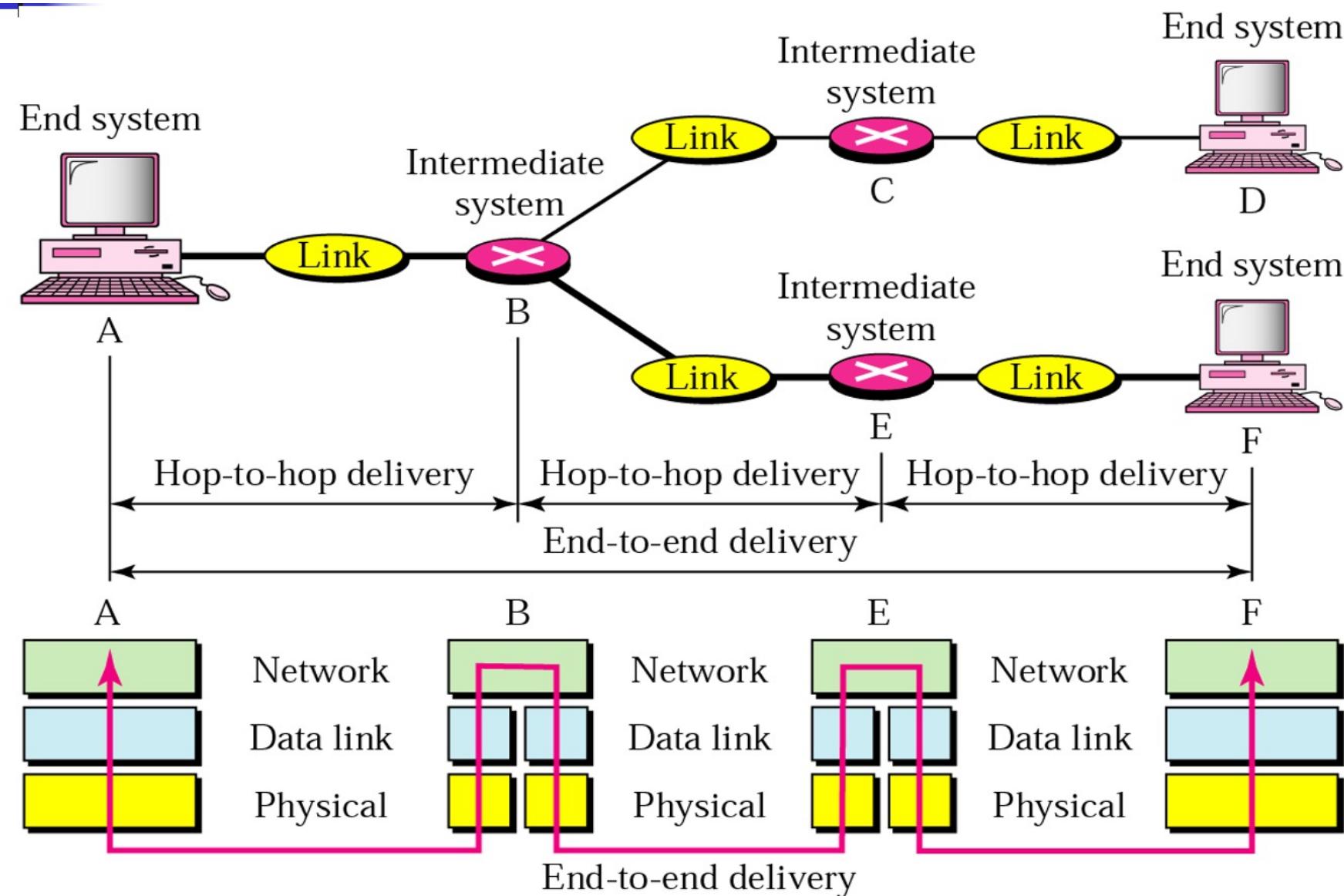
Network Layer

Functions

1. Interface between the host and the network
(the network layer is typically the boundary between the host and subnet)
2. Routing
3. Logical Addressing-----IP Addressing
3. Internetworking (A path may traverse different network technologies (e.g., Ethernet, point-to-point links, etc.)

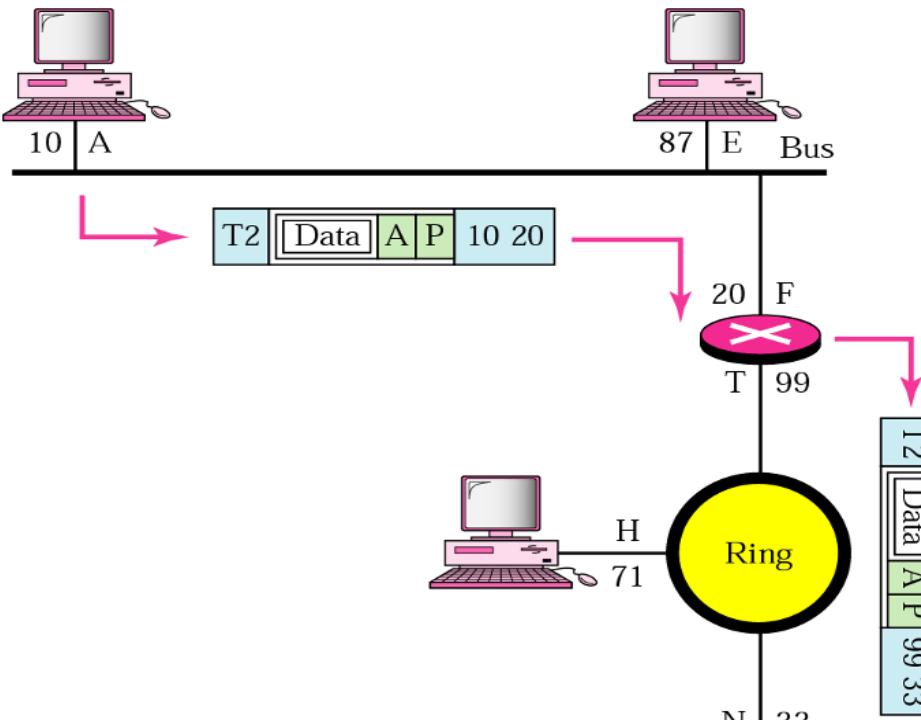
Network Layer

Source to Destination Delivery

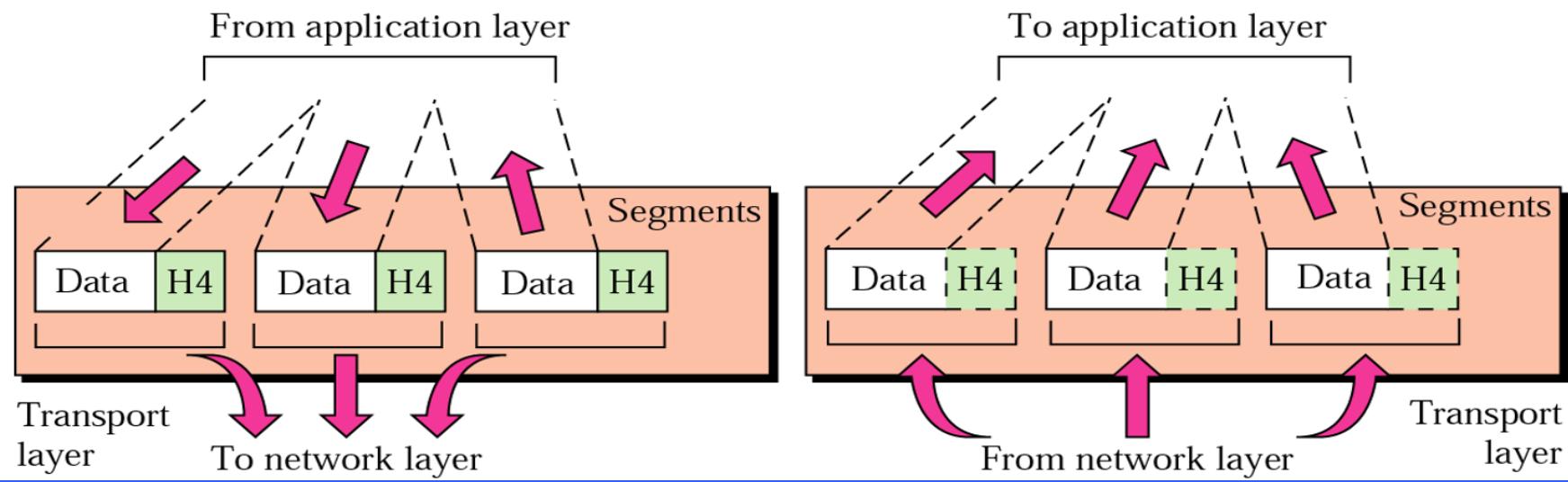


Network Layer Example

In Figure 2.11 we want to send data from a node with network address A and physical address 10, located on one LAN, to a node with a network address P and physical address 95, located on another LAN. Because the two devices are located on different networks, we cannot use physical addresses only; the physical addresses only have local jurisdiction. What we need here are universal addresses that can pass through the LAN boundaries. The network (logical) addresses have this characteristic.

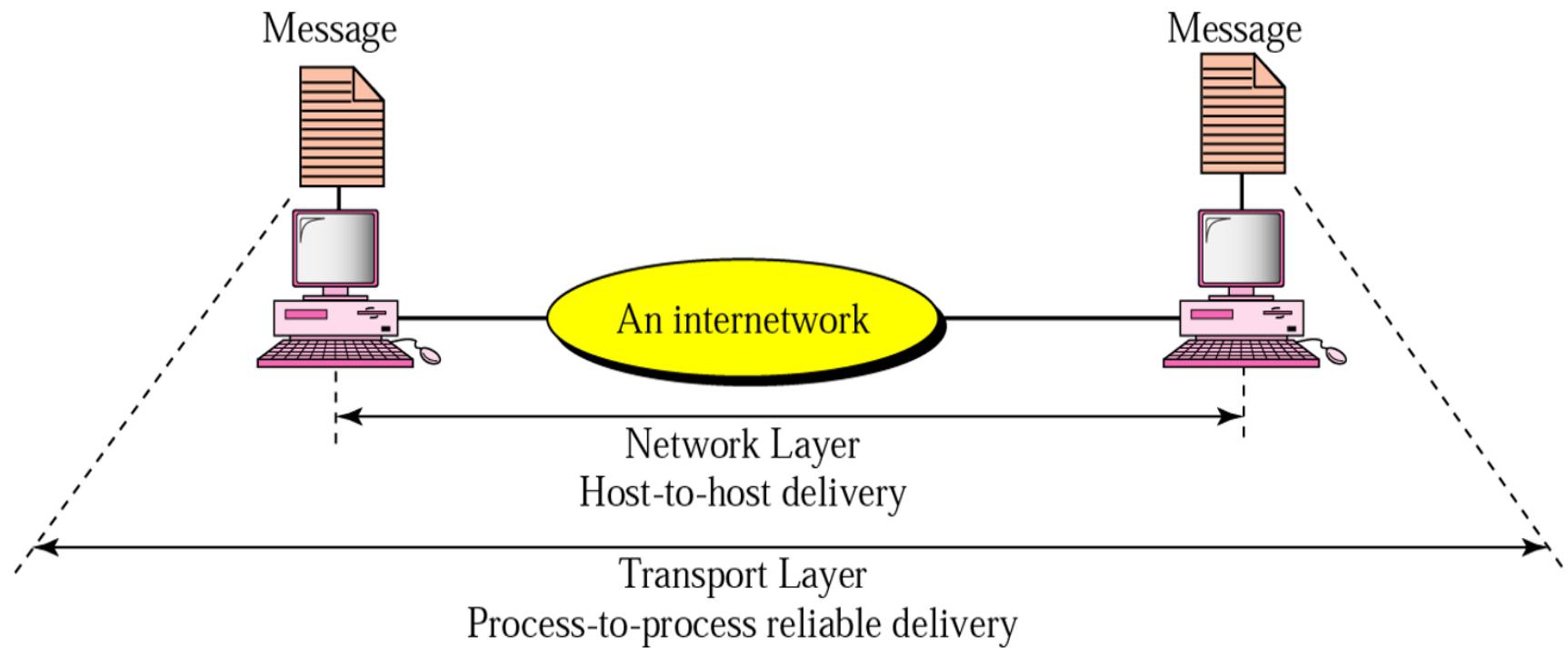


Transport Layer



The transport layer is responsible for delivery of a message from one process to another.

Transport Layer

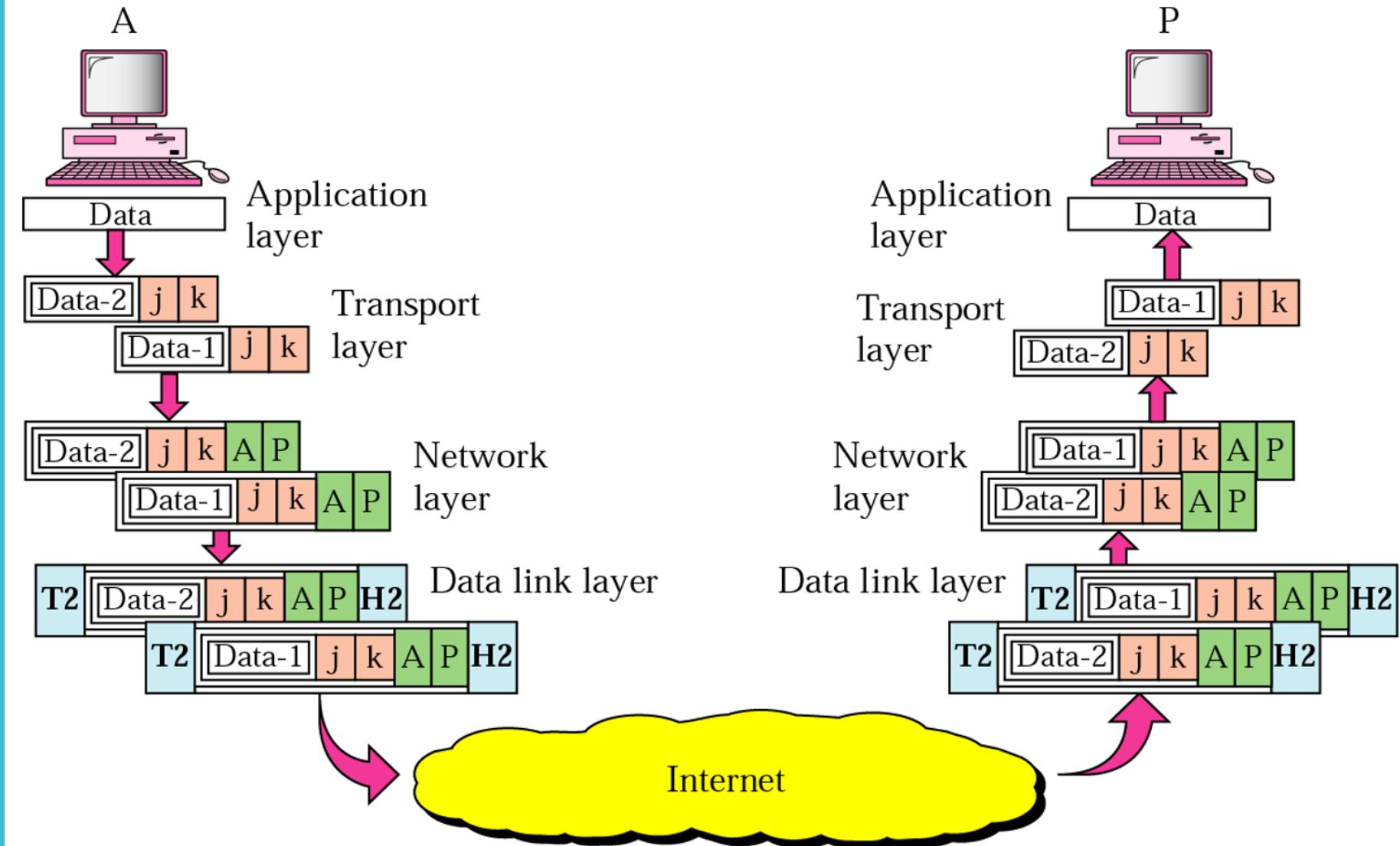


Transport Layer

Functions

- The transport level provides **end-to-end communication (Process to Process Delivery)** between processes executing on different machines.
- **Segmentation**
- **Service Point Addressing**
- **Negotiation of Quality and Type of Services.**
- **Deal with congestion control**
- **Connection establishment and termination.**
- **Multiplexing – Demultiplexing.**
- **Error control**

Transport Layer



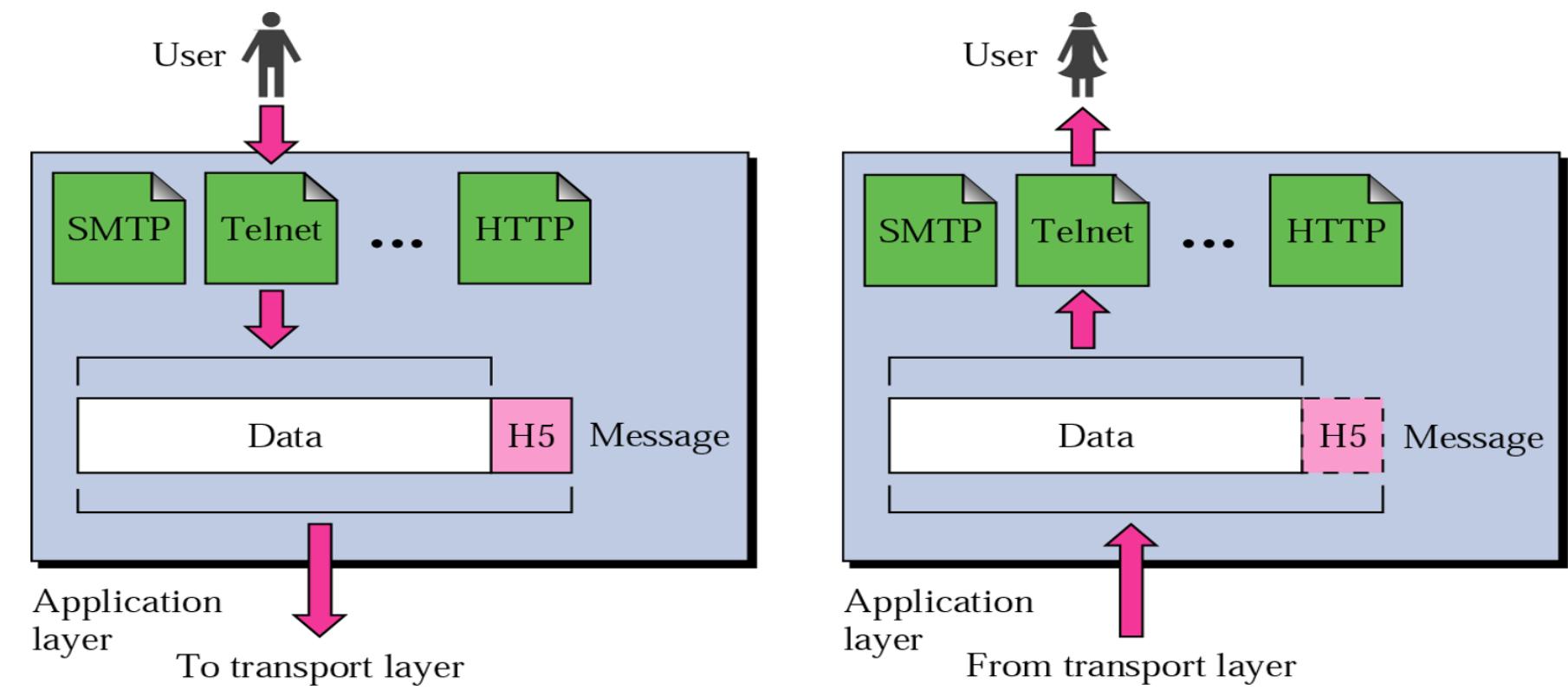
Session Layer Functions

- This layer manages **Dialogue Control**. Session can allow traffic to go in both direction at the same time, or in only one direction at one time.
- **Token management**. For some protocols, it is required that both sides don't attempt same operation at the same time. To manage these activities, the session layer provides tokens that can be exchanged. Only one side that is holding token can perform the critical operation.
- **Synchronization/Check Pointing**: Session layer provides a way to insert checkpoints into data streams, so that after a crash, only the data transferred after the last checkpoint have to be repeated.

Presentation Layer

- This layer is concerned with the **Syntax and Semantics of the information transmitted**. A few of the services that the Presentation layer provides are:
- Encoding data in a standard agreed-upon way.
- It manages the **abstract data structures** and converts from representation used inside the computer to network standard representation and back.
- Translation
- Encryption/ Decryption
- Composition
- Compression/ Decompression

Application Layer



The application layer is responsible for providing services to the user.

Application Layer

Functions

- **File transfer (FTP):** Connect to a remote machine and send or fetch an arbitrary file. FTP deals with authentication, listing a directory contents, ASCII or binary files, etc.
- **Remote login (telnet):** A remote terminal protocol that allows a user at one site to establish a TCP connection to another site, and then pass keystrokes from the local host to the remote host.
- **Mail (SMTP):** Allow a mail delivery agent on a local machine to connect to a mail delivery agent on a remote machine and deliver mail.
- **News (NNTP):** Allows communication between a news server and a news client.
- **Web (HTTP):** Base protocol for communication on the World Wide Web.

MIME: Multi Purpose Internet Mail Extension

TCP/IP Reference Model

OSI Model

Application layer

Presentation layer

Session layer

Transport layer

Network layer

Data link layer

Physical layer

TCP/IP Model

Application layer
(including Telnet,
FTP, and SMTP)

Transport layer
(TCP and UDP)

Internet layer

Link layer

Five-Layer Model

Application layer

Transport layer

Network layer

Data link layer

Physical layer

Difference between OSI and TCP/IP Model

FUNCTION	TCP/IP MODEL	OSI MODEL
Definition	TCP/IP stands for Transmission control protocol/ Internet protocol	OSI stands for Open systems Interconnection
Developed by	It is developed by DOD (Department of Defence) project agency.	OSI model is developed by ISO (International standard organization).
Technology/ Platform	It comprises of a set of standard protocols which lead to development of the Internet. It is a communication medium which provides connection between hosts.	It is an independent standard and generic protocol used as a communication gateway between network and end user.
Delivery of Packets	No guaranteed delivery of packets at transport layer.	Transport layer provides guaranteed delivery of packets.
Approach	Based on horizontal approach.	Based on vertical approach.
Application Layer	Session and presentation layers are not separate, both are included in application layer.	Session and presentation layers are separate

Difference between OSI and TCP/IP Model

Continue..

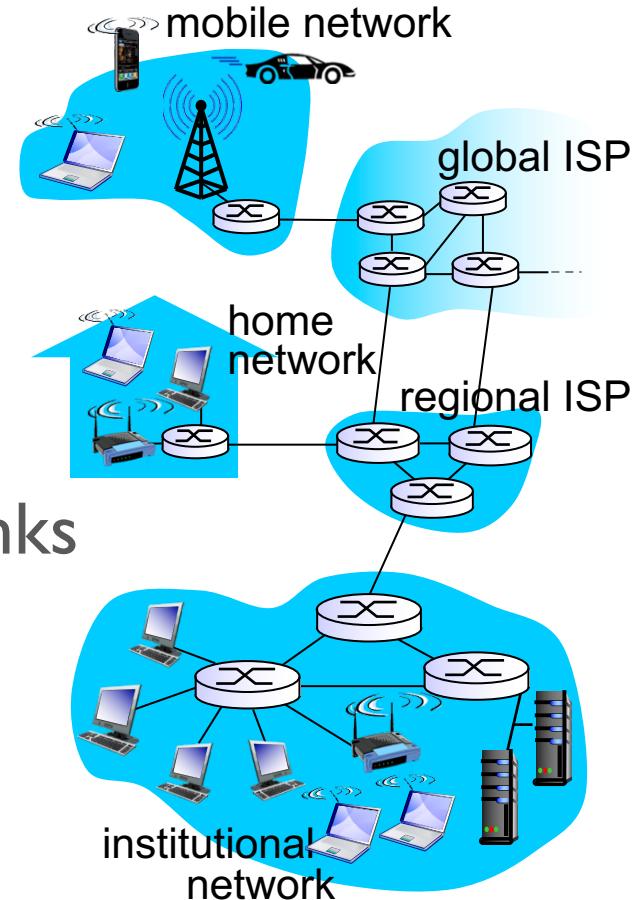
FUNCTION	TCP/IP MODEL	OSI MODEL
Type of Model	Implemented model of OSI model.	It is a reference model on which various networks are built.
Network layer	Network layer provides only connectionless service.	Network layer provides connection oriented and connection less services (Both)
Replaceable/ Non-replaceable Protocols	Protocols can't be easily replaceable	In OSI model protocols are hidden and can be easily replaceable when technology changes occur
Number of Layers	Comprises of four layers	It comprises of seven layers
Protocol Dependent/Independent	Services, protocols, and interfaces are not properly segregated but are protocol dependent	Services, protocols and interfaces are defined and it is protocol independent
Usage	Widely used model	Limited usage of the model
Standardization of devices	Do not provide standardization of devices	Standardization of devices like router, switches, load balancers and other hardware devices

Network Edge

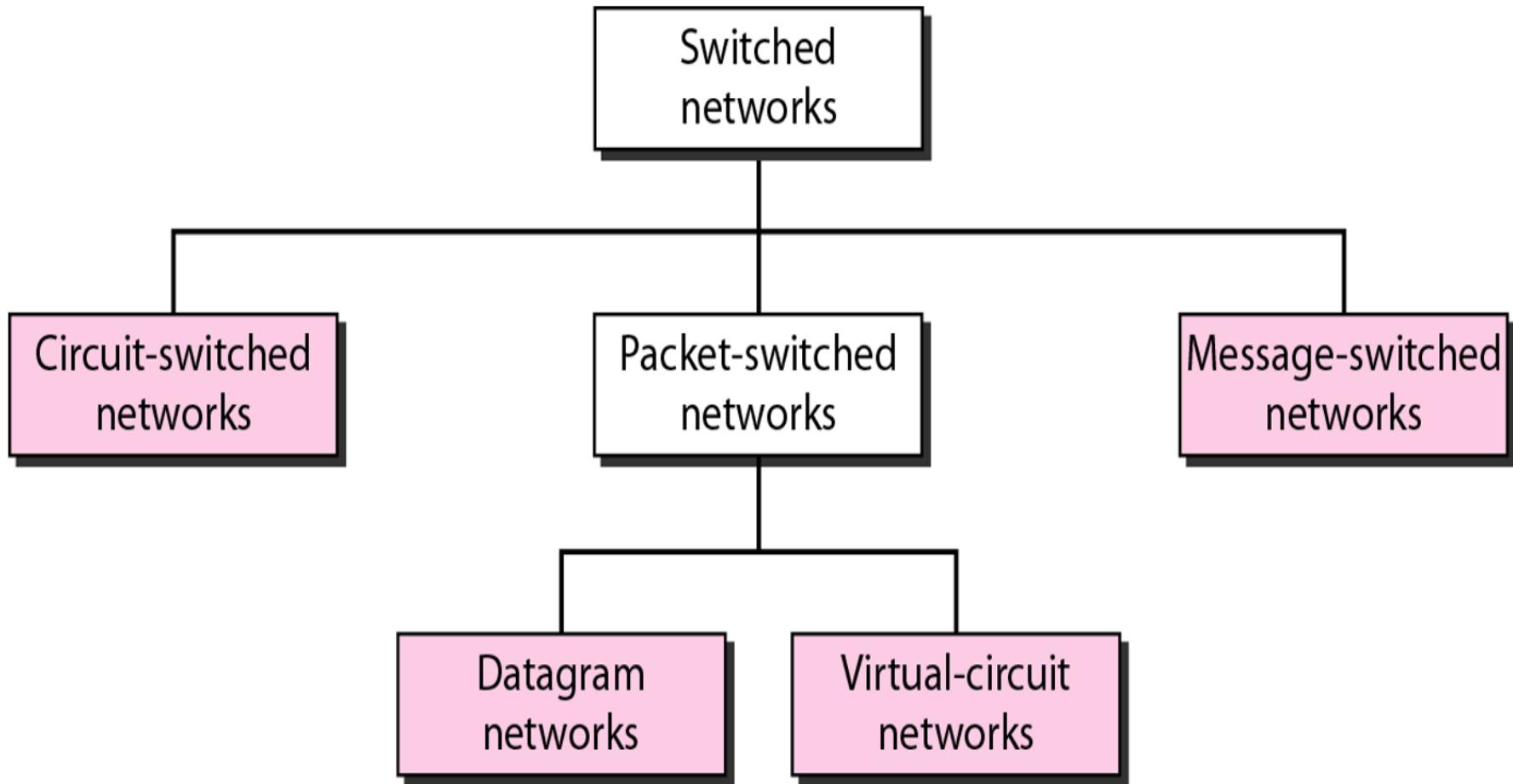
- An edge device is **any piece of hardware that controls data flow at the boundary between two networks.**
- Edge devices fulfil a variety of roles, depending on what type of device they are, but they essentially serve as network entry (or exit) points.
- Some common functions of edge devices are the **transmission, routing, processing, monitoring, filtering, translation and storage of data passing between networks.**
- Edge devices are used by **enterprises and service providers.**

Closer Look of Network

- *network edge:*
 - hosts: clients and servers
 - servers often in data centers
- *access networks, physical media:*
 - wired, wireless communication links



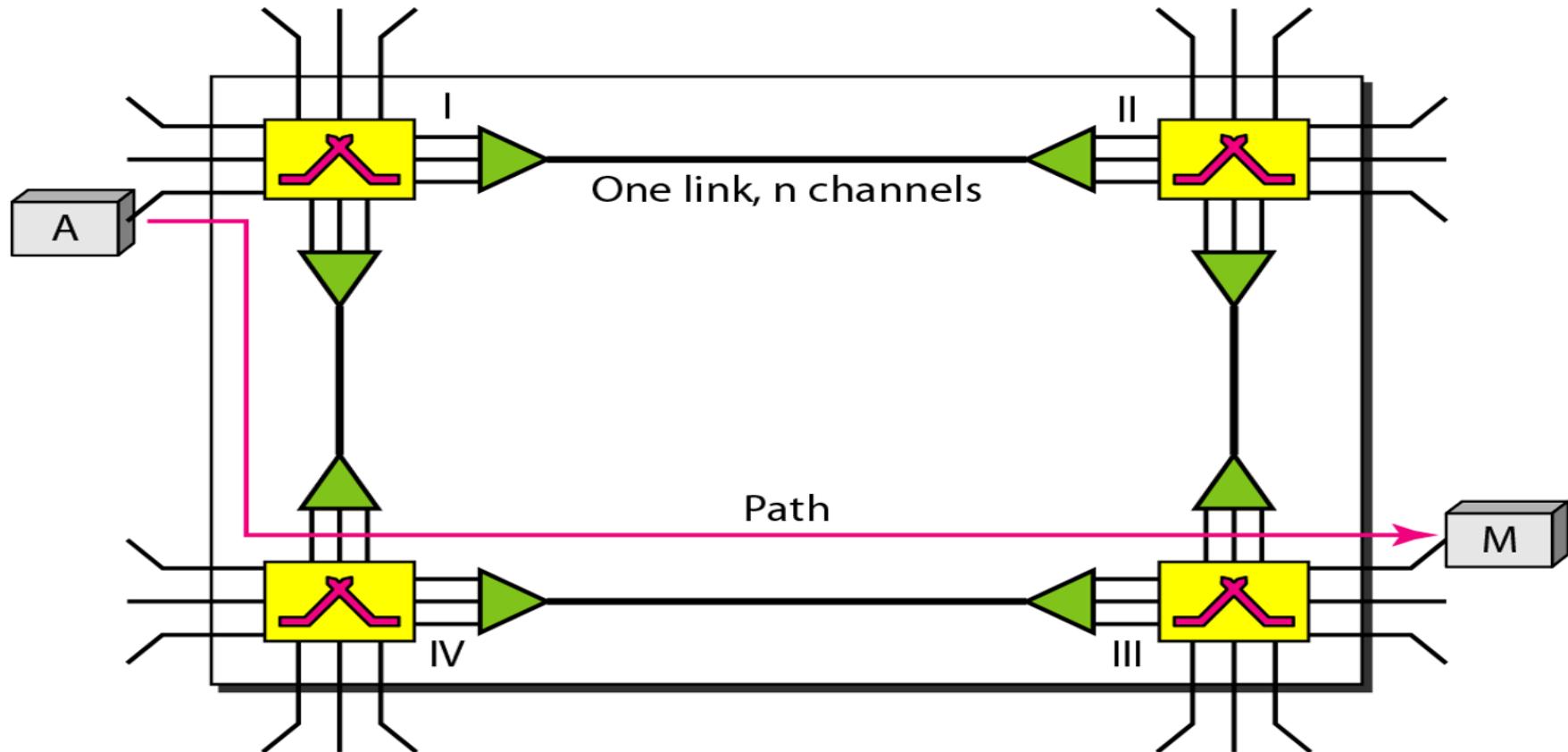
Network Core



Circuit-switching

Note

A circuit-switched network is made of a set of switches connected by physical links, in which each link is divided into n channels.



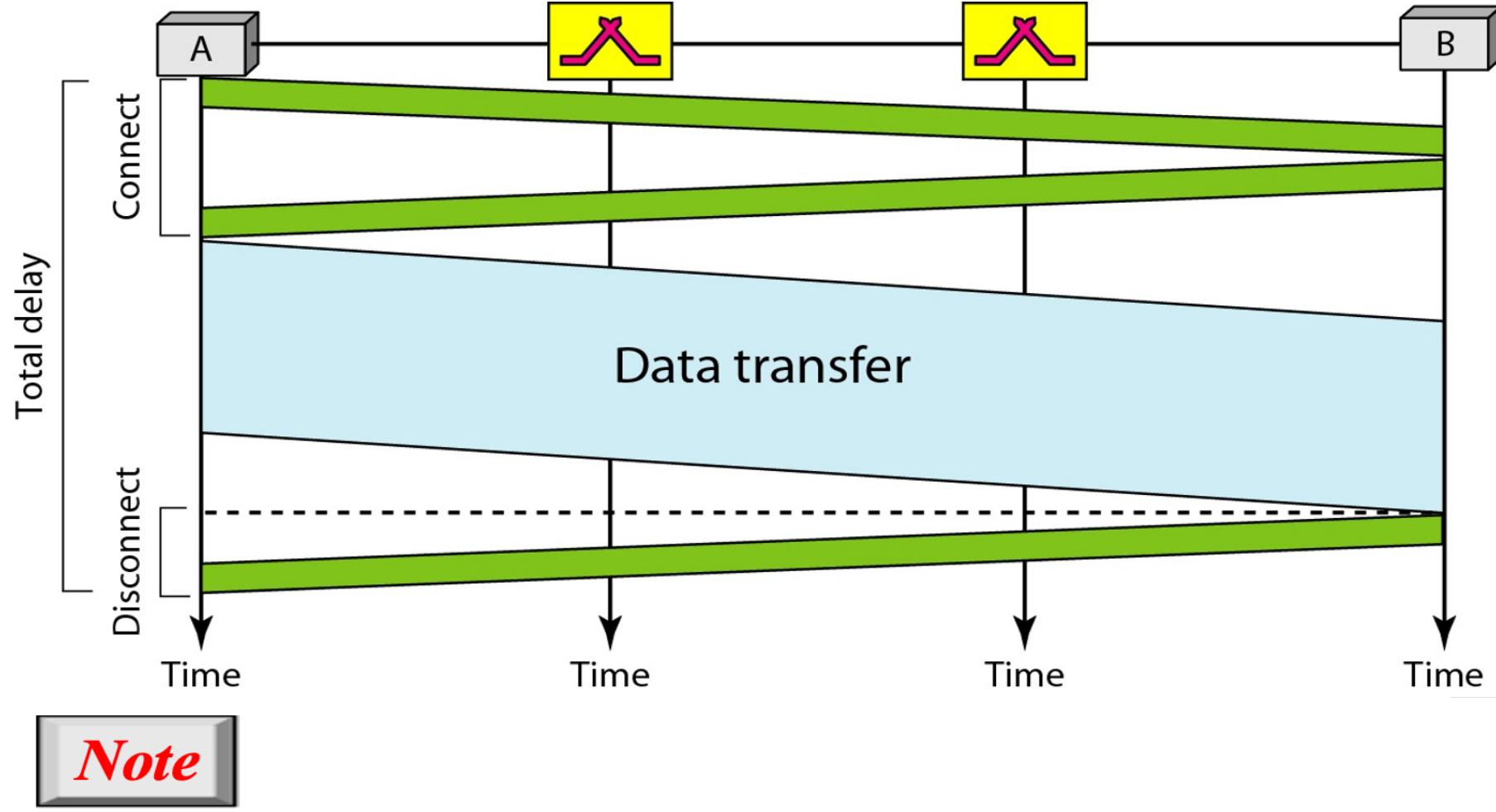
Circuit-switching

A circuit-switched network consists of a set of switches connected by physical links. A connection between two stations is a dedicated path made of one or more links. However, each connection uses only one dedicated channel on each link. Each link is normally divided into n channels by using FDM or TDM.

- In circuit switching network resources (bandwidth) is divided into pieces and bit delay is constant during a connection.
- The dedicated path/circuit established between sender and receiver provides a guaranteed data rate.
- Data can be transmitted without any delays once the circuit is established.
- **Telephone system network** is the one of example of Circuit switching.
- TDM (Time Division Multiplexing) and FDM (Frequency Division Multiplexing) are two methods of multiplexing multiple signals into a single carrier.

Circuit-switching

Delay



Switching at the physical layer in the traditional telephone network uses the circuit-switching approach.

Circuit-switching

Advantages and Disadvantages

Advantages

- It uses a **fixed bandwidth**.
- A dedicated communication channel increases the quality of communication.
- Data is transmitted with a **fixed data rate**.
- **No waiting time at switches**.
- Suitable for long continuous communication.

Disadvantages

- A dedicated connection makes it impossible to transmit other data even if the channel is free.
- **Resources are not utilized fully**.
- The time required to establish the physical link between the two stations is too long.
- As a dedicated path has to be established for each connection, **circuit switching is more expensive**.
- Even if there is no transfer of data, the link is still maintained until it is terminated by users. By this channel remains ideal for a long time thereby making circuit switching inefficient.
- **Dedicated channels require more bandwidth**.

Packet Switching

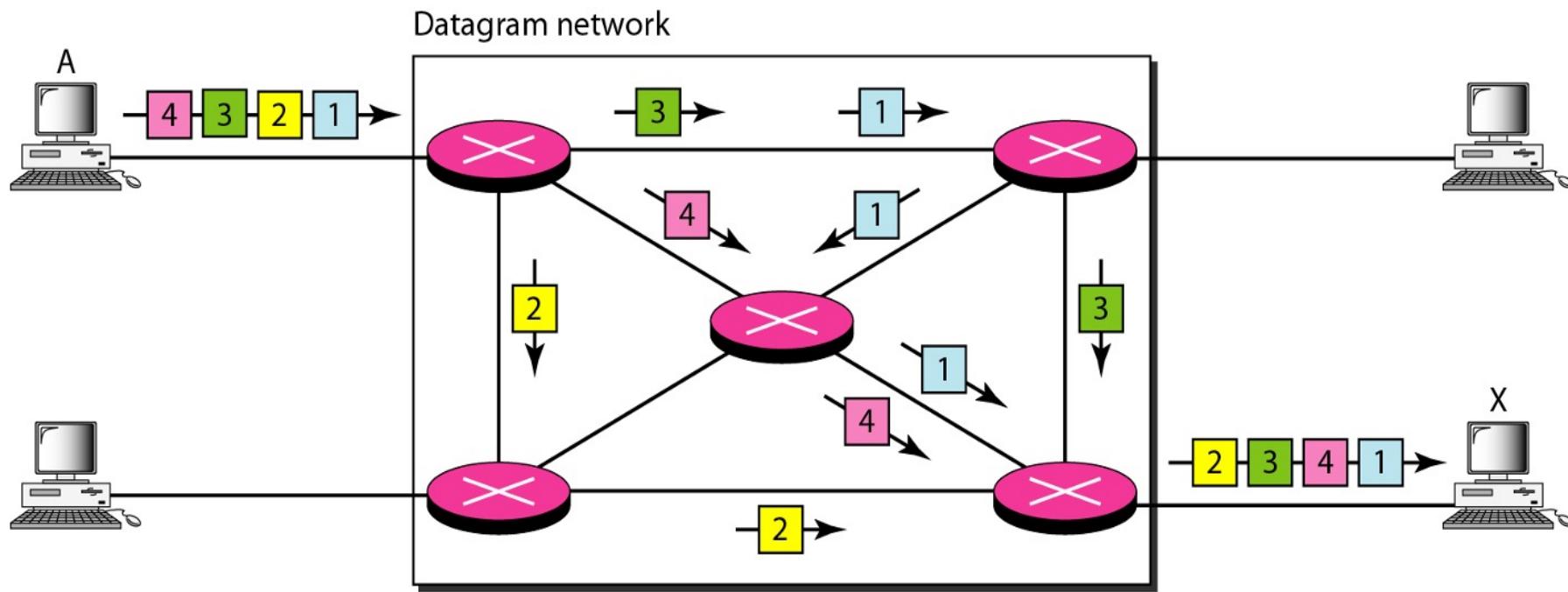
Note

In a packet-switched network, there is no resource reservation; resources are allocated on demand.

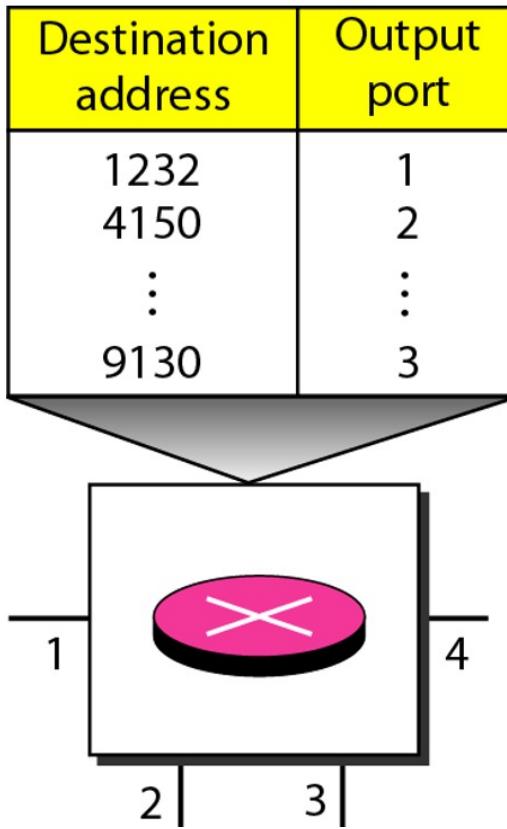
- Packet switching is a method of **transferring the data to a network in form of packets**.
- In order to transfer the file fast and efficient manner over the network and minimize the transmission latency, the **data is broken into small pieces of variable length, called Packet**.
- At the destination, all these small-parts (packets) has to be reassembled, belonging to the same file.
- A packet composes of payload and various control information. **No pre-setup or reservation of resources is needed.**

Datagram Network

In data communications, we need to send messages from one end system to another. If the message is going to pass through a packet-switched network, it needs to be divided into packets of fixed or variable size. The size of the packet is determined by the network and the governing protocol.



Datagram Network (Routing Table)



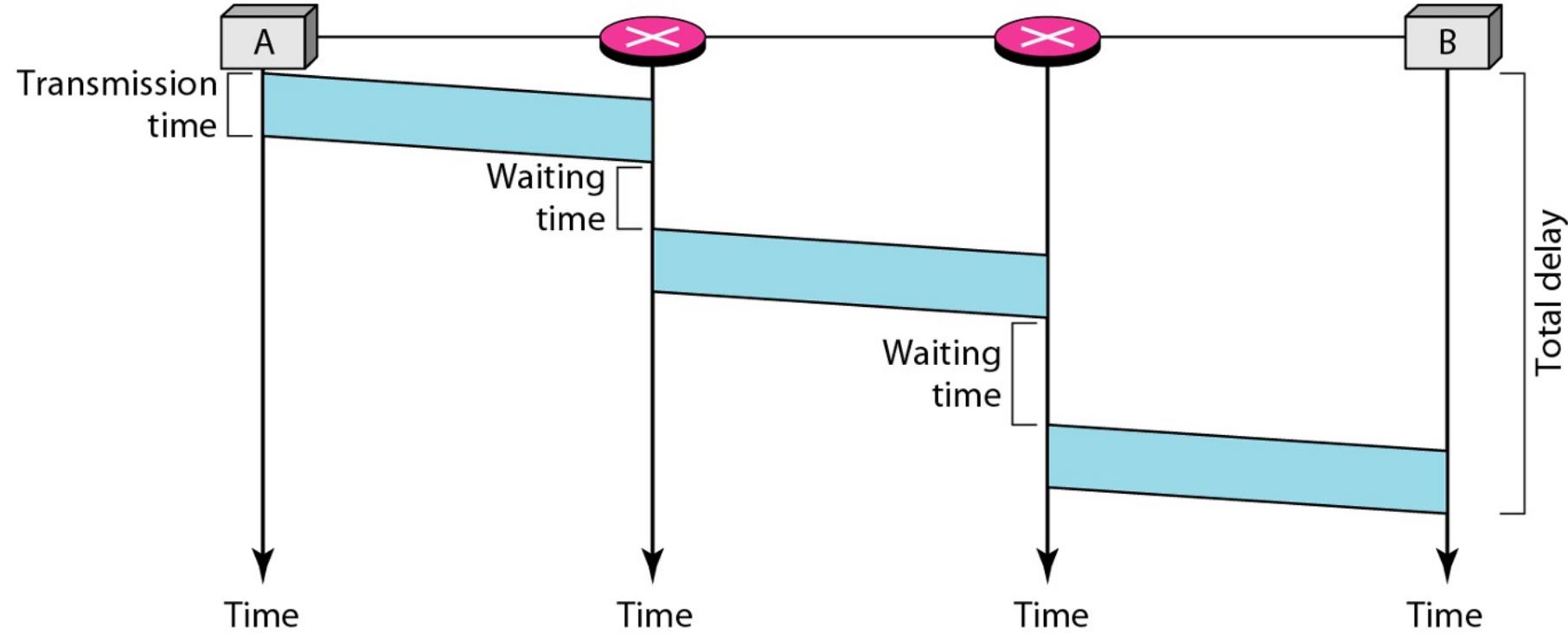
Note

A switch in a datagram network uses a routing table that is based on the destination address.

Note

The destination address in the header of a packet in a datagram network remains the same during the entire journey of the packet.

Datagram Network (Delay)



Note

Switching at the Internet is done by using the datagram approach to packet switching at the network layer.

Virtual Circuit Network

A virtual-circuit network is a cross between a circuit-switched network and a datagram network. It has some characteristics of both.

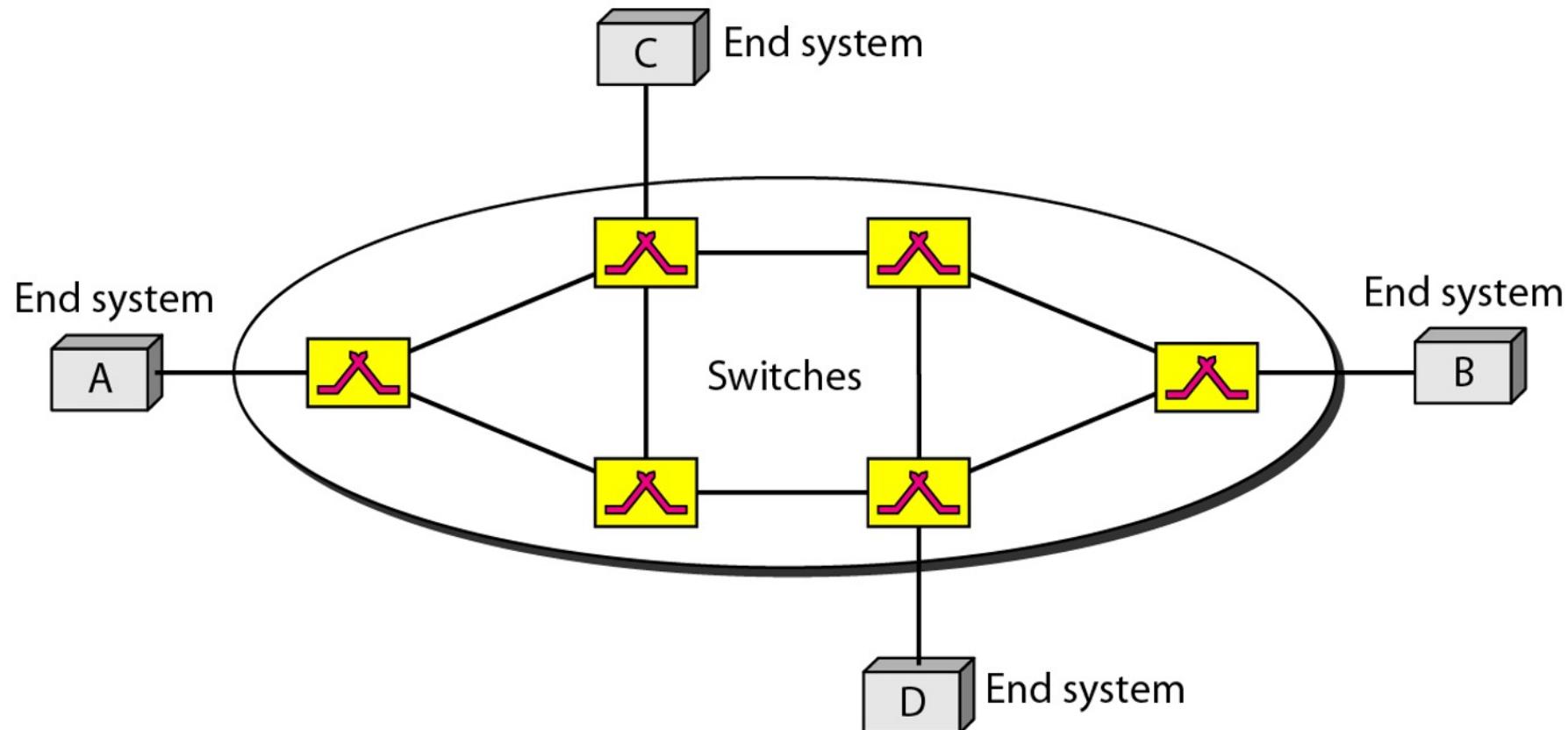


Figure: Virtual-circuit identifier

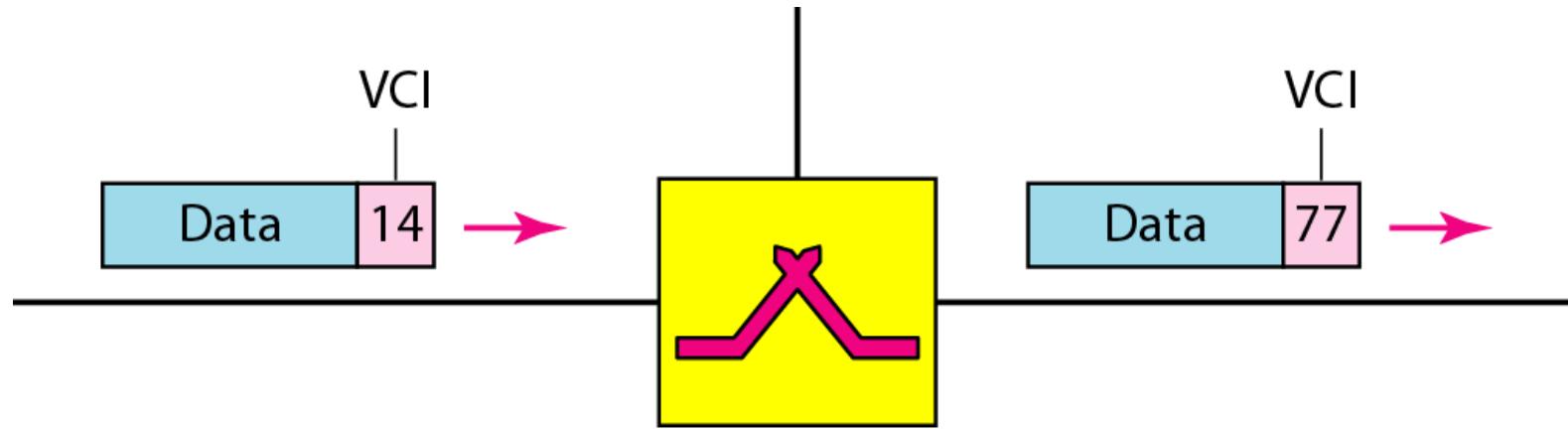


Figure: Switch and tables in a virtual-circuit network

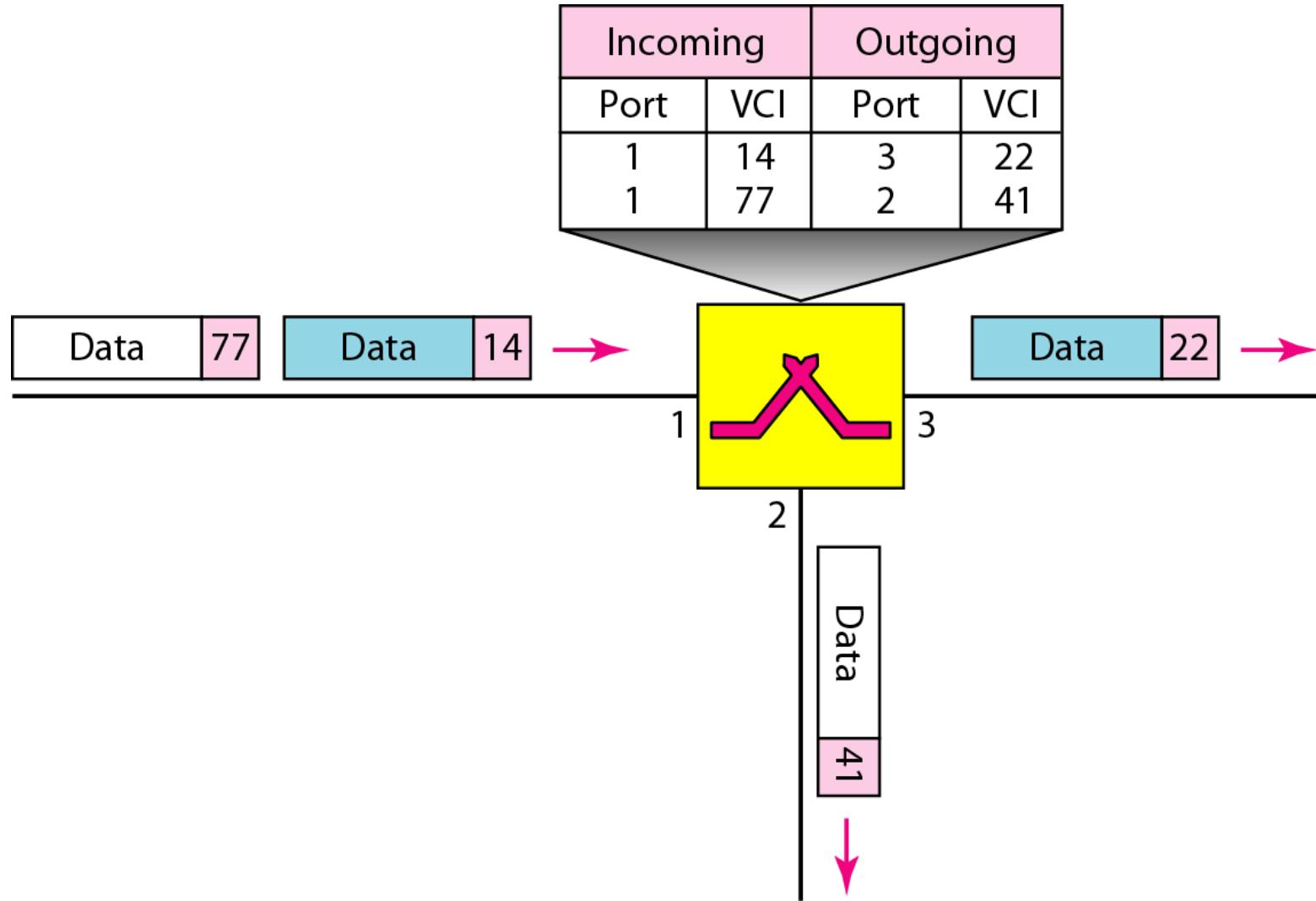


Figure: Source-to-destination data transfer in a virtual-circuit network

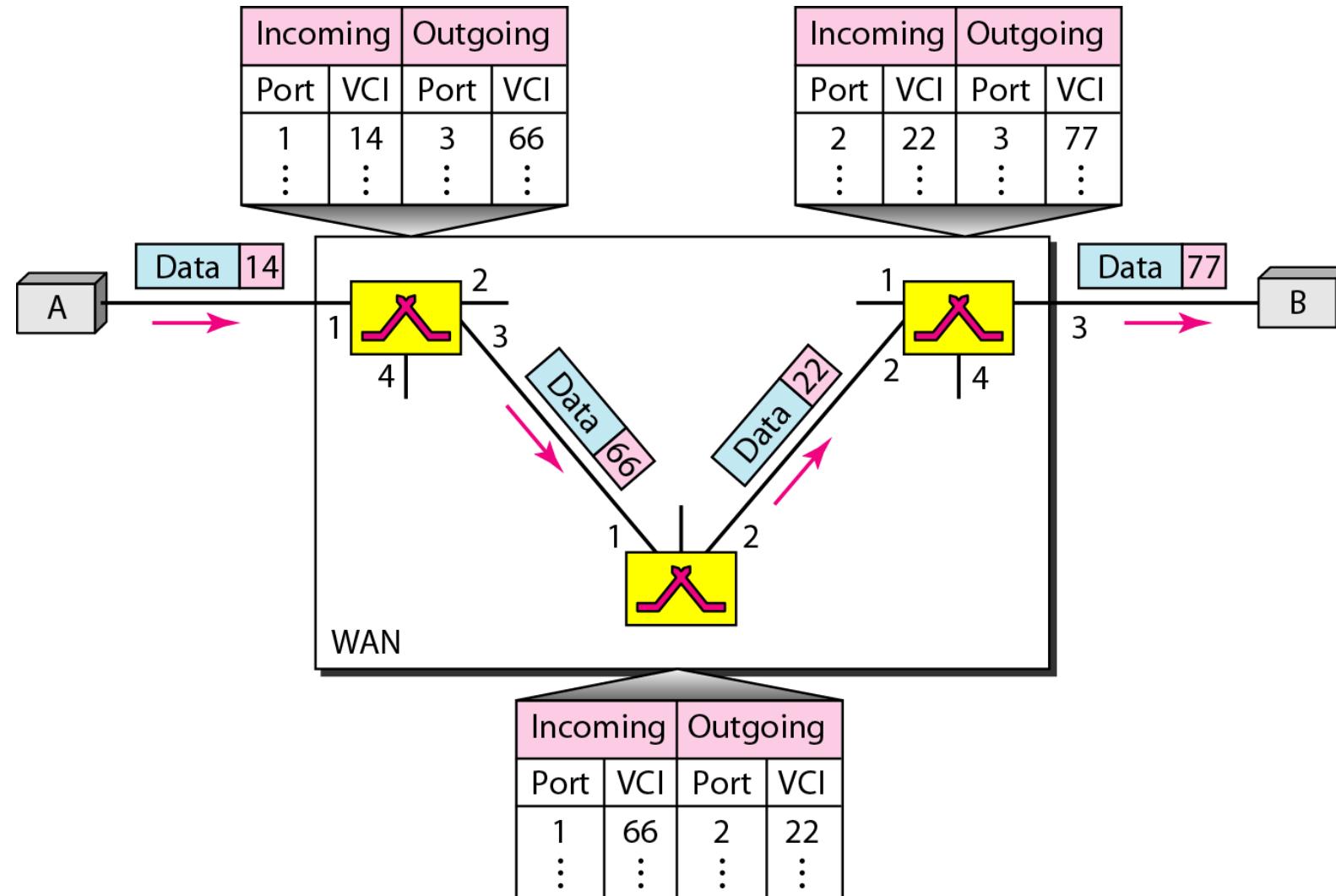


Figure: Setup request in a virtual-circuit network

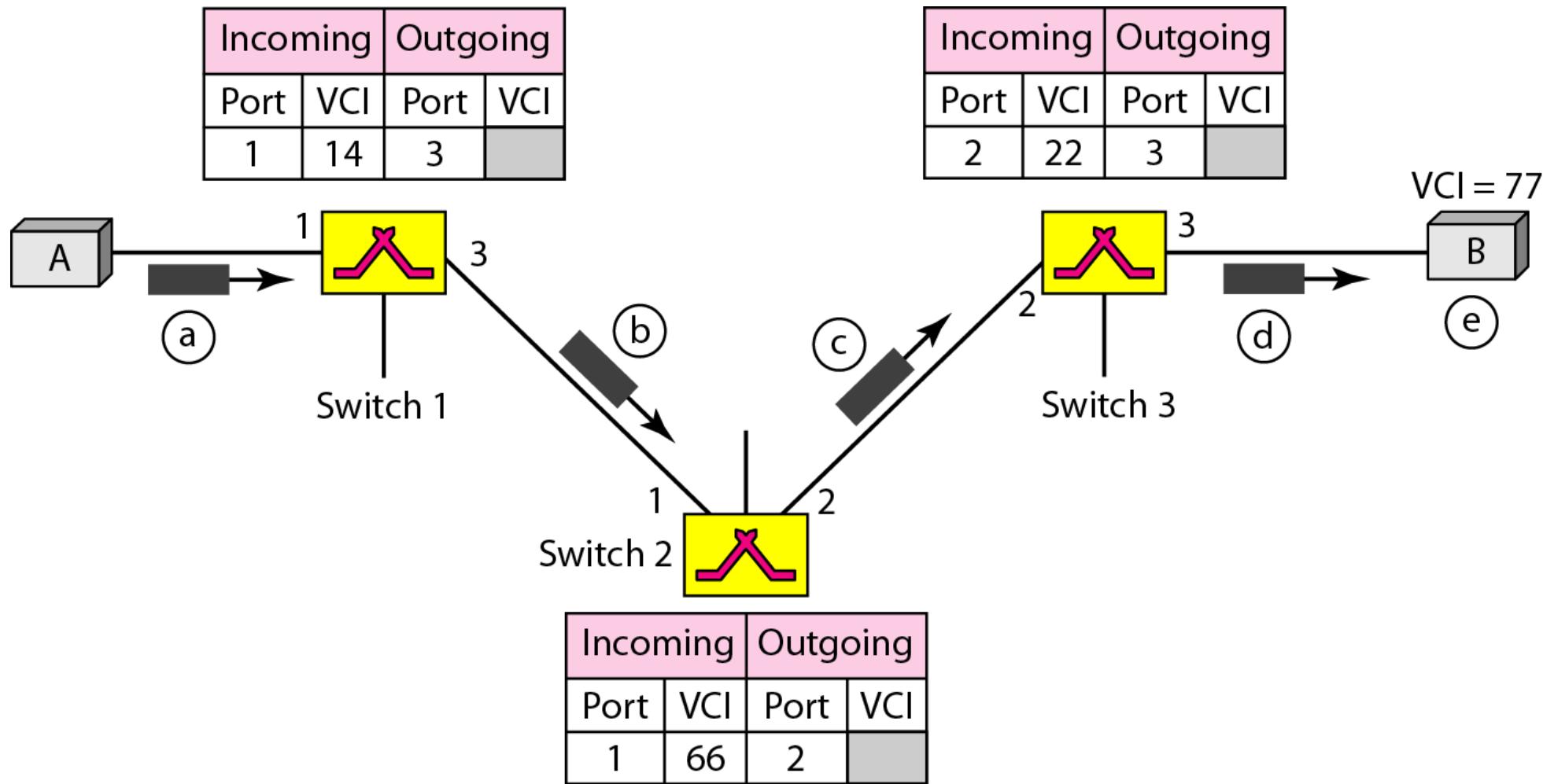
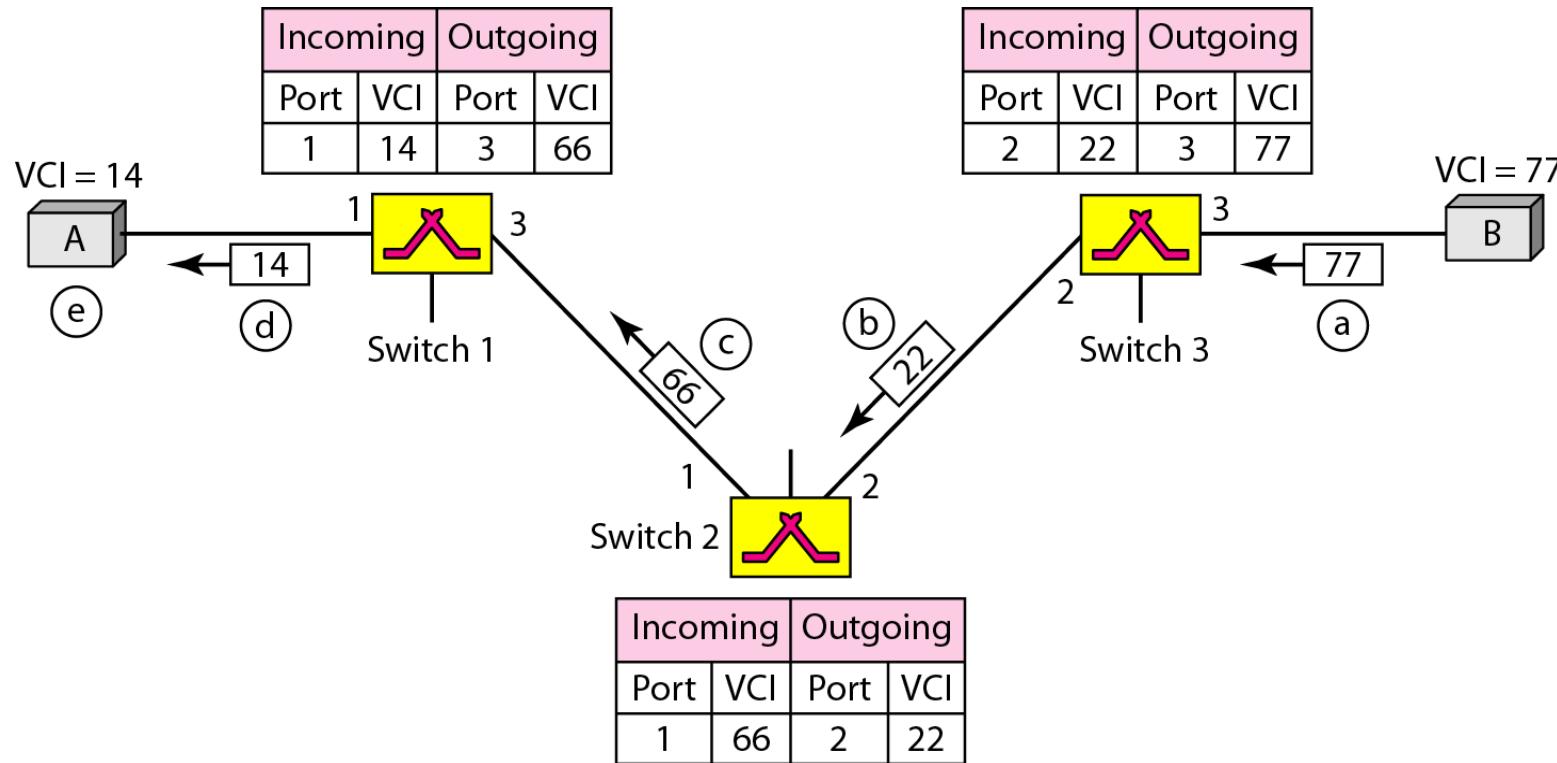


Figure: Setup acknowledgment in a virtual-circuit network



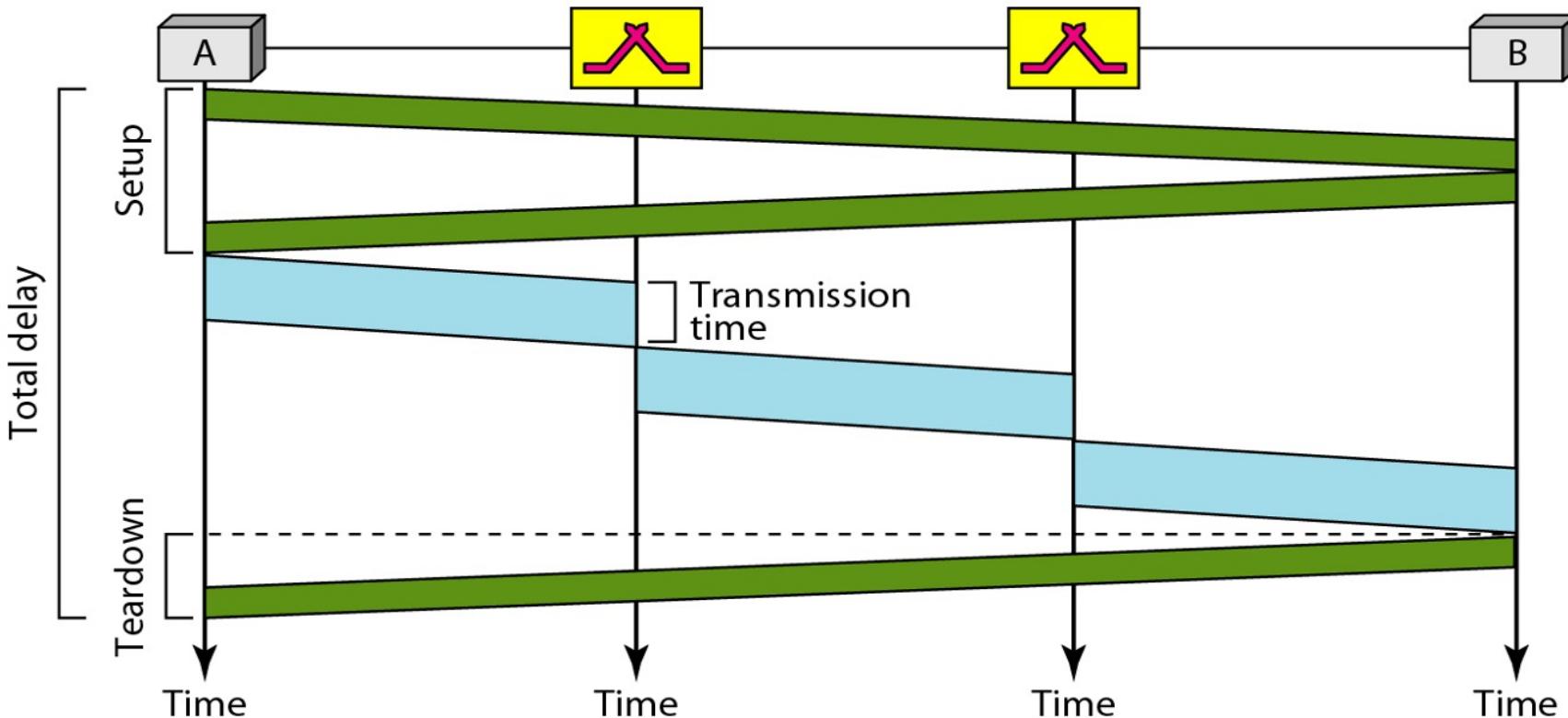
Note

Switching at the data link layer in a switched WAN is normally implemented by using virtual-circuit techniques.

Virtual Circuit Network (Delay)

Note

In virtual-circuit switching, all packets belonging to the same source and destination travel the same path; but the packets may arrive at the destination with different delays if resource allocation is on demand.



Packet Switching

Advantages and Disadvantages

Advantages:

- Packet switching is **cost effective**, because switching devices do not need massive amount of secondary storage.
- Packet switching offers **improved delay characteristics**, because there are no long messages in the queue (maximum packet size is fixed).
- Packet can be **rerouted** if there is any problem, such as, busy or disabled links.
- The advantage of packet switching is that **many network users can share the same channel at the same time**.
- Packet switching can maximize link efficiency by making optimal use of link bandwidth.

Disadvantages:

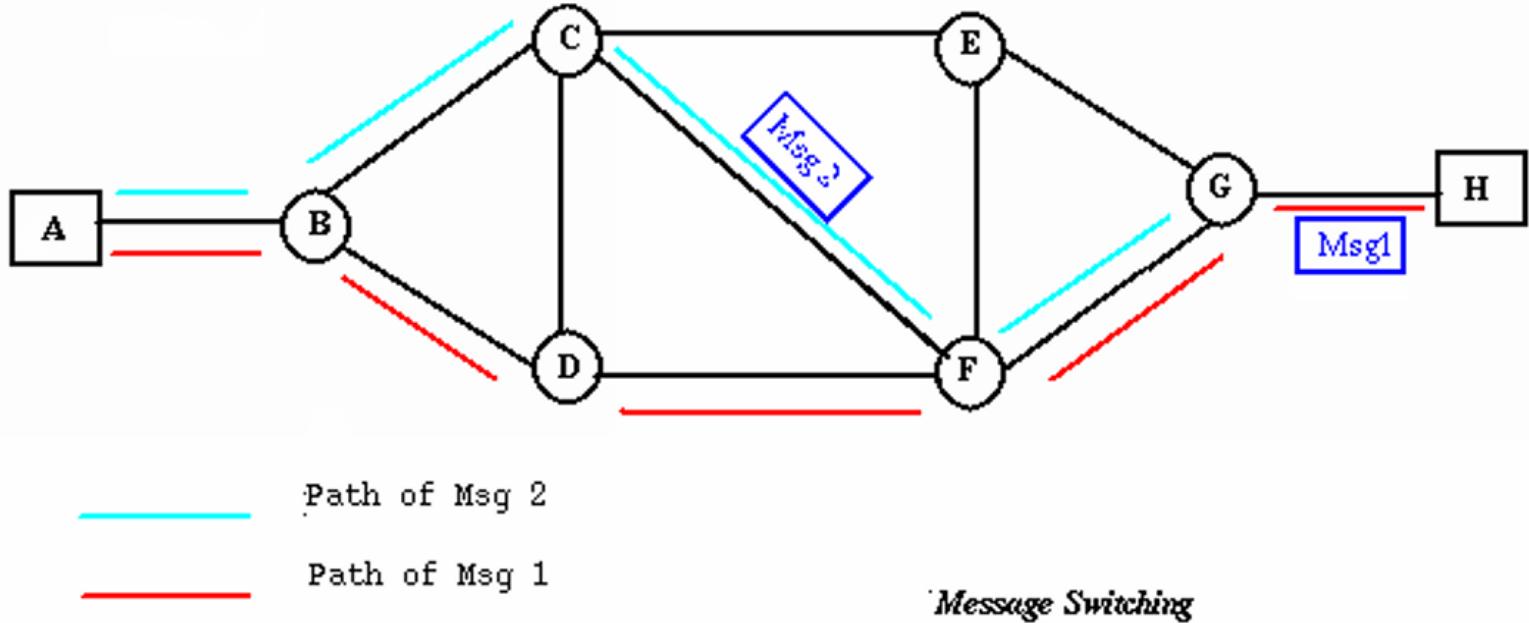
- Protocols for packet switching are typically **more complex**.
- It can add some initial costs in implementation.
- If packet is lost, sender needs to retransmit the data.
- Another disadvantage is that packet-switched systems still can't deliver the same quality as dedicated circuits in applications requiring very little delay - like voice conversations or moving images.

Message Switching (Store and Forward Network)

- With message switching there is no need to establish a dedicated path between two stations.
- When a station sends a message, the destination address is appended to the message.
- The message is then transmitted through the network, in its entirety, from node to node.
- Each node receives the entire message, stores it in its entirety on disk, and then transmits the message to the next node.
- This type of network is called a **store-and-forward network**.

Message Switching

(Store and Forward Network)



A message-switching node is typically a general-purpose computer. The device needs sufficient secondary storage capacity to store the incoming messages, which could be long. A time delay is introduced using this type of scheme due to store-and-forward time plus the time required to find the next node in the transmission path.

Message Switching

Advantages and Disadvantages

Advantages:

- Channel efficiency can be greater than circuit-switched systems because more devices share the channel.
- Traffic congestion can be reduced because messages may be temporarily stored to route.
- Message priorities can be established due to the store-and-forward technique.
- Message broadcasting can be achieved using a broadcast address appended to the message.

Disadvantages

- Message switching is not compatible with interactive applications.
- Store-and-forward devices are expensive because they must have large disks to hold potentially long messages.

Connection-less versus Connection-oriented

Criteria	Connection-Oriented	Connection-Less
Connection	Prior connection needs to be established.	No prior connection is established.
Resource Allocation	Resources need to be allocated.	No prior allocation of resource is required.
Reliability	It ensures reliable transfer of data.	Reliability is not guaranteed as it is a best effort service.
Congestion	Congestion is not at all possible.	Congestion can occur likely.
Transfer mode	It can be implemented either using Circuit Switching or VCs.	It is implemented using Packet Switching.
Retransmission	It is possible to retransmit the lost data bits.	It is not possible.
Suitability	It is suitable for long and steady communication.	It is suitable for bursty transmissions.
Signaling	Connection is established through process of signaling.	There is no concept of signaling.
Packet travel	In this packets travel to their destination node in a sequential manner.	In this packets reach the destination in a random manner.
Delay	There is more delay in transfer of information, but once connection established faster delivery.	There is no delay due absence of connection establishment phase.

History of Computer Networks

S. No	Period	Method	History
1	Late 1950	SAGE (Semi – Automatic Ground Environment)	It was used at U.S Military Radar system.
2	1960	SABRE(Semi Automatic Business Research Environment)	At Commercial Airline Reservation system online connected with two main frame computers.
		Packet switching	<p>Packet switching was developed by Paul Baran and Donald Devices to transfer the information between computers and network.</p> <p>NPL network (National Physical Laboratory) at united kingdom local area network (LAN) using line speed of 768kbit/s was implemented by Davies pioneered</p>
3	1963	Intergalactic Computer network	Intergalactic Computer network was send by J.C.RLicklider to his office colleagues discussing about this concept, a computer network engaged to access communication with users of computers.
4	1965	Telephone switch	At first widely used Telephone switch was introduced by Western Electric which implemented true computer control.
5	1966	WAN (Wide Area Network)	An experimental paper on WAN (Wide Area Network) has been published by Thomas Marill and Lawrence G.Roberts published in the area of time sharing.

History of Computer Networks

6	1969-1970	ARPANET (Hierarchical routing after 1970's Internet today)	<p>First In 1969, four nodes of ARPANET were connected between four universities namely the university of California at Los Angeles, at Santa Barbara, the Stanford Research Institute and the university of Utah using the 50 Kbit/s circuits.</p> <p>Packet –switched networks was the theoretical work to model was performed by Leonard Kleinrock, ARPANET was which underpinned the development of it and his theoretical work on hierarchical routing in late 1970 s with his student Farouk Kamoun remains critical to the operation of the Internet today.</p>
7	1972	X.25 TCP/IP	Using X.25 as commercial services were deployed then was using an infrastructure for expanding TCP/IP networks.
8	1973	Hosts	In 1973, a French network named CYCLADES was the first for making hosts which is responsible for reliable delivery of data, later it became centralized service of network in itself.
9	1973-1979	Ethernet	A memo at Xerox PARC was written by Robert Metcalfe describing Ethernet in 1973, in an Aloha based networking system which was developed in 1960s by Norman Abramson and colleagues at the University of Hawaii. At July 1976 the paper published "Ethernet: Distributed Packet Switching for Local Computer Networks" by Robert Metcalfe and David Boggs, then collaborated on many patents received in 1977 and 1978. Robert Metcalfe pursued making on open standard at 1979.

History of Computer Networks

10	1976	ARCNET	ARCNET was created by John Murphy of Data point corporation in which token-passing network was used first to share the storage device in 1976.
11	1995	NEW FIBRE OPTIC CABLES	The speed capacity of transmission for Ethernet was slightly elevated from 10 Mbit/s to 100Mbit/sat 1995. After 19913, Ethernet supported transmission speed capacity towards gigabit. Frequently, highest speeds up to 100 Gbit/s were appended (still 2016). Ethernet has ability to grow easily (such as quick compatible to support new fiber optic cable speed)