Transmission Media & Switching

Course Code: **COE 3201** Course Title: **Data Communication**

Dept. of Computer Engineering
Faculty of Engineering

Lecture No:	**11**	**Week No:**	**12**	**Semester:**	
Lecturer:					

Lecture Outline

1. The first section introduces the transmission media and defines its position in the Internet model. It shows that we can classify transmission media into two broad categories: guided and unguided media.

2. The second section discusses guided media. The first part describes twisted-pair cables and their characteristics and applications. The second part describes coaxial cables and their characteristics and applications

3. The third section discusses unguided media. The first part describes radio waves and their characteristics and applications. The second part describes microwaves and their characteristics and applications.

4. The fourth Section discuss about Switching Techniques

Transmission Medium

Transmission media are actually located below the physical layer and are directly controlled by the physical layer. We could say that transmission media belong to layer zero. Figure shows the position of transmission media in relation to the physical layer.

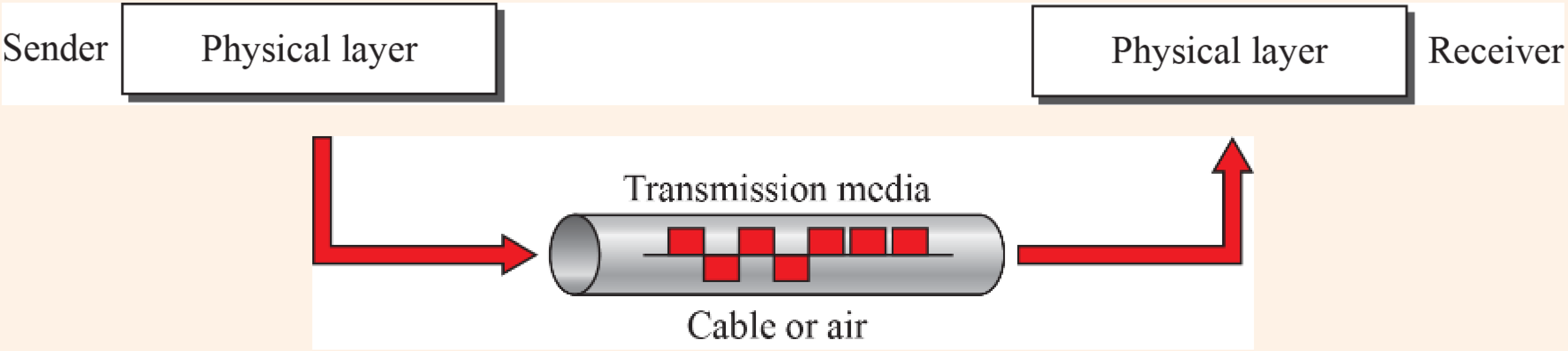


Figure : Transmission media and physical layer

Transmission media

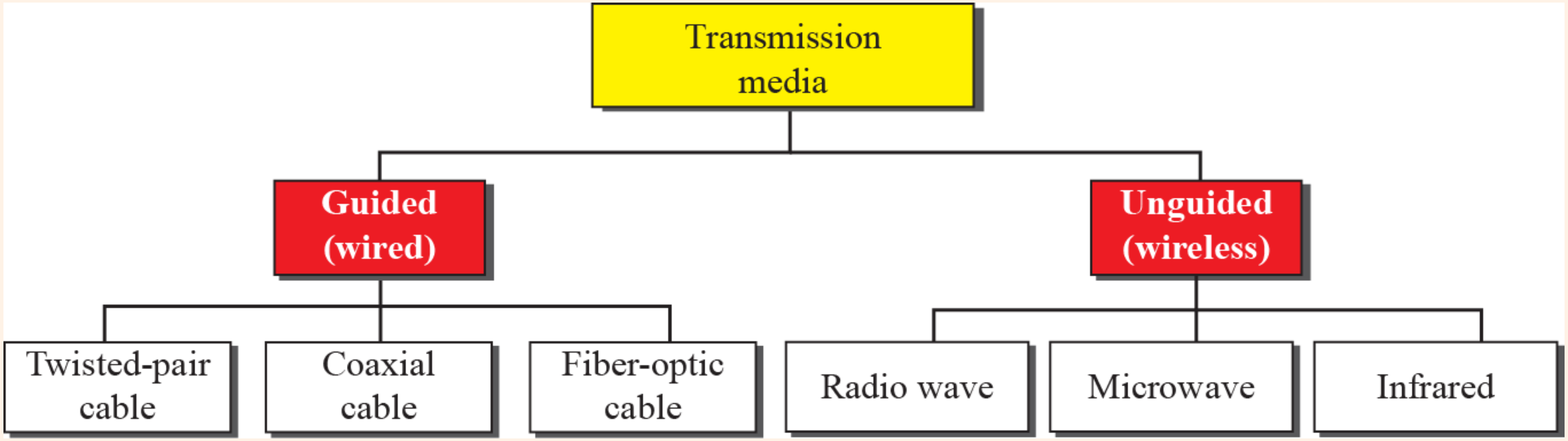


Figure : Classes of transmission media

GUIDED MEDIA

Guided media, which are those that provide a conduit from one device to another, include twisted-pair cable, coaxial cable, and fiber-optic cable. A signal traveling along any of these media is directed and contained by the physical limits of the medium.

A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together, as shown in Figure 7.3.

One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference. The receiver uses the difference between the two.

In addition to the signal sent by the sender on one of the wires, interference (noise) and crosstalk may affect both wires and create unwanted signals.

Twisted-Pair Cable

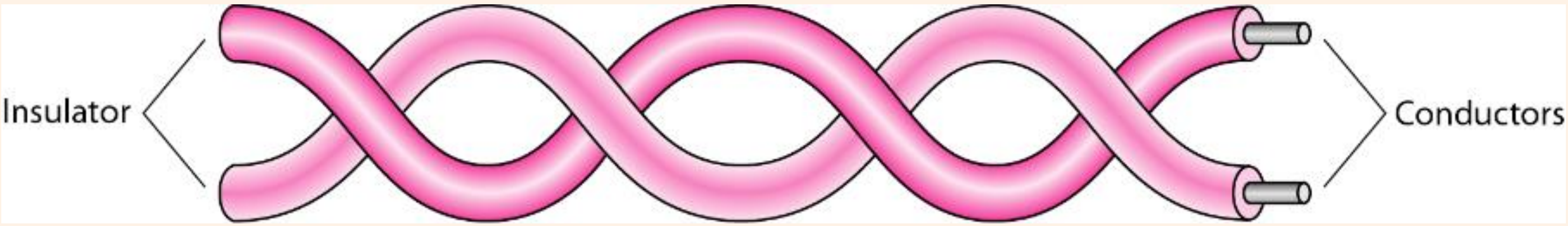


Figure 7.3: Twisted-pair cable

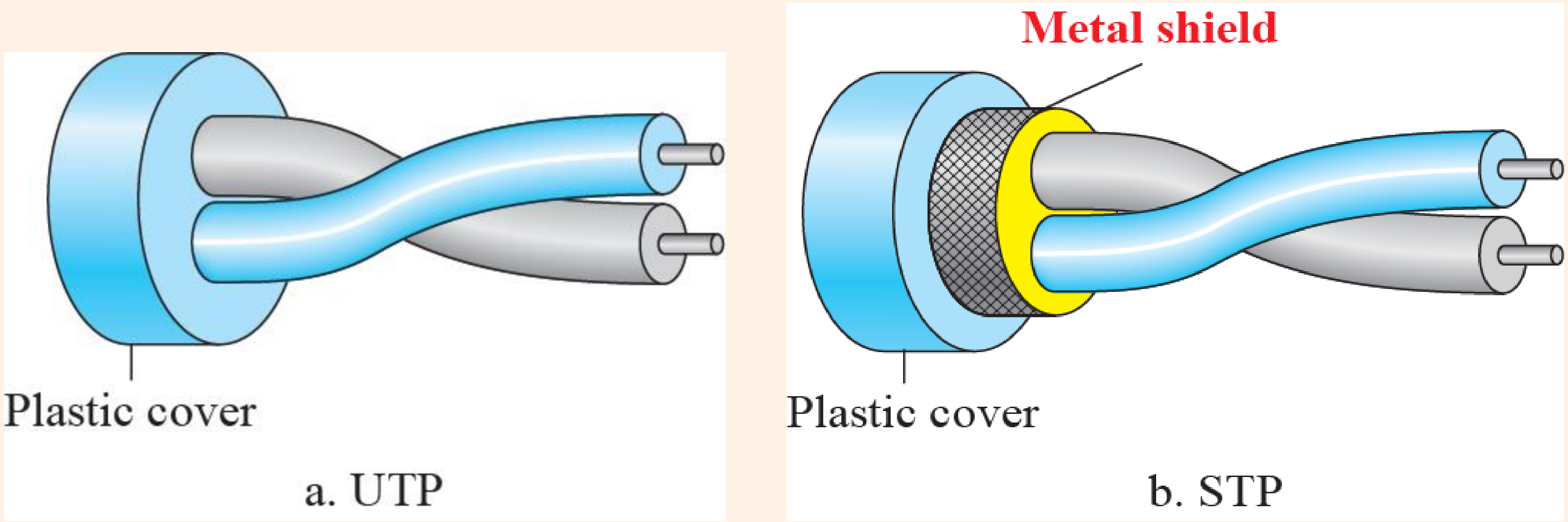
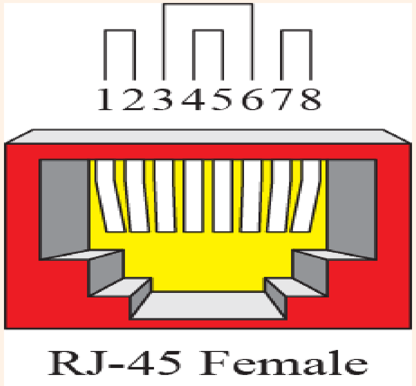


Figure 7.4: UTP and STP cables

Twisted-Pair Cable

Table 7.1: Categories of unshielded twisted-pair cables

Category	*Specification*	*Data Rate (Mbps)*	*Use*
1	Unshielded twisted-pair used in telephone	< 0.1	Telephone
2	Unshielded twisted-pair originally used in T lines	2	T-1 lines
3	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in Token Ring networks	20	LANs
5	Cable wire is normally 24 AWG with a jacket and outside sheath	100	LANs



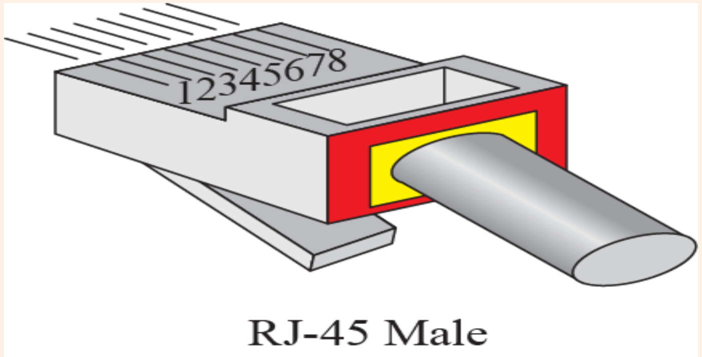


Figure 7.5: UTP Connectors

Coaxial Cable

Coaxial cable (or coax) carries signals of higher frequency ranges than those in twisted pair cable, in part because the two media are constructed quite differently. Instead of having two wires, coax has a central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid, or a combination of the two. The outer metallic wrapping serves both as a shield against noise and as the second conductor, which completes the circuit.

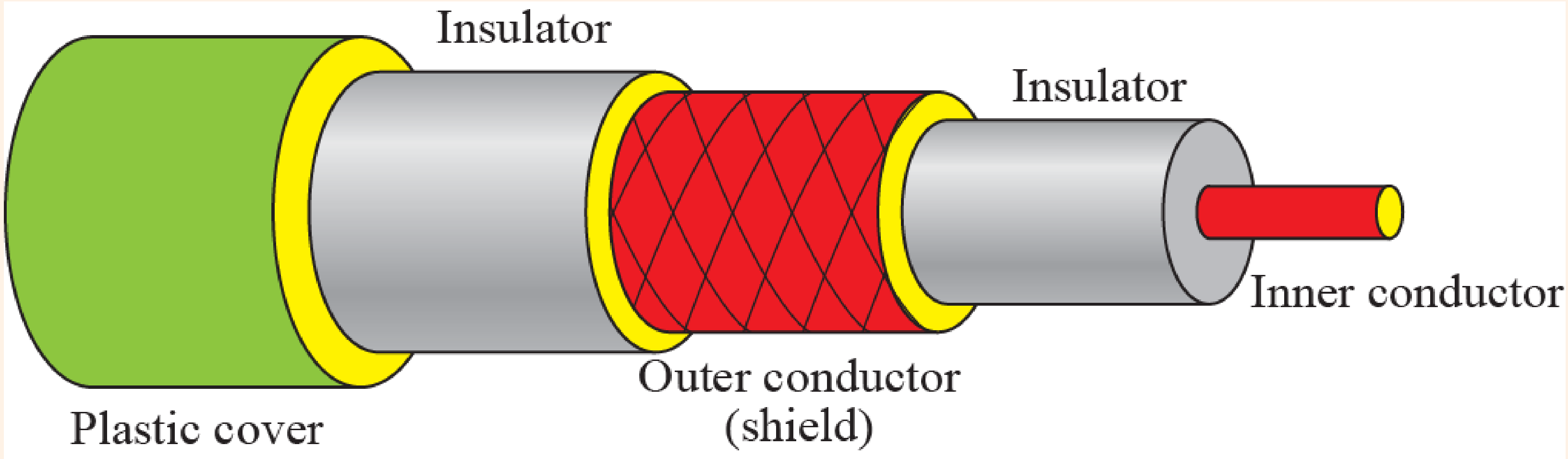


Figure 7.7: Coaxial cable

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

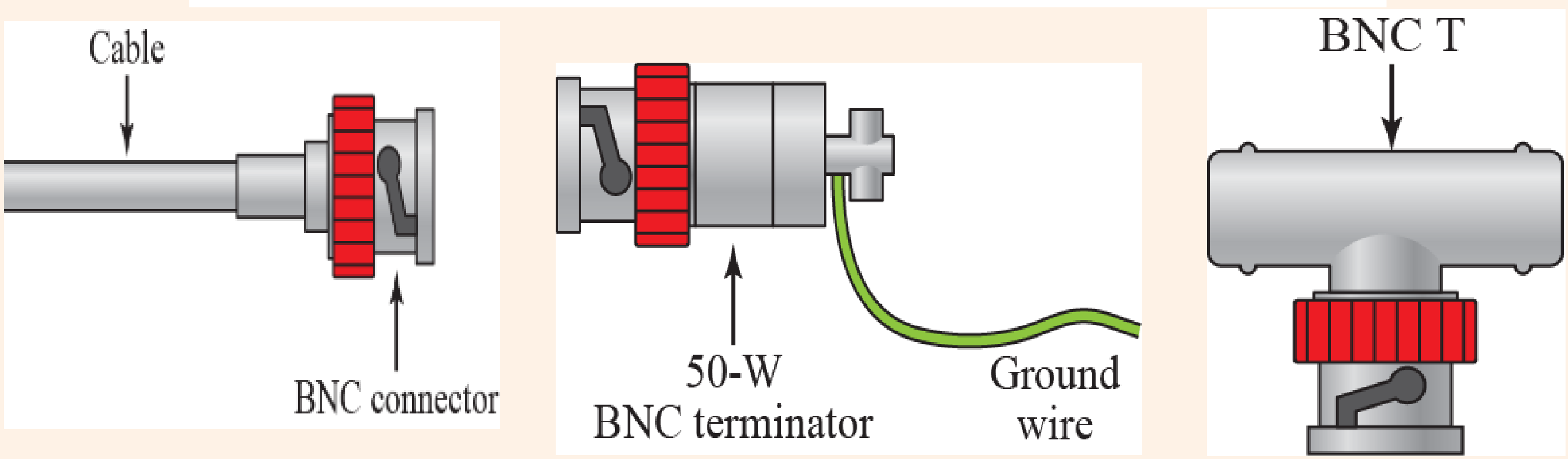


Figure 7.8: BNC connectors

Fiber-Optic Cable

A fiber-optic cable is made of glass or plastic and transmits signals in the form of light. To understand optical fiber, we first need to explore several aspects of the nature of light.

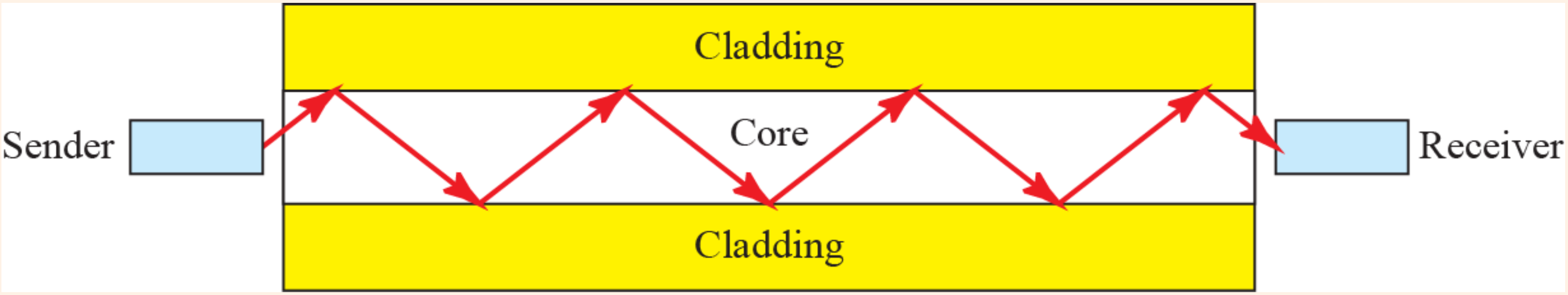


Figure 7.11: Optical fiber

Type	*Core (µm)*	*Cladding (µm)*	*Mode*
50/125	50.0	125	Multimode, graded index
62.5/125	62.5	125	Multimode, graded index
100/125	100.0	125	Multimode, graded index
7/125	7.0	125	Single mode

Table 7.3: Fiber types

Fiber-Optic Cable

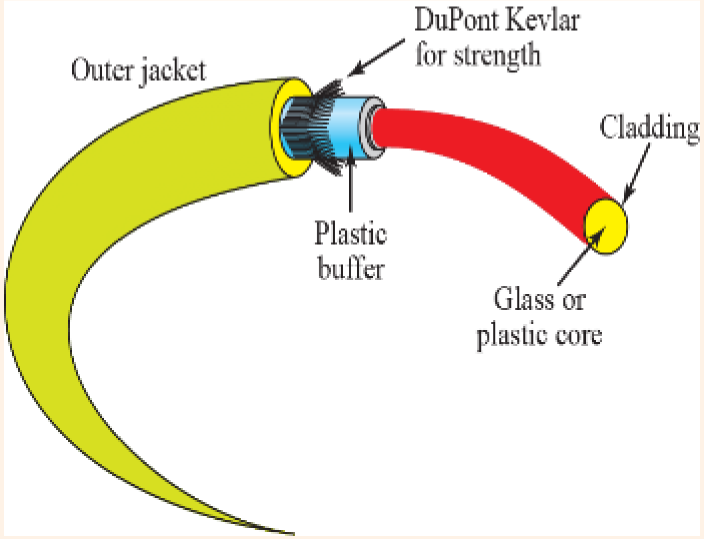


Figure 7.14: Fiber connection

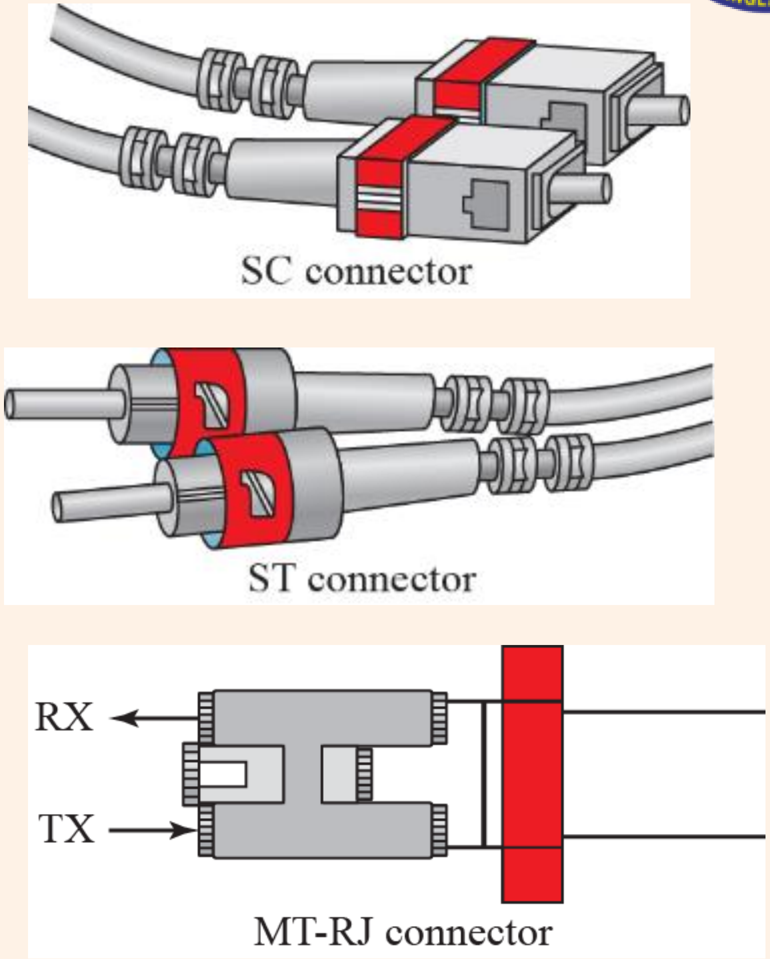


Figure 7.15: Fiber-optic cable connector

UNGUIDED MEDIA

Unguided medium transport waves without using a physical conductor. This type of communication is often referred to as wireless communication. Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them.

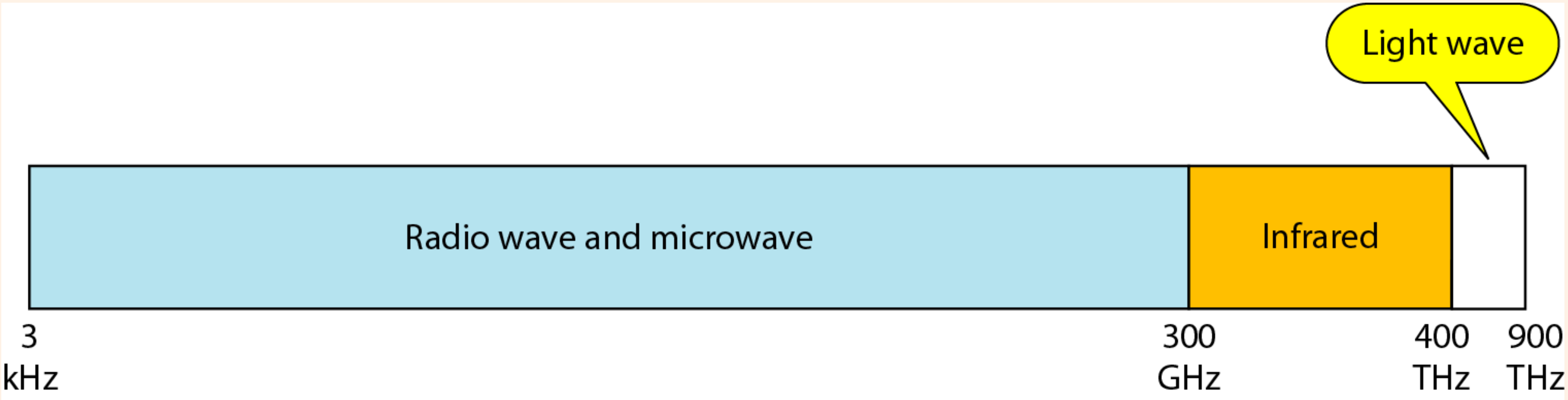


Figure 7.17: Electromagnetic spectrum for wireless communication

UNGUIDED MEDIA

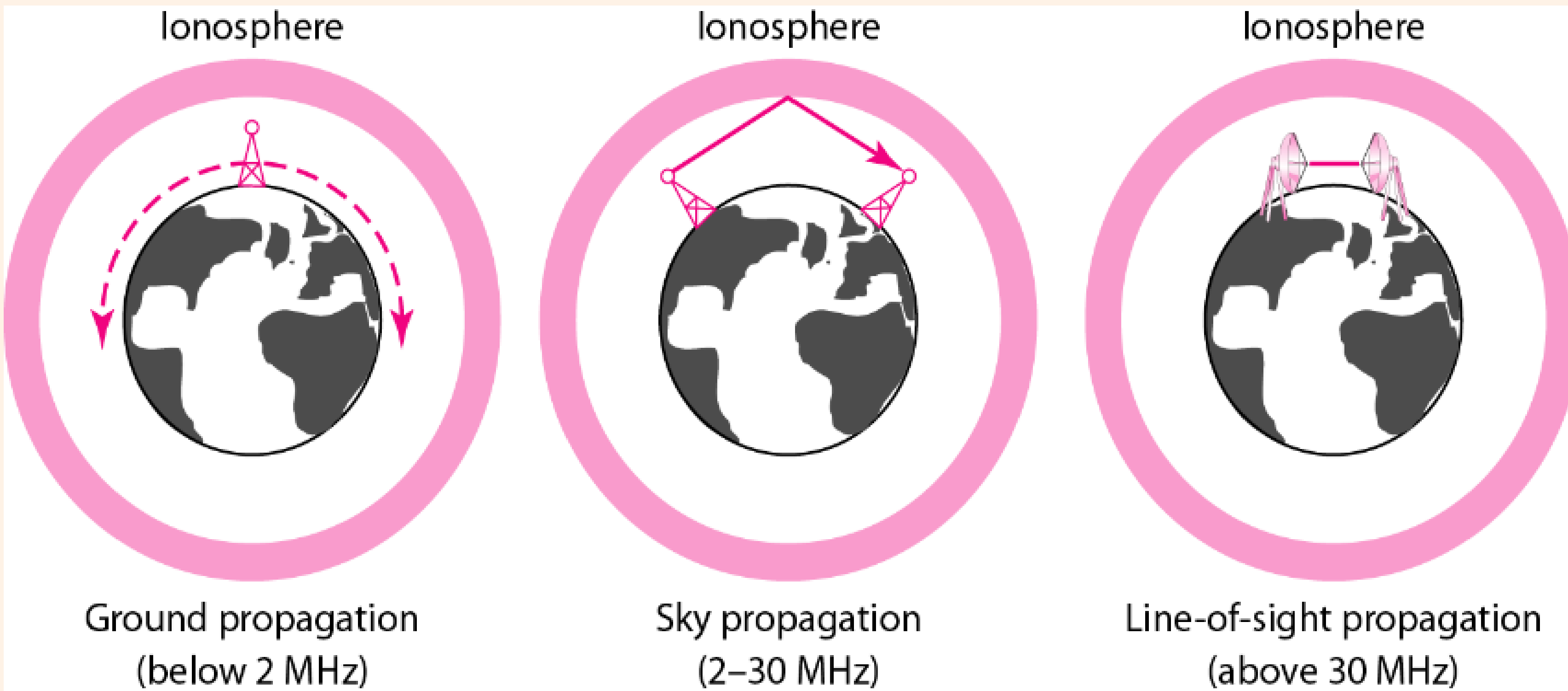


Figure 7.18: Propagation methods

UNGUIDED MEDIA

Table 7.4: Bands

Band	*Range*	*Propagation*	*Application*
very low frequency (VLF)	3–30 kHz	Ground	Long-range radio navigation
low frequency (LF)	30–300 kHz	Ground	Radio beacons and navigational locators
middle frequency (MF)	300 kHz–3 MHz	Sky	AM radio
high frequency (HF)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft
very high frequency (VHF)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
ultrahigh frequency (UHF)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
superhigh frequency (SF)	3–30 GHz	Line-of-sight	Satellite
extremely high frequency (EHF)	30–300 GHz	Line-of-sight	Radar, satellite

Radio Waves

Although there is no clear-cut demarcation between radio waves and microwaves, electromagnetic waves ranging in frequencies between 3 kHz and 1 GHz are normally called radio waves; waves ranging in frequencies between 1 and 300 GHz are called microwaves. However, the behavior of the waves, rather than the frequencies, is a better criterion for classification.

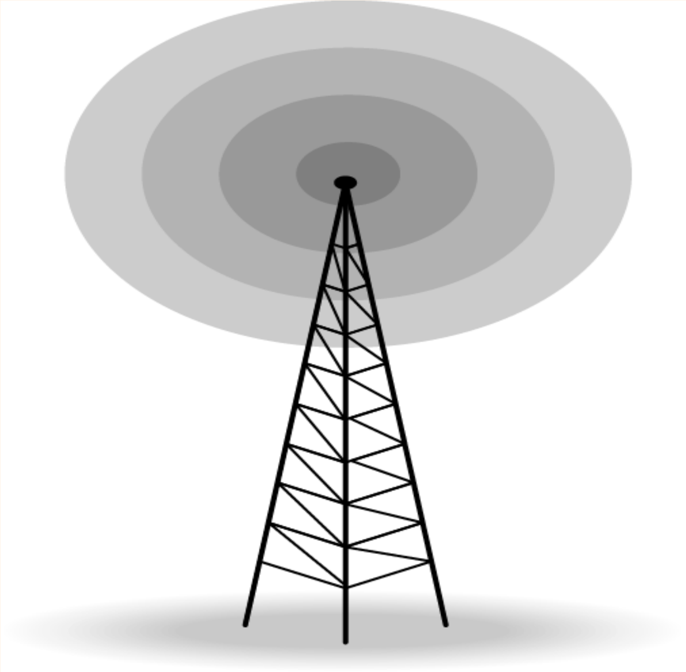


Figure 7.19:* *Omnidirectional antenna

Microwaves

Electromagnetic waves having frequencies between 1 and 300 GHz are called microwaves. Microwaves are unidirectional. When an antenna transmits microwaves, they can be narrowly focused. This means that the sending and receiving antennas need to be aligned. The unidirectional property has an obvious advantage. A pair of antennas can be aligned without interfering with another pair of aligned antennas.

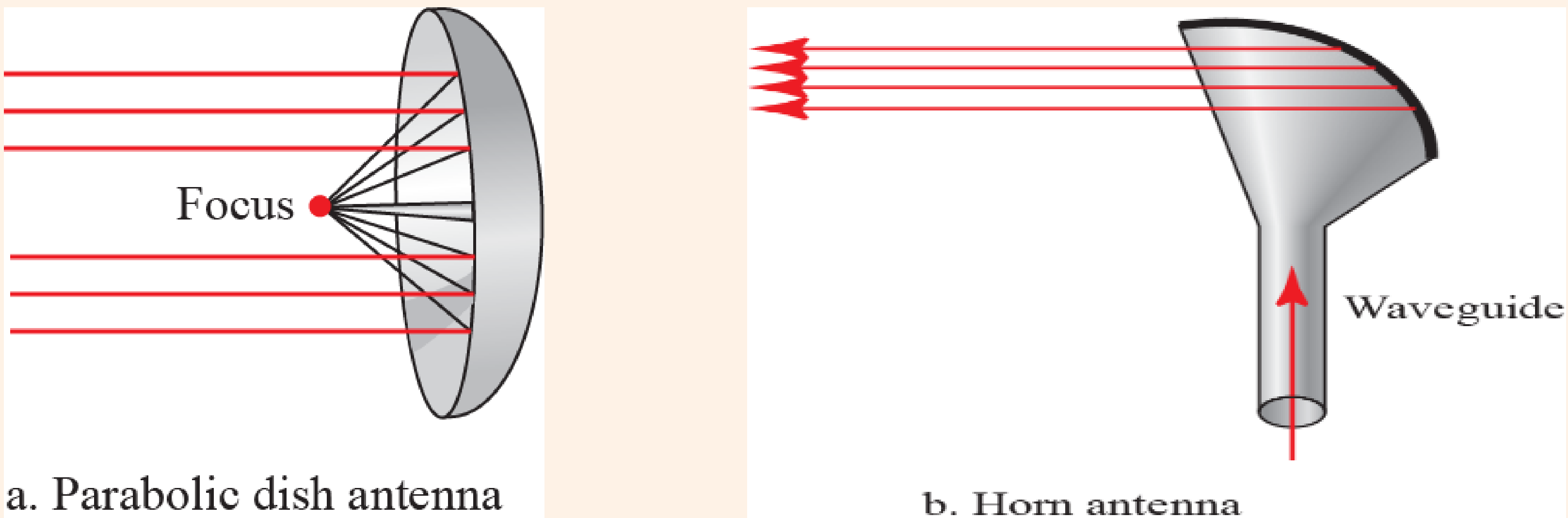


Figure 7.20: Unidirectional antenna

Infrared

Infrared waves, with frequencies from 300 GHz to 400 THz (wavelengths from 1 mm to 770 nm), can be used for short-range communication. Infrared waves, having high frequencies, cannot penetrate walls. This advantageous characteristic prevents interference between one system and another; a short-range communication system in one room cannot be affected by another system in the next room. When we use our infrared remote control, we do not interfere with the use of the remote by our neighbors.

Switching Techniques

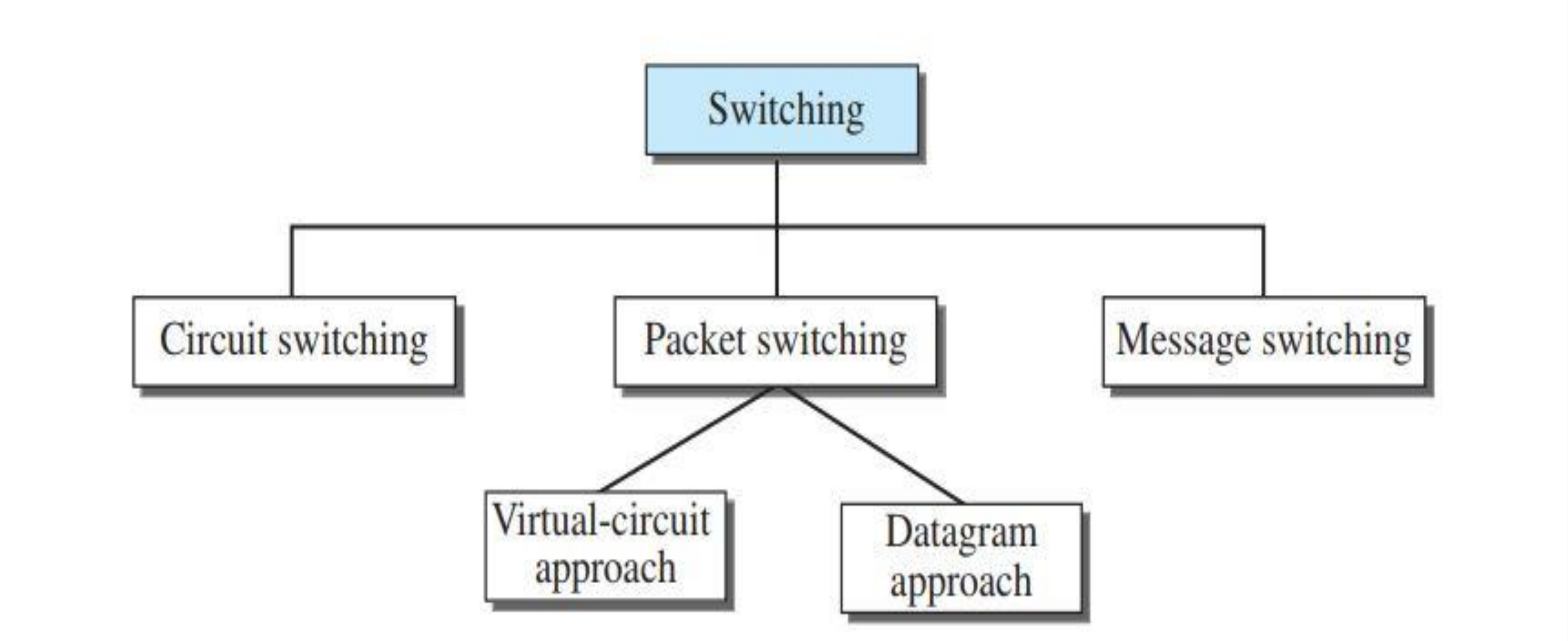


Figure : Taxonomy of switched networks

Switching and TCP/IP Layers

Switching can happen at several layers of the TCP/IP protocol suite.

Switching at Physical Layer: At the physical layer, we can have only circuit switching. There are no packets exchanged at the physical layer. The switches at the physical layer allow signals to travel in one path or another.

Switching at Data-Link Layer At the data-link layer, we can have packet switching. However, the term packet in this case means frames or cells. Packet switching at the data-link layer is normally done using a virtual-circuit approach.

Switching at Network Layer At the network layer, we can have packet switching. In this case, either a virtual-circuit approach or a datagram approach can be used. Currently the Internet uses a datagram approach, but the tendency is to move to a virtual-circuit approach.

Switching at Application Layer At the application layer, we can have only message switching. The communication at the application layer occurs by exchanging messages. Conceptually, we can say that communication using e-mail is a kind of message-switched communication, but we do not see any network that actually can be called a message-switched network.

Circuit Switched Network

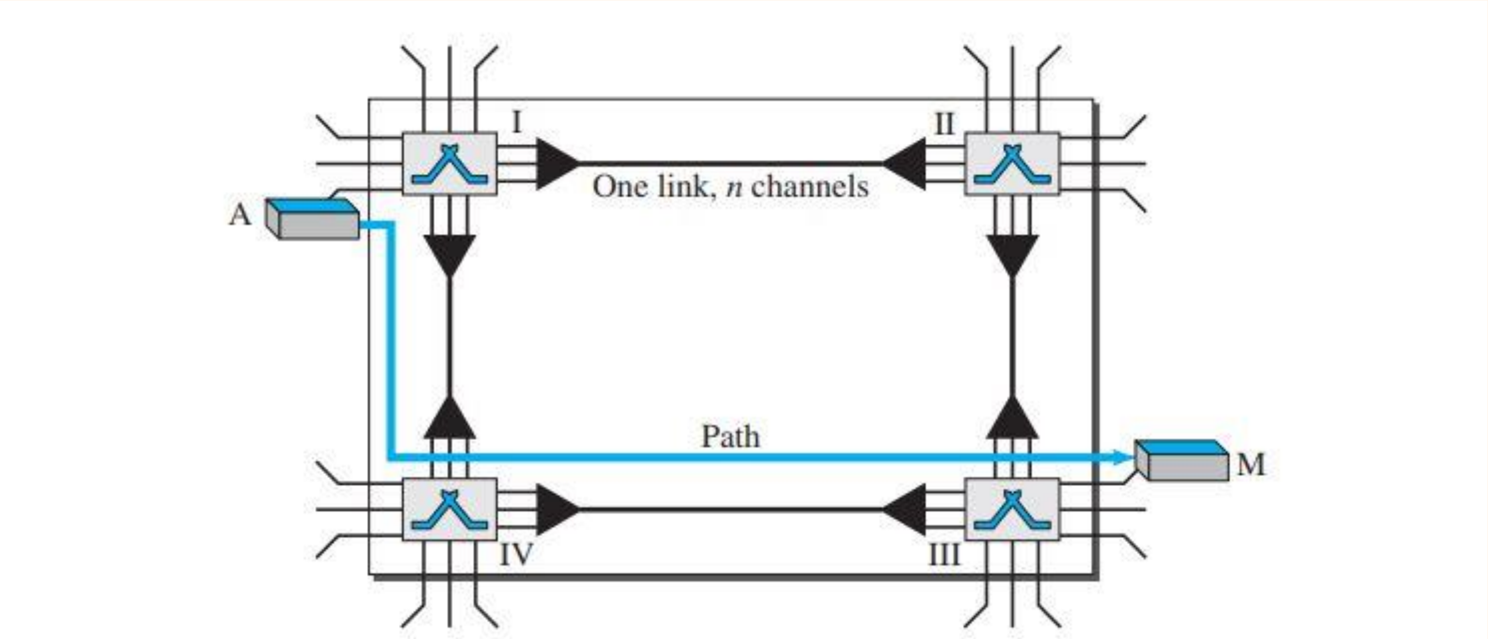


Figure: A trivial circuit-switched network

Circuit Switched Network

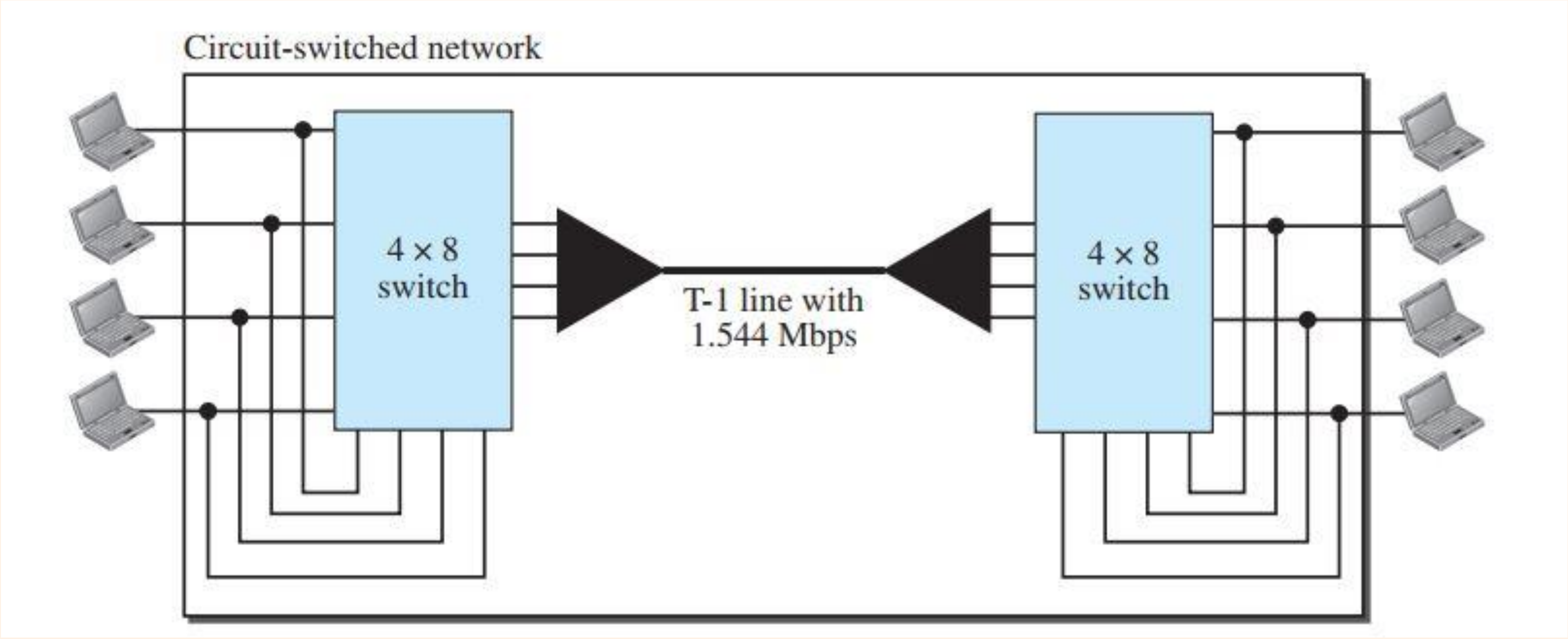


Figure: Circuit-switched network used in Example

Circuit Switched Network

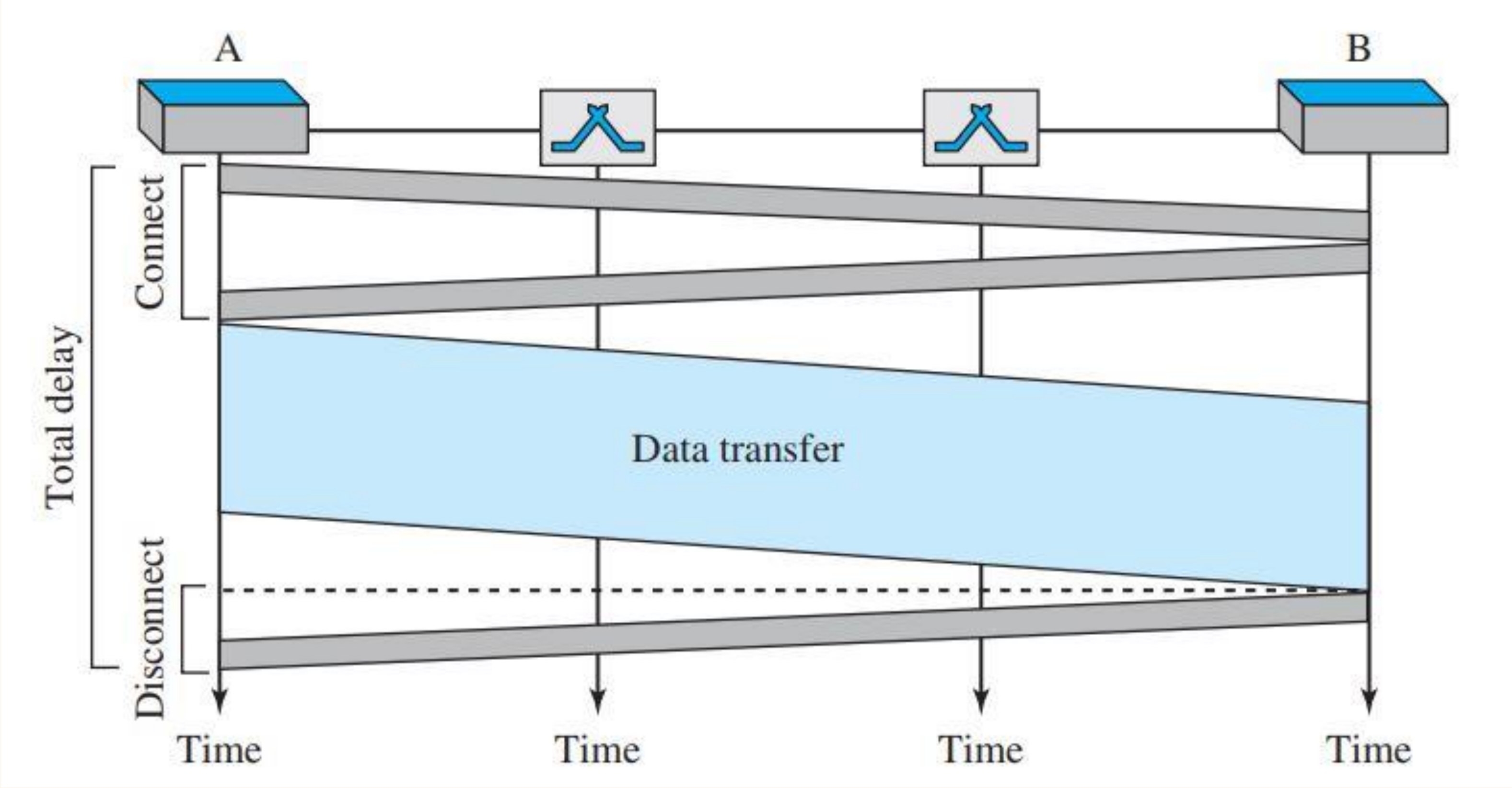


Figure: Delay in a circuit-switched network

Packet Switching

- Messages are broken into small segments of bit-sequences and they are called packets. As packets are restricted to a specific size, they can be routed more rapidly.
- Packets have the following structure:

  - Header carries control information (e.g., destination id, source id, message id, packet id, control info)

- Each packet is passed through the network from node to node along some path (**Routing**)

- At each node the entire packet is received, stored briefly, and then forwarded to the next node (**Store-and-Forward Networks**)

- Typically no storage is required at nodes/switches for packets.

Datagram Packet Switched Network

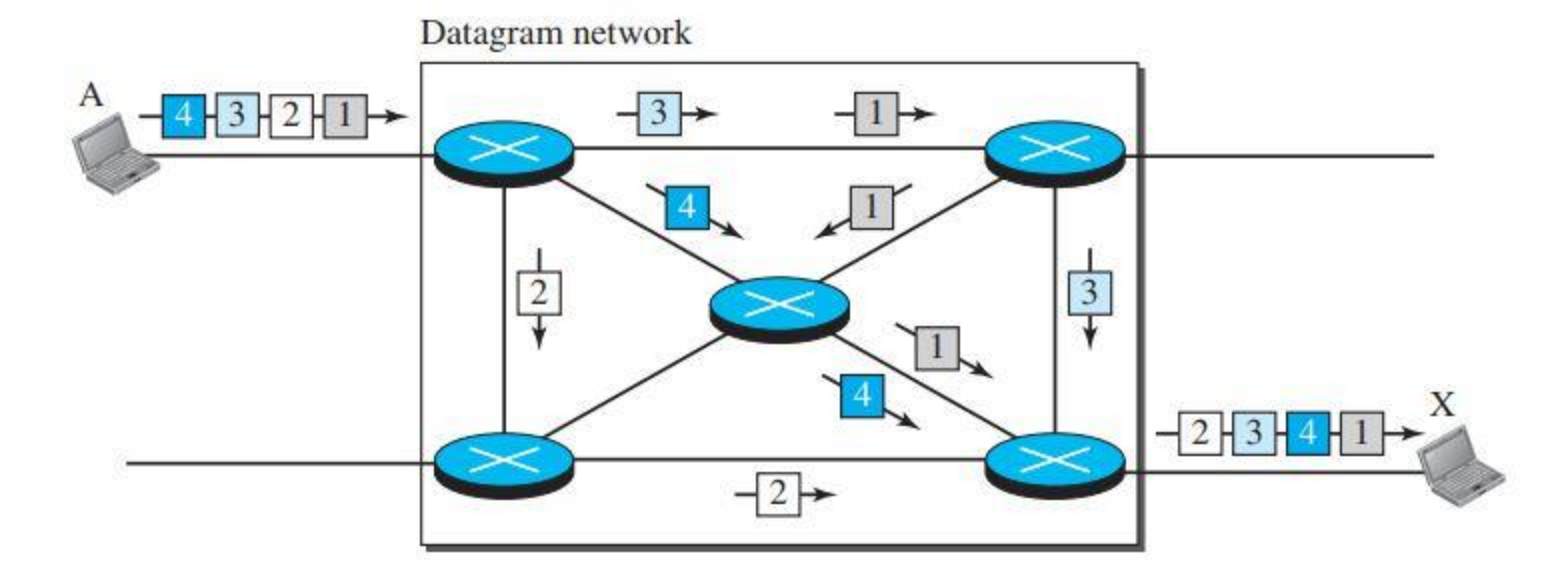


Figure: A datagram network with four switches (routers)

Datagram Packet Switched Network

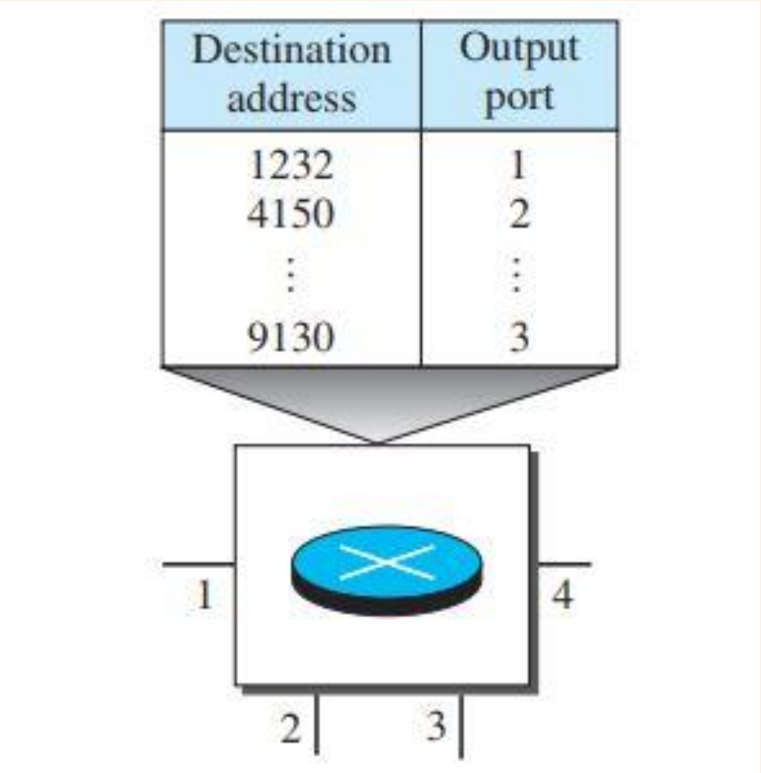
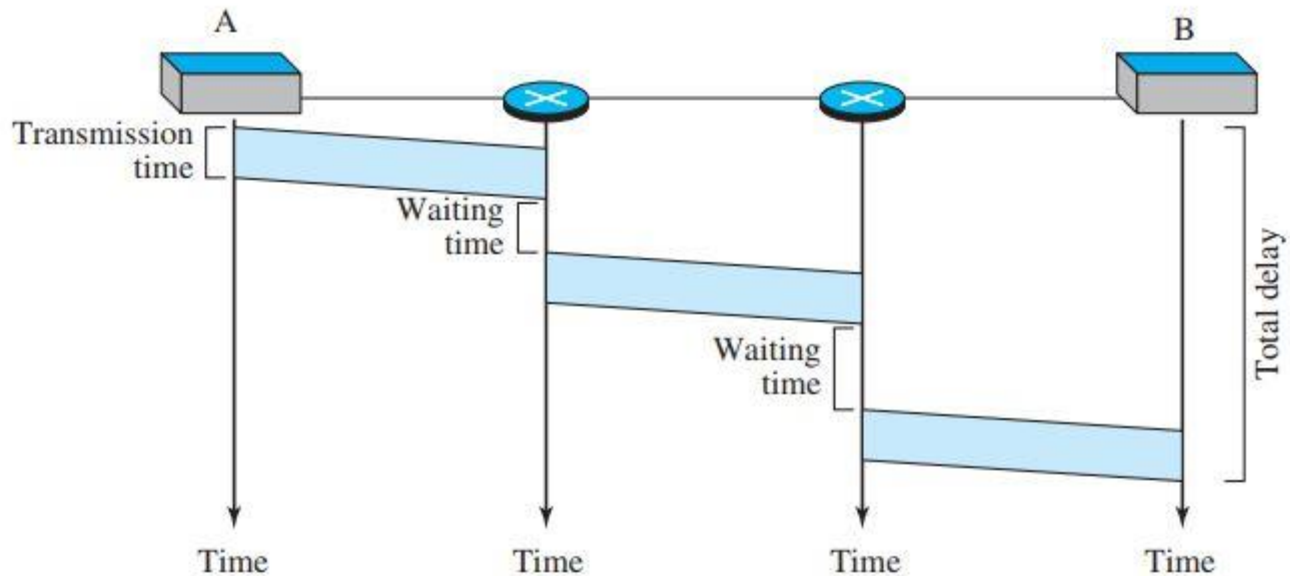


Figure: Routing table in a datagram network

- ❑ A switch in a datagram network uses a routing table that is based on the destination address.
- ❑ The destination address in the header of a packet in a datagram network remains the same during the entire journey of the packet.

Datagram Packet Switched Network



The packet travels through two switches. There are three transmission times ($3T$), three propagation delays (slopes 3τ of the lines), and two waiting times ($w_1 + w_2$). We ignore the processing time in each switch. The total delay is

$$\textbf{Total delay} = 3T + 3\tau + w_1 + w_2$$

Figure: Delay in a datagram network

Virtual Circuit Packet Switched Network

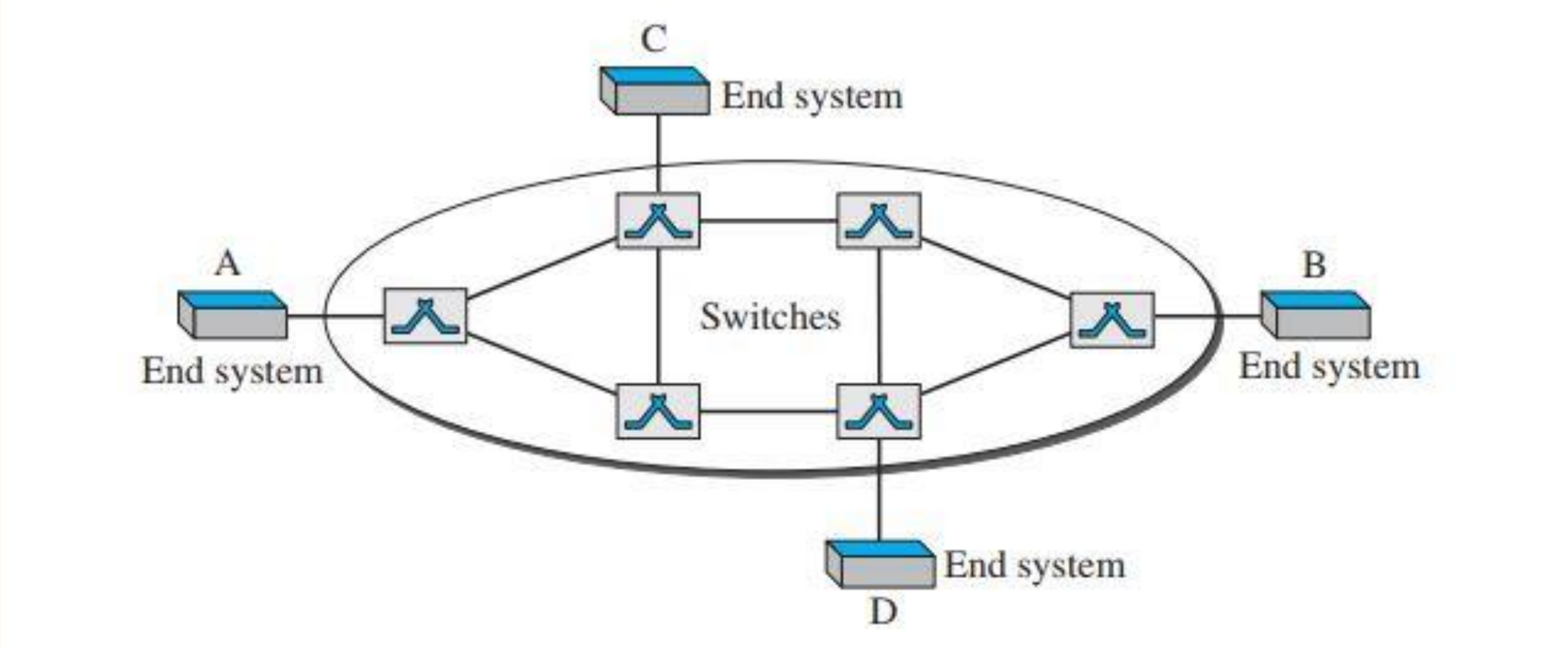


Figure: Virtual-circuit network

Virtual Circuit Packet Switched Network

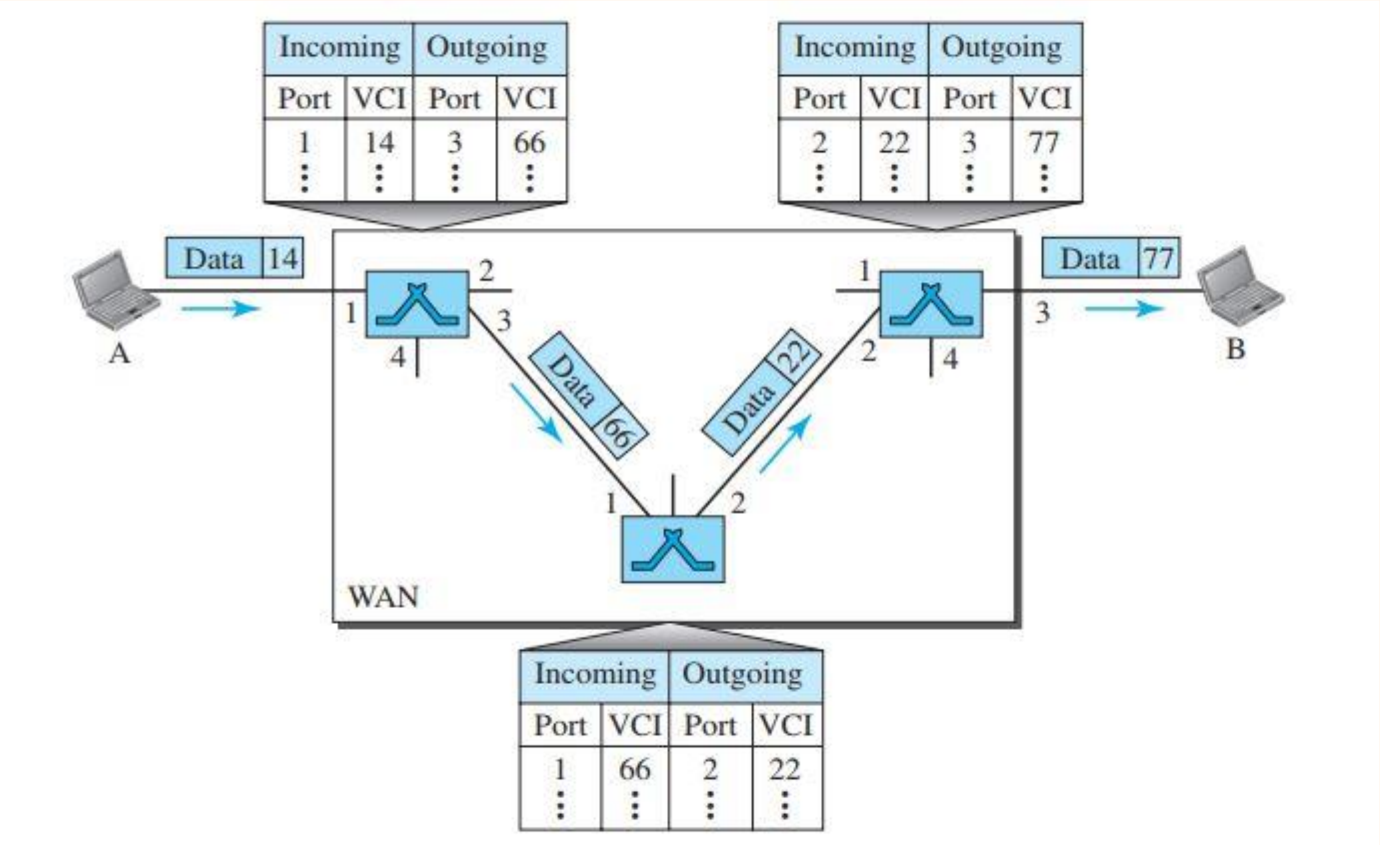


Figure: Source-to-destination data transfer in a virtual-circuit network

Virtual Circuit Packet Switched Network

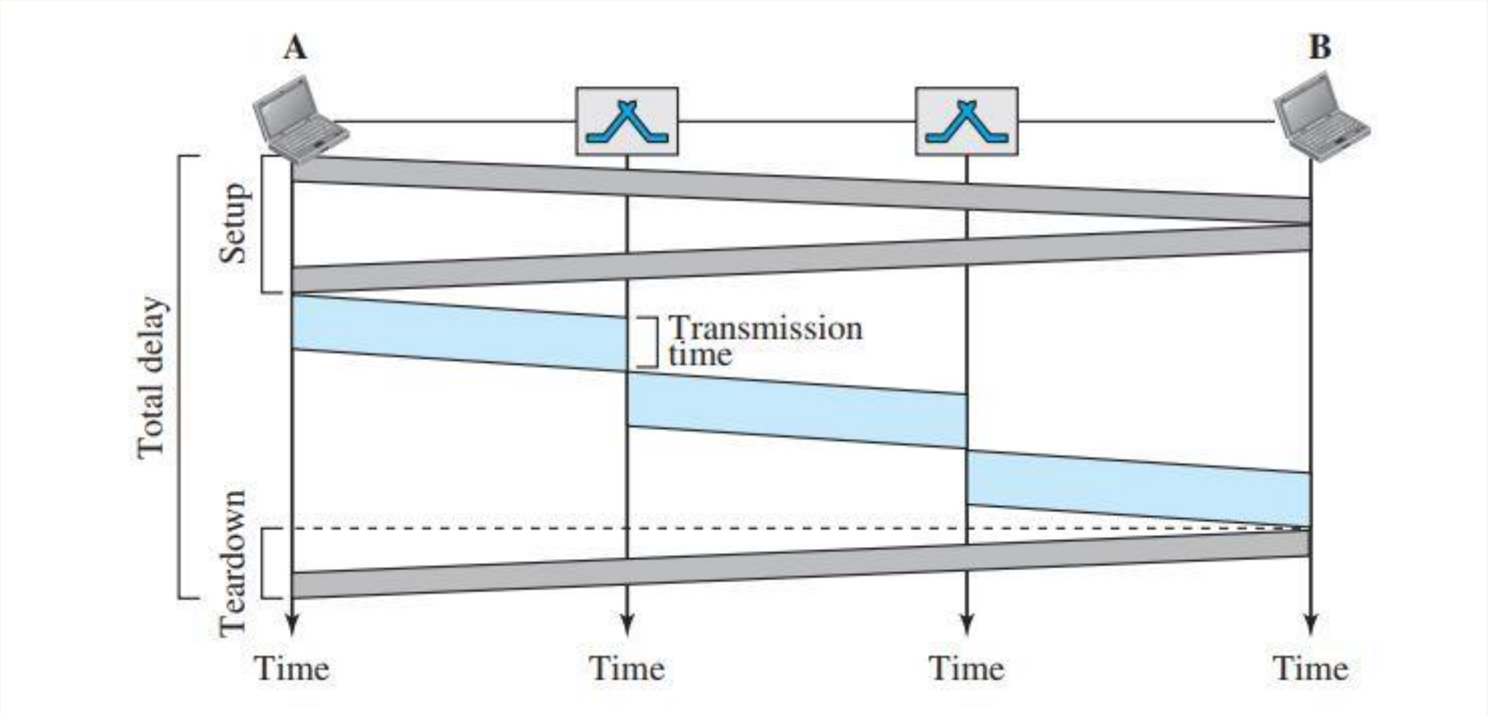


Figure: Delay in a virtual-circuit network

Books

1. Forouzan, B. A. "Data Communication and Networking. Tata McGraw." (2005).

References

1. Prakash C. Gupta, “Data communications”, Prentice Hall India Pvt.
2. William Stallings, "Data and Computer Communications”, Pearson
3. Forouzan, B. A. "Data Communication and Networking. Tata McGraw." (2005).