

# COMPUTER NETWORKS

## Text book

Behrouz A Forouzan, “Data Communications and Networking”, 5<sup>th</sup> Edition, McGrawHill, 2013, ISBN: 1-25-906475-3.

## Module 1

Data communication, Networks, Network types,  
Network models, TCP/IP suite and OSI model

## Syllabus:

- Introduction: Data communication: Components, Data representation, Data flow,
- Networks: Network criteria, Physical Structures,
- Network types: LAN, WAN, Switching, The Internet. (1.1,1.2, 1.3(1.3.1to 1.3.4 of Text)
- Network Models: Protocol Layering: Scenarios, Principles, Logical Connections,
- TCP/IP Protocol Suite: Layered Architecture, Layers in TCP/IP suite, Description of layers, Encapsulation and Decapsulation, Addressing, Multiplexing and Demultiplexing,
- The OSI Model: OSI Versus TCP/IP. (2.1, 2.2, 2.3 of Text)

## Data communications

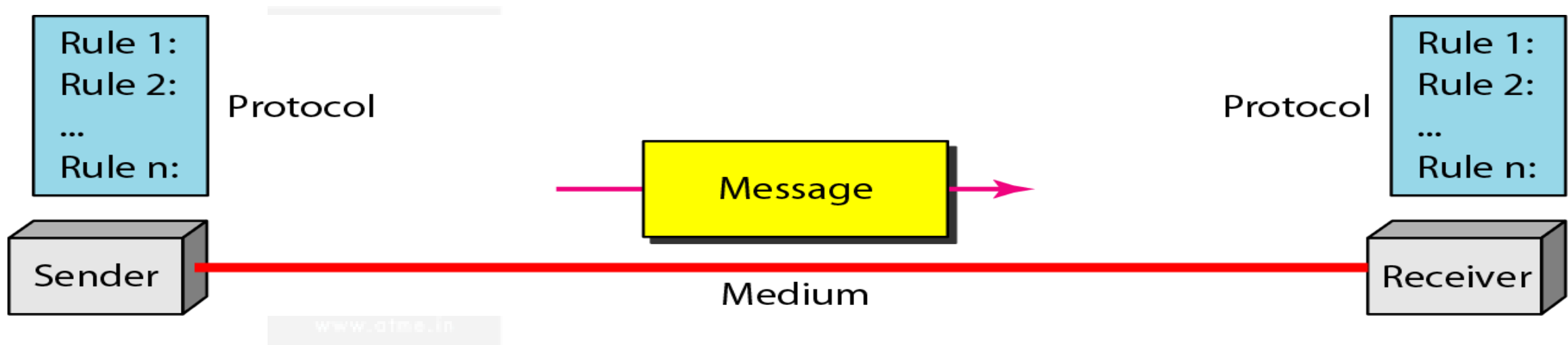
- **Data communications** are the exchange of data between two devices via some form of transmission medium such as a wire cable. For data communications to occur, the communicating devices must be part of a communication system made up of a combination of hardware (physical equipment) and software (programs).

# CHARACTERISTICS

The effectiveness of a data communications system depends on four fundamental characteristics: delivery, accuracy, timeliness, and jitter.

- **Delivery**-The system must deliver data to the correct destination. Data must be received by the intended device or user and only by that device or user.
- **Accuracy**- The system must deliver the data accurately. Data that have been altered in transmission and left uncorrected are unusable.
- **Timeliness**. The system must deliver data in a timely manner. Data delivered late are useless. In the case of video and audio, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called real-time transmission.
- **Jitter**. Jitter refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio or video packets. For example, let us assume that video packets are sent every 30 ms. If some of the packets arrive with 30-ms delay and others with 40-ms delay, an uneven quality in the video is the result.

# Components

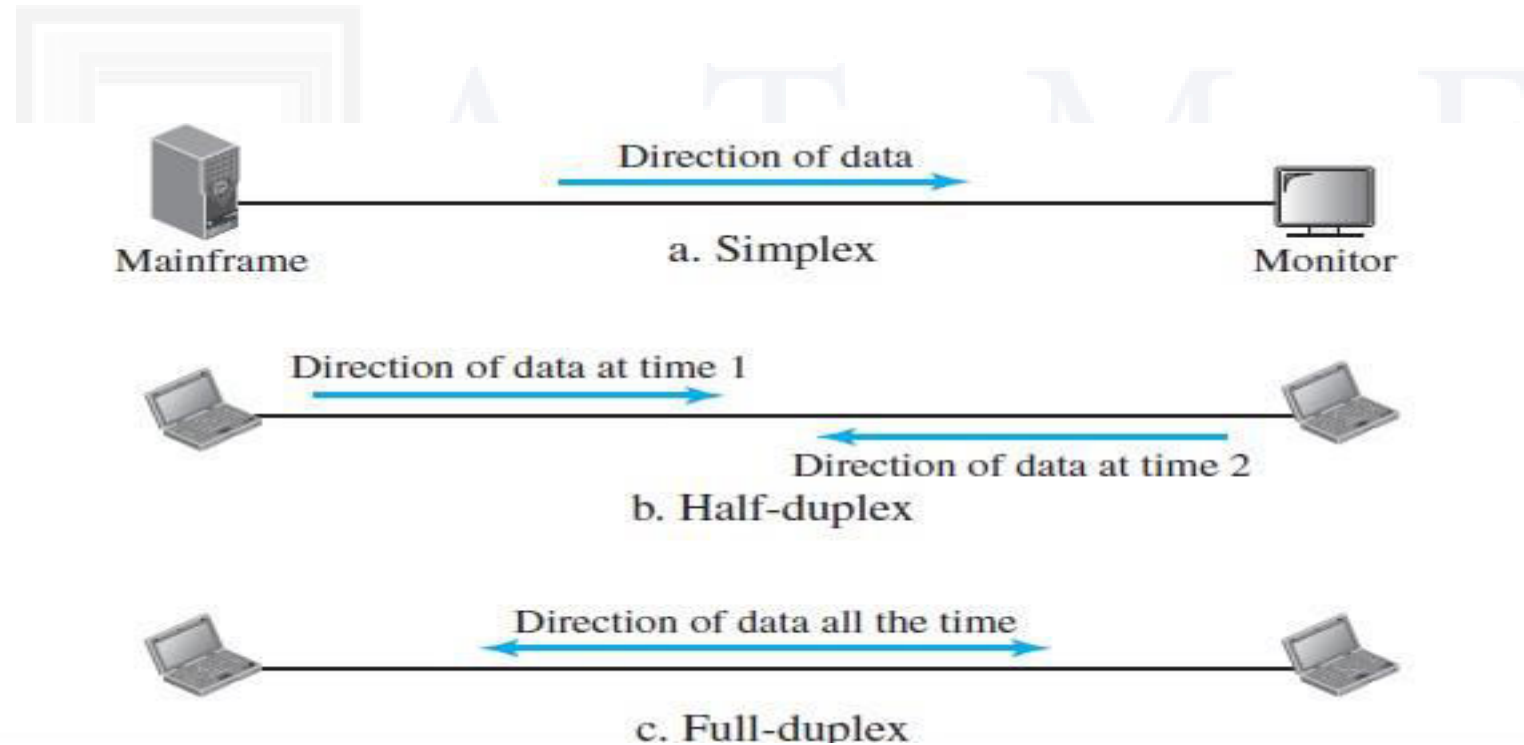


# Data Representation

- **Text** -In data communications, text is represented as a bit pattern, a sequence of bits (0s or 1s). Different sets of bit patterns have been designed to represent text symbols. Each set is called a code, and the process of representing symbols is called coding.
- **Audio**- Audio refers to the recording or broadcasting of sound or music. Audio is by nature different from text, numbers, or images. It is continuous, not discrete. Even when we use a microphone to change voice or music to an electric signal, we create a continuous signal.
- **Video**- Video refers to the recording or broadcasting of a picture or movie. Video can either be produced as a continuous entity (e.g., by a TV camera), or it can be a combination of images, each a discrete entity, arranged to convey the idea of motion.

# Data Flow

Communication between two devices can be simplex, half-duplex, or full-duplex as shown in Figure





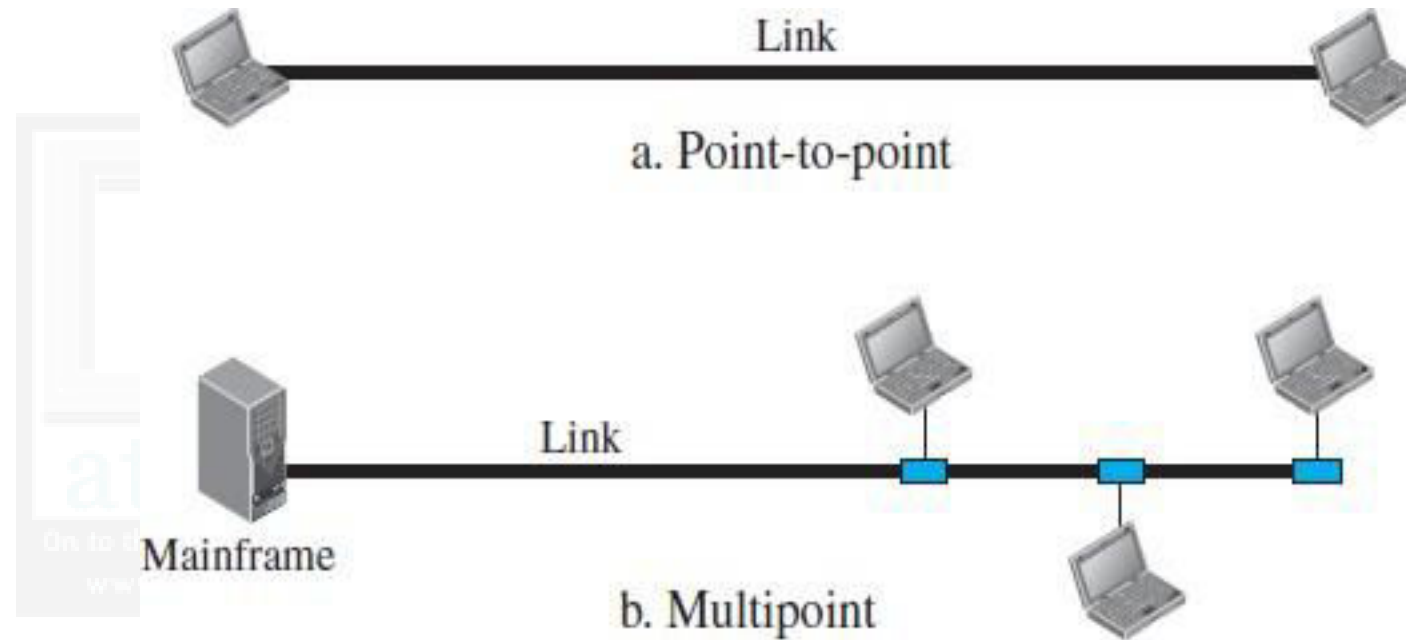
- A network is the interconnection of a set of devices capable of communication. a device can be a host (or an end system as it is sometimes called) such as a large computer, desktop, laptop, workstation, cellular phone, or security system.
- **Network Criteria-** A network must be able to meet a certain number of criteria. The most important of these are performance, reliability, and security.

A network is two or more devices connected through links. A link is a communications pathway that transfers data from one device to another.

There are two possible types of connections:

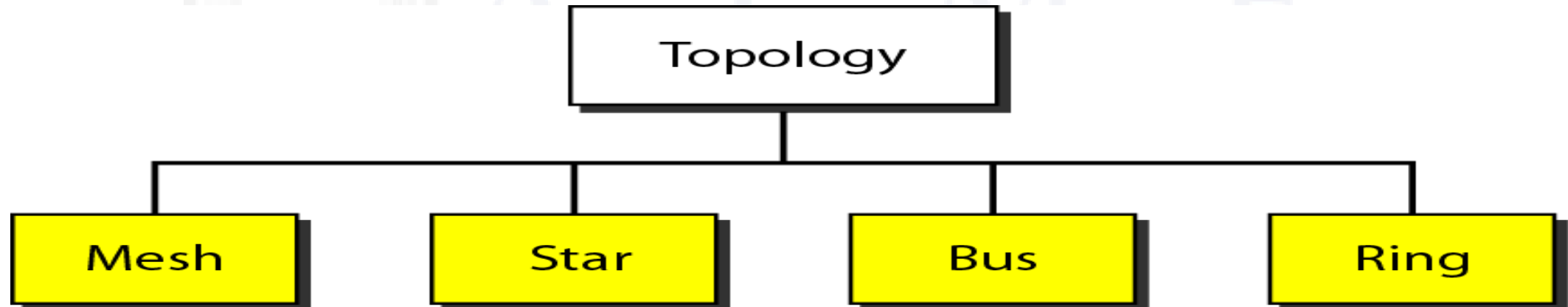
**Point-to-Point** -A point-to-point connection provides a dedicated link between two devices. The entire capacity of the link is reserved for transmission between those two devices. Most point-to-point connections use an actual length of wire or cable to connect the two ends, but other options, such as microwave or satellite links, are also possible (see Figure a).

**Multipoint** A multipoint (also called multidrop) connection is one in which more than two specific devices share a single link (see Figure b).



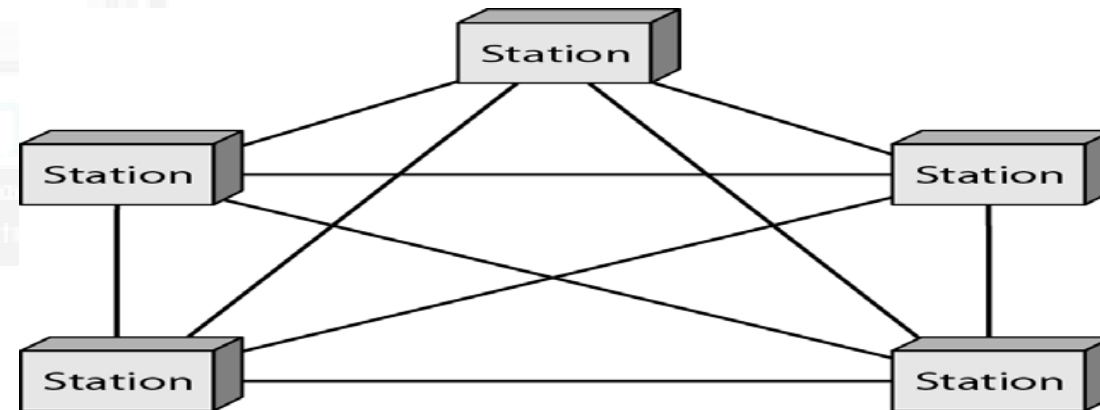
# Physical Topology

- There are four basic topologies possible: mesh, star, bus, and ring.



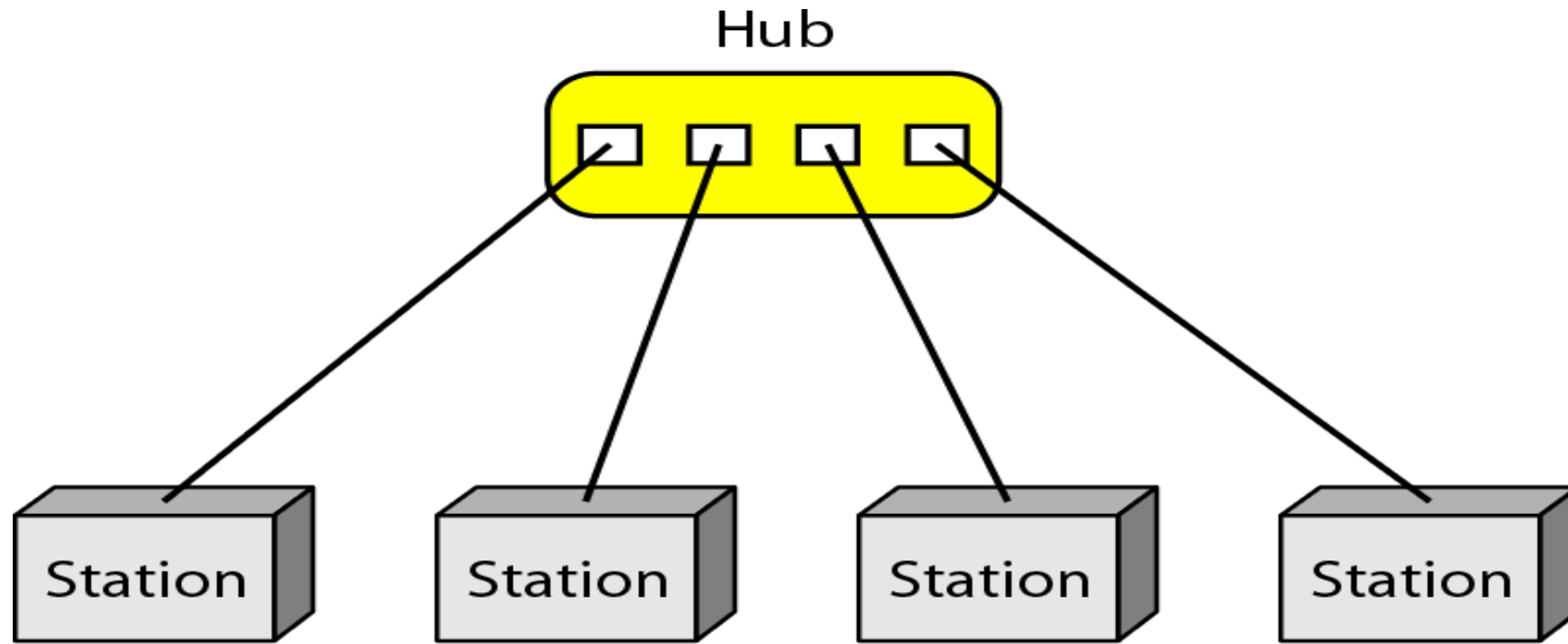
# Mesh Topology

- In a mesh topology, every device has a dedicated point-to-point link to every other device. The term dedicated means that the link carries traffic only between the two devices it connects.



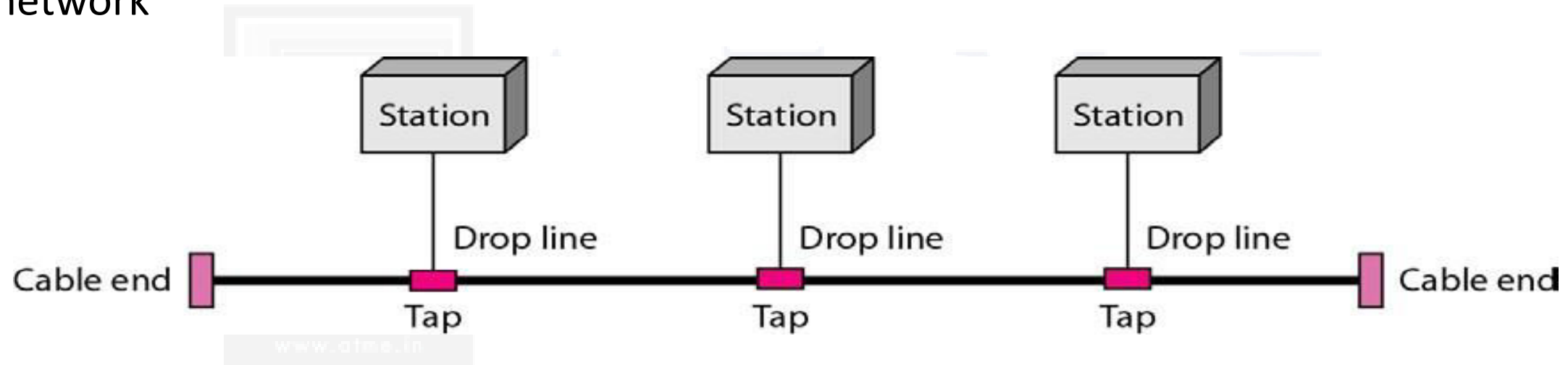
# Star Topology

- In a star topology, each device has a dedicated point-to-point link only to a central controller, usually called a hub. The devices are not directly linked to one another. A star topology does not allow direct traffic between devices. The controller acts as an exchange: If one device wants to send data to another, it sends the data to the controller, which then relays the data to the other connected device



# Bus Topology

A bus topology, is multipoint. One long cable acts as a backbone to link all the devices in a network



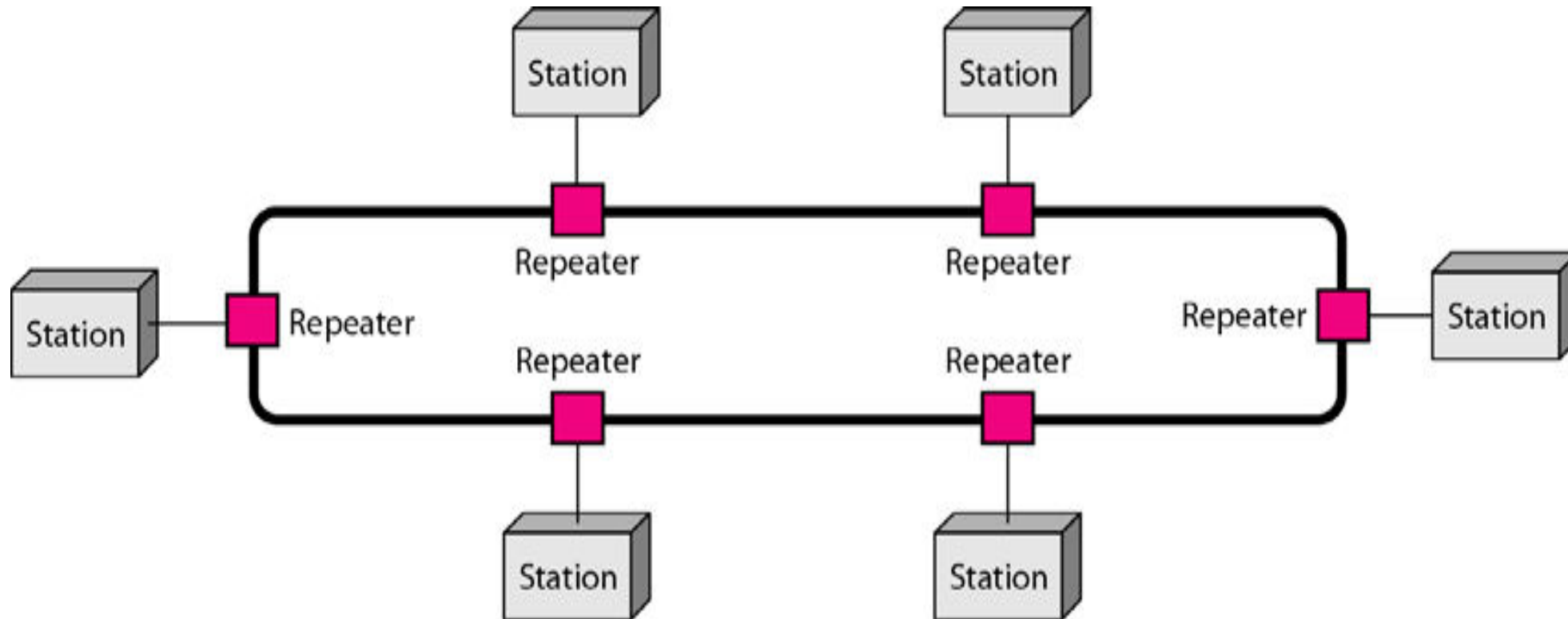
Nodes are connected to the bus cable by drop lines and taps. A drop line is a connection running between the device and the main cable.

A tap is a connector that either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core.



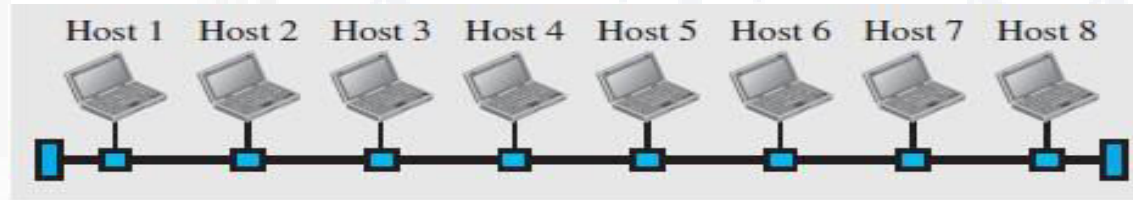
# Ring Topology

- In a ring topology, each device has a dedicated point-to-point connection with only the two devices on either side of it. A signal is passed along the ring in one direction, from device to device, until it reaches its destination.
- Each device in the ring incorporates a repeater. When a device receives a signal intended for another device, its repeater regenerates the bits and passes them along

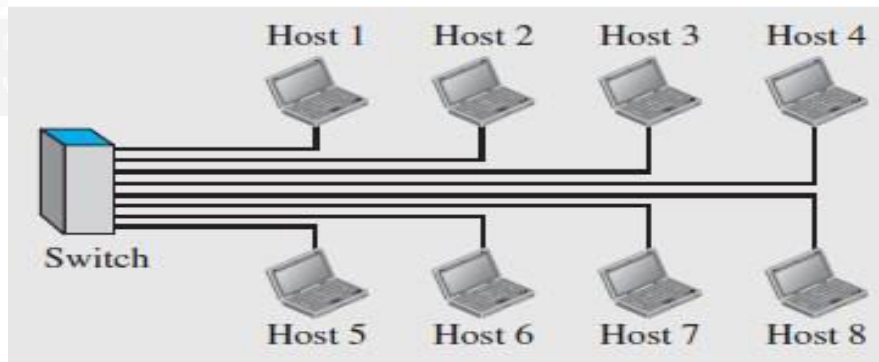


# NETWORK TYPES

## Local Area Network (LAN)-









a. LAN with a common cable (past)



b. LAN with a switch (today)

### Legend

-  A host (of any type)
-  A switch
-  A cable tap
-  A cable end
-  The common cable
-  A connection

## Wide Area Network

Legend

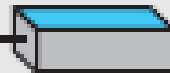


A connecting device



Connecting medium

To another  
network



To another  
network

Legend



A switch



Connecting medium

To another  
network

To another  
network

To another  
network

To another  
network

To another  
network

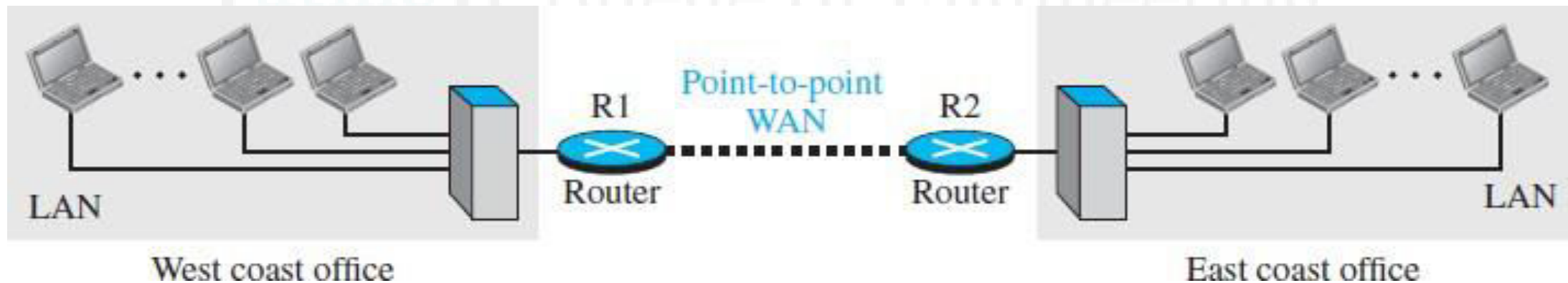
To another  
network

To another  
network

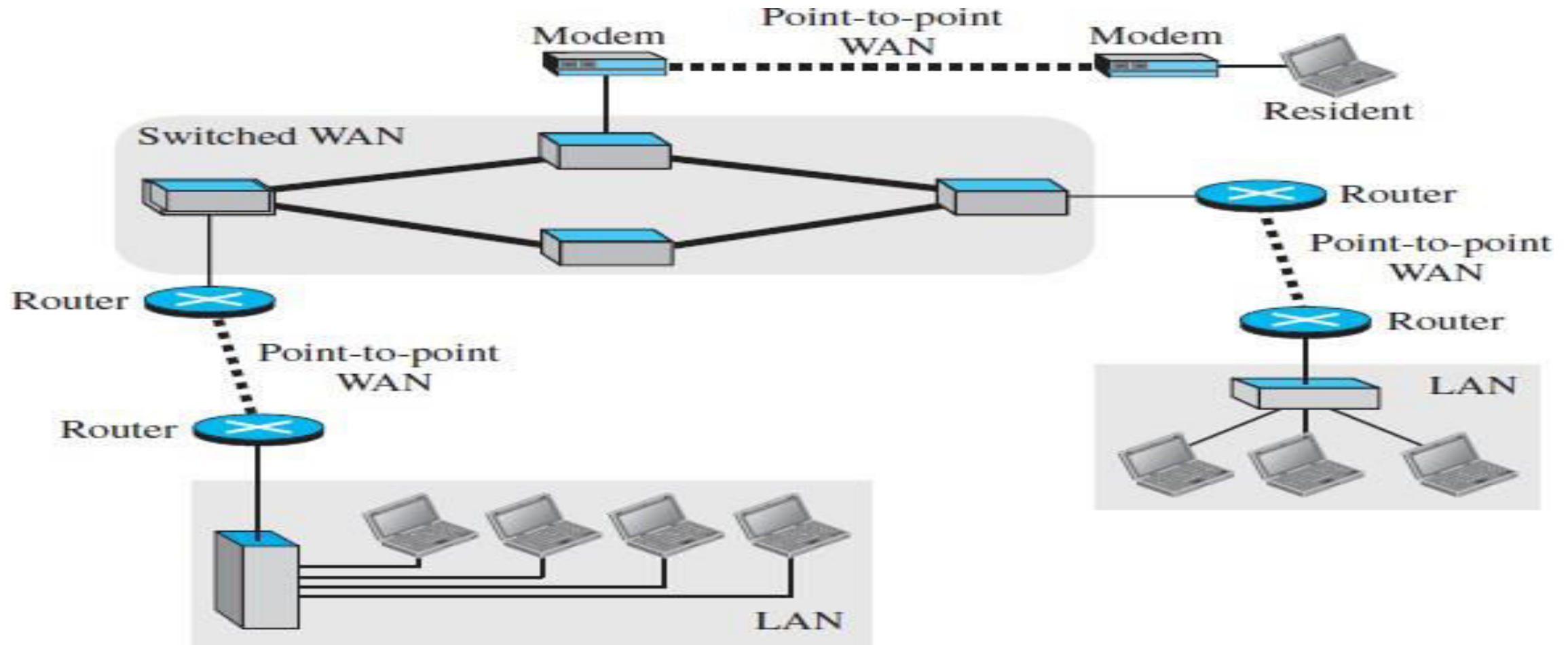
To another  
network

# Internetwork

Today, it is very rare to see a LAN or a WAN in isolation; they are connected to one another. When two or more networks are connected, they make an internetwork, or internet.



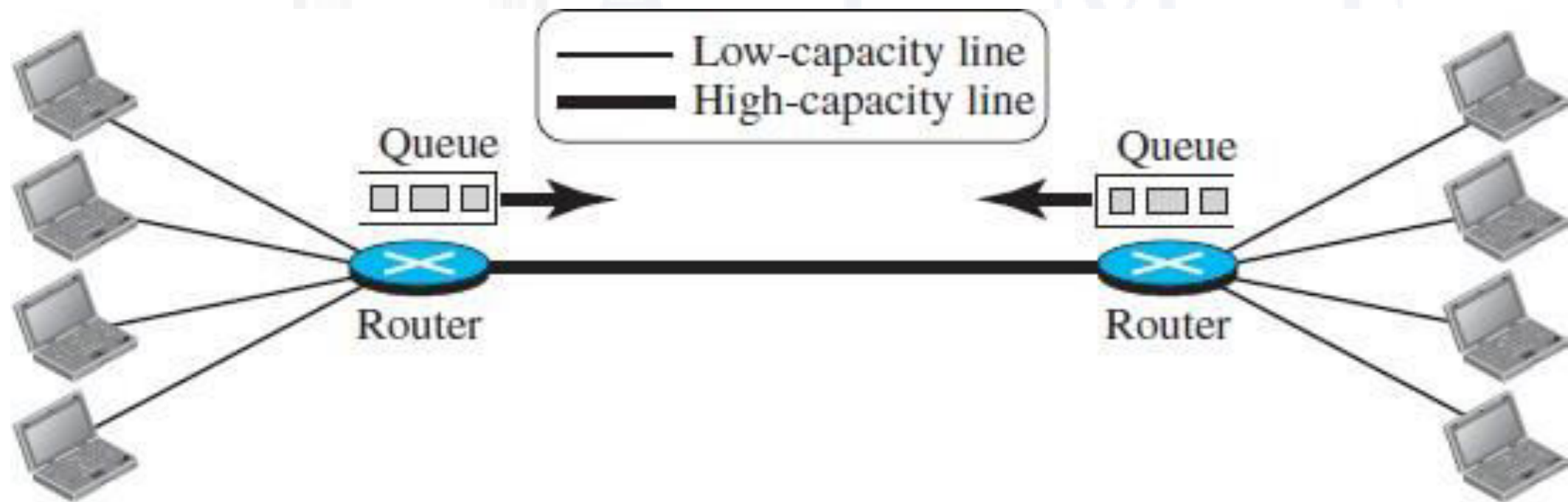
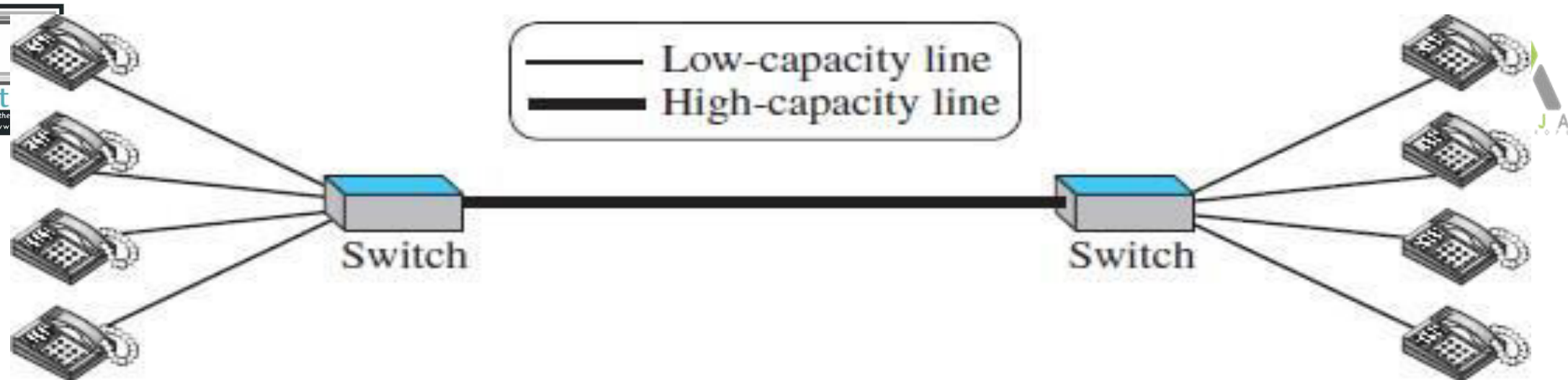
## A heterogeneous network made of four WANs and three LANs



# Switching

An internet is a switched network in which a switch connects at least two links together. A switch needs to forward data from a network to another network when required. The two most common types of switched networks are circuit-switched and packet-switched networks.

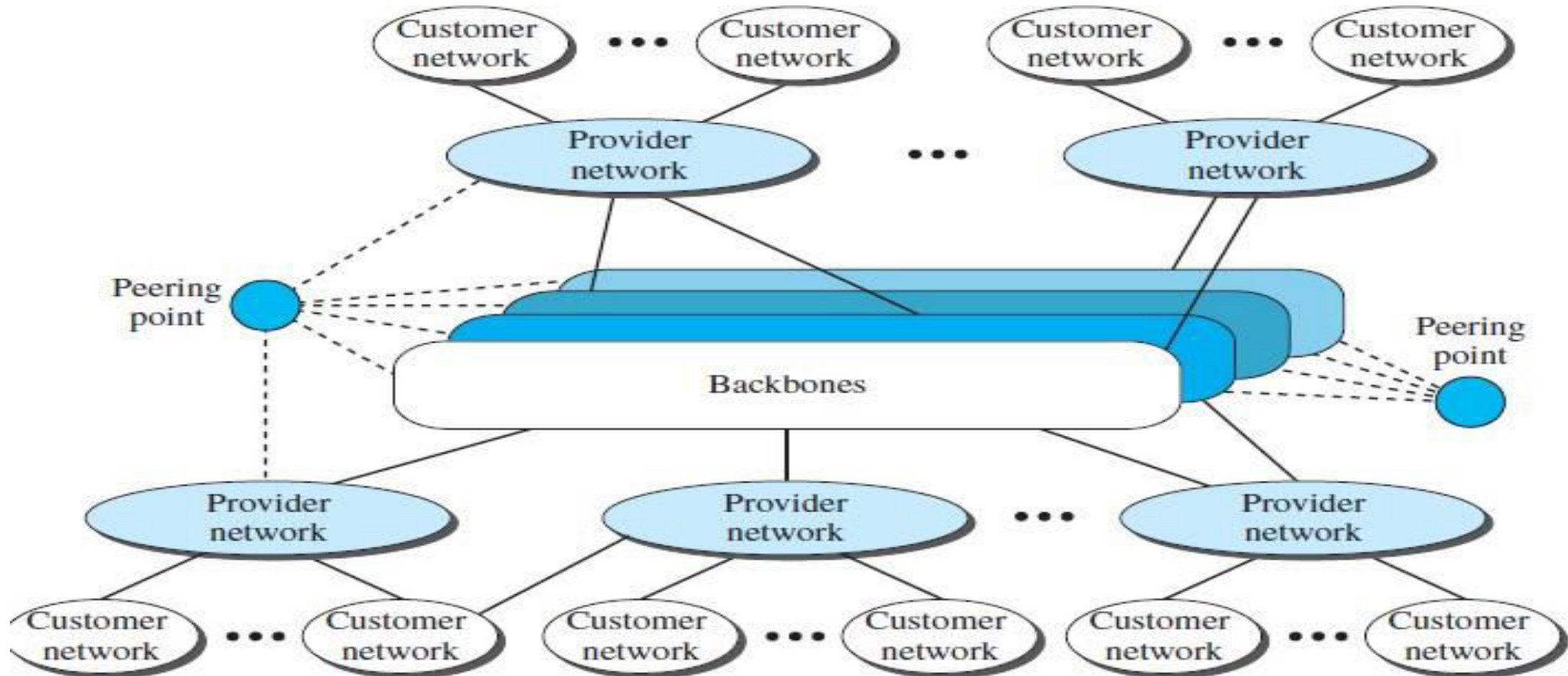






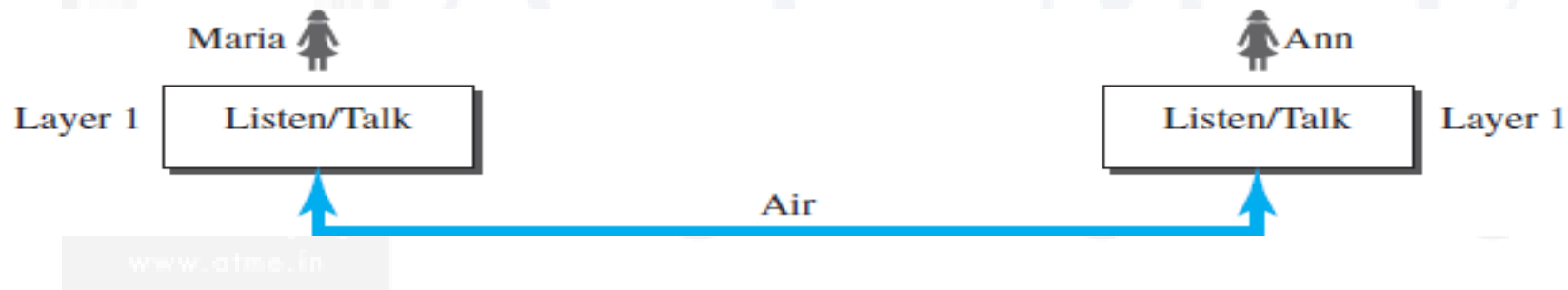
# The Internet

- An internet (note the lowercase i) is two or more networks that can communicate with each other. The most notable internet is called the Internet (uppercase I), and is composed of thousands of interconnected networks.

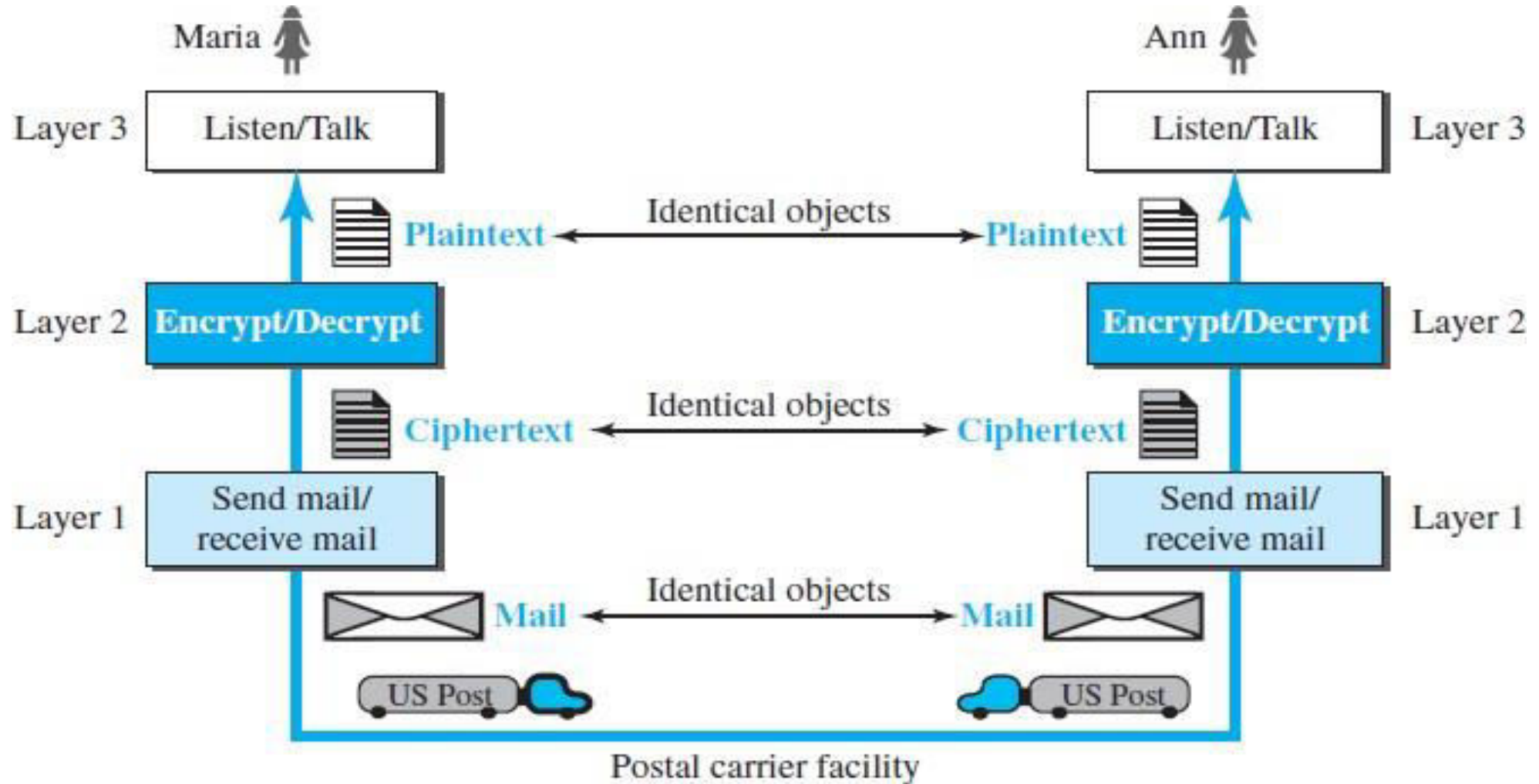


# Network Models

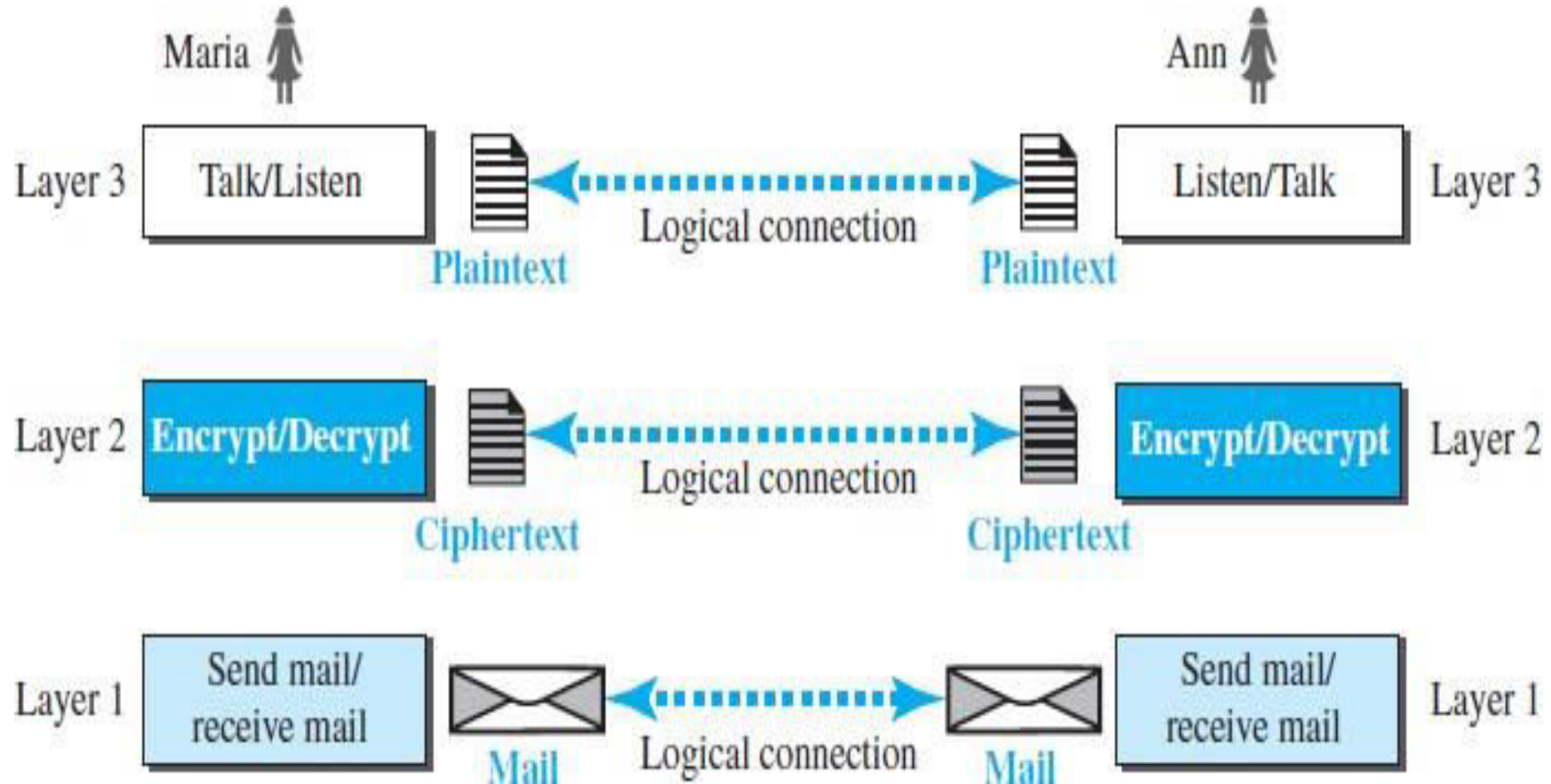
## Single layer protocol



# A three layer protocol



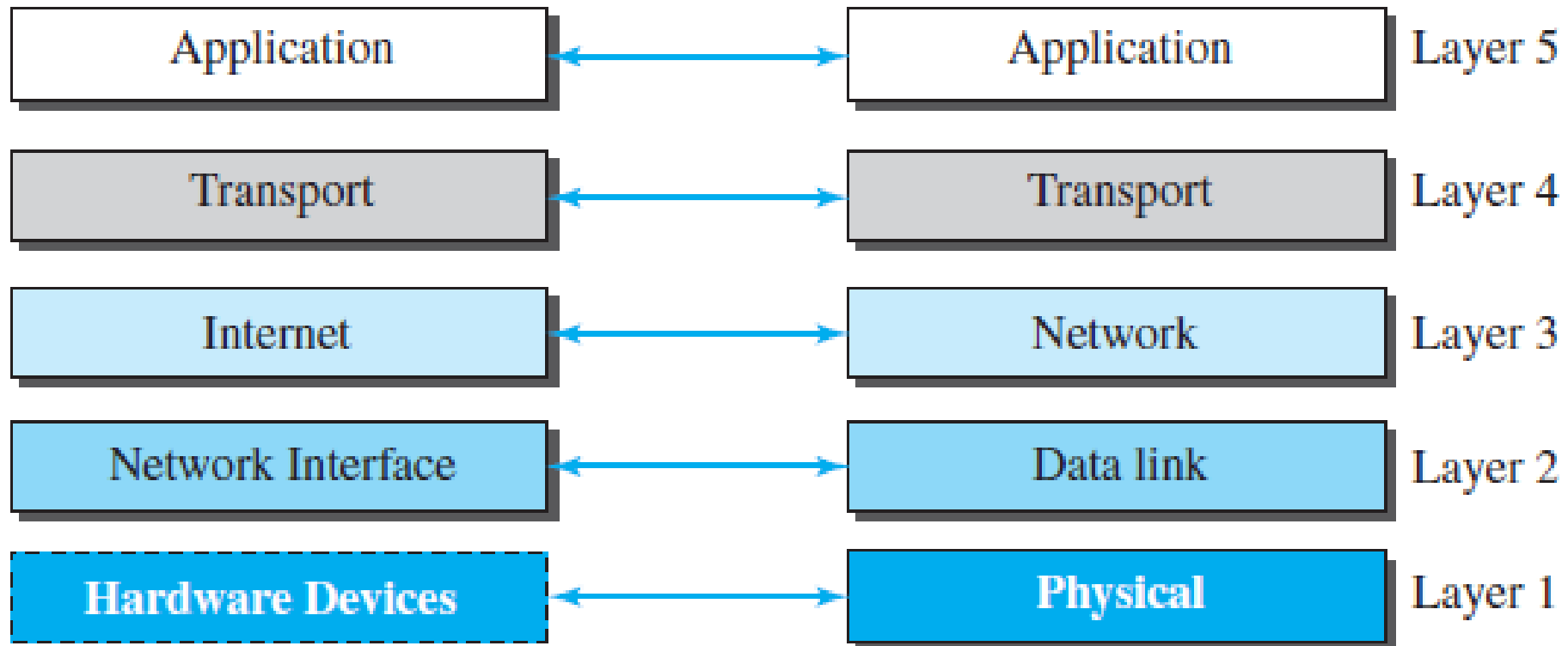
- Logical connection between peer layer



# TCP/IP PROTOCOL SUITE

- TCP/IP is a protocol suite (a set of protocols organized in different layers) used in the Internet today. It is a hierarchical protocol made up of interactive modules, each of which provides a specific functionality. The term hierarchical means that each upper level protocol is supported by the services provided by one or more lower level protocols. The original TCP/IP protocol suite was defined as four software layers built upon the hardware.

# Layered Architecture

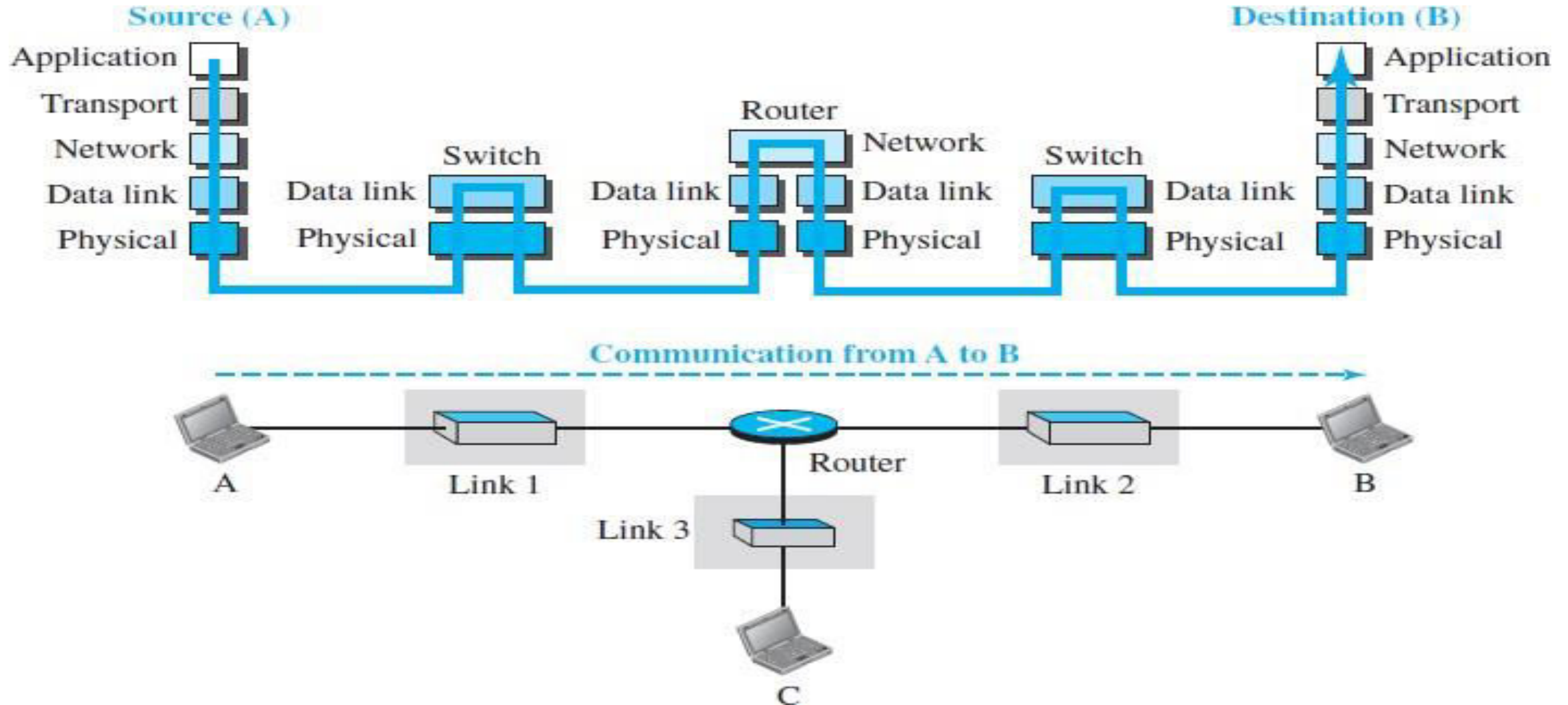


a. Original layers

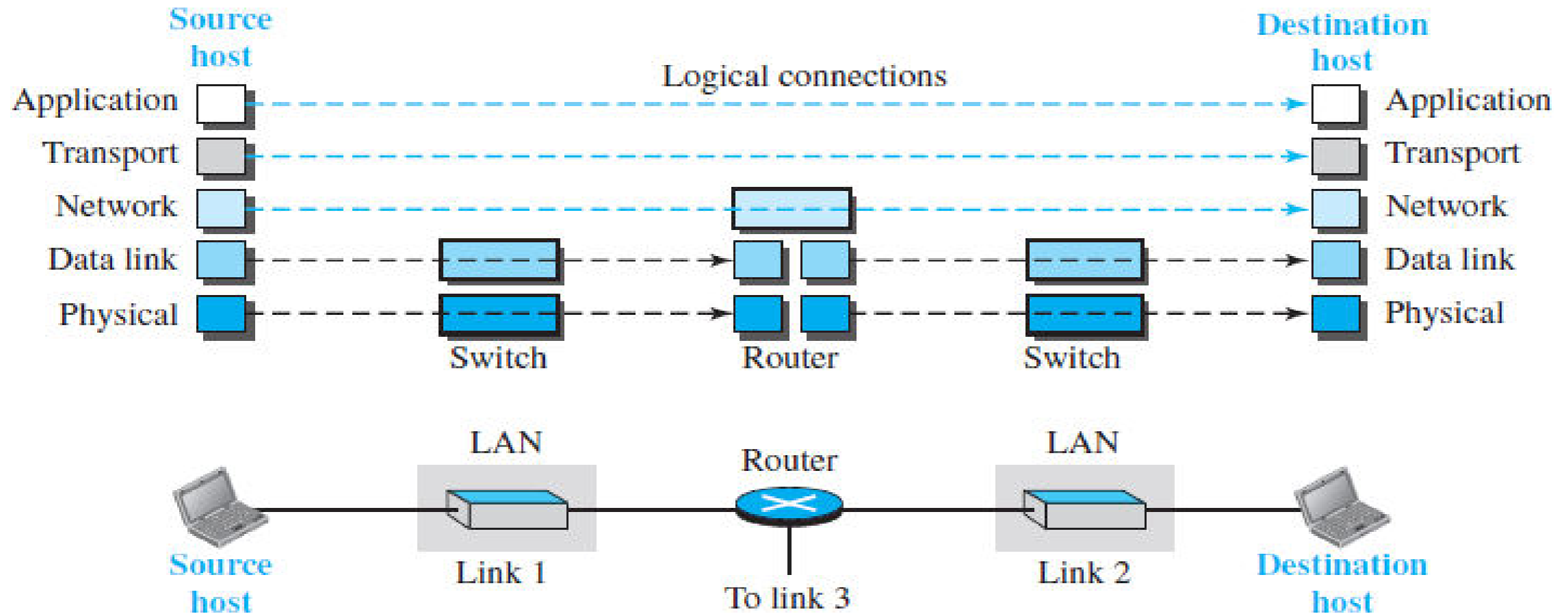
b. Layers used in this book



## Communication through an internet

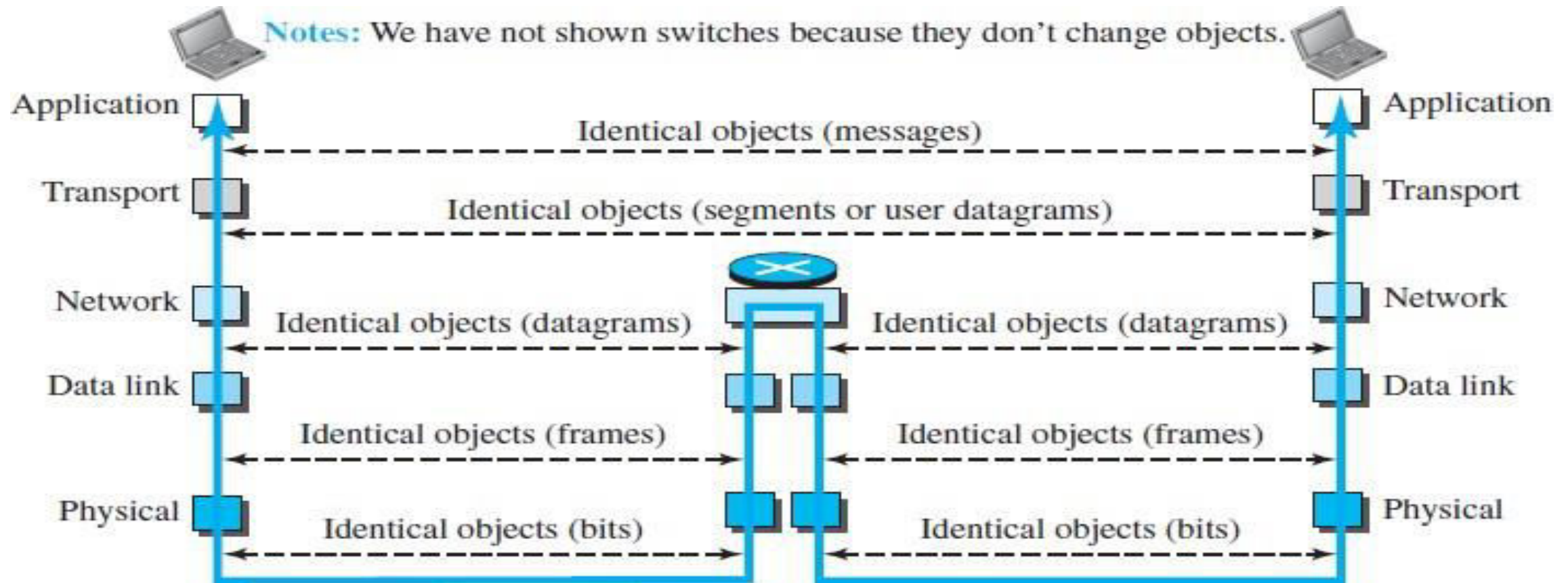


# Layers in the TCP/IP Protocol Suite





# Identical objects in the TCP/IP protocol suite



# Physical Layer

- Physical layer is responsible for **carrying individual bits** in a frame across the link. Although the physical layer is the lowest level in the TCP/IP protocol suite, the communication between two devices at the physical layer is still a logical communication because there is another, hidden layer, the transmission media, under the physical layer.
- Two devices are connected by a transmission medium (cable or air). Transmission medium does not carry bits, **it carries electrical or optical signals**. So the bits received in a frame from the data-link layer are transformed and sent through the transmission media, but we can think that the logical unit between two physical layers in two devices is a bit. There are several protocols that transform a bit to a signal.
- The physical layer of TCP/IP describes hardware standards such as IEEE 802.3, the specification for Ethernet network media, and RS-232, the specification for standard pin connectors.

# Data-link Layer

- Internet is made up of several links (LANs and WANs) connected by routers. The data-link layer is responsible for taking the datagram and moving it across the link.(node to node communication)
- The link can be a wired LAN with a link-layer switch, a wireless LAN, a wired WAN, or a wireless WAN. We can also have different protocols used with any link type.
- In each case, the data-link layer is responsible for moving the packet through the link. TCP/IP does not define any specific protocol for the data-link layer. It supports all the standard and proprietary protocols. The data-link layer takes a datagram and encapsulates it in a packet called a frame.
- Each link-layer protocol provide a different service like framing, Flow control, Error control and congestion control.

# Network Layer

- The network layer is responsible for creating a connection between the source computer and the destination computer. The communication at the network layer is **host-to-host**. However, since there can be several routers from the source to the destination, the routers in the path are responsible for choosing the **best route** for each packet.
- **The network layer is responsible packetizing and routing and forwarding the packet through possible routes. others services are error and flow control, congestion control.**
- The network layer in the Internet includes the main protocol, Internet Protocol (IP), that defines the format of the packet, **called a datagram** at the network layer. IP also defines the format and the structure of addresses used in this layer.

# Transport Layer

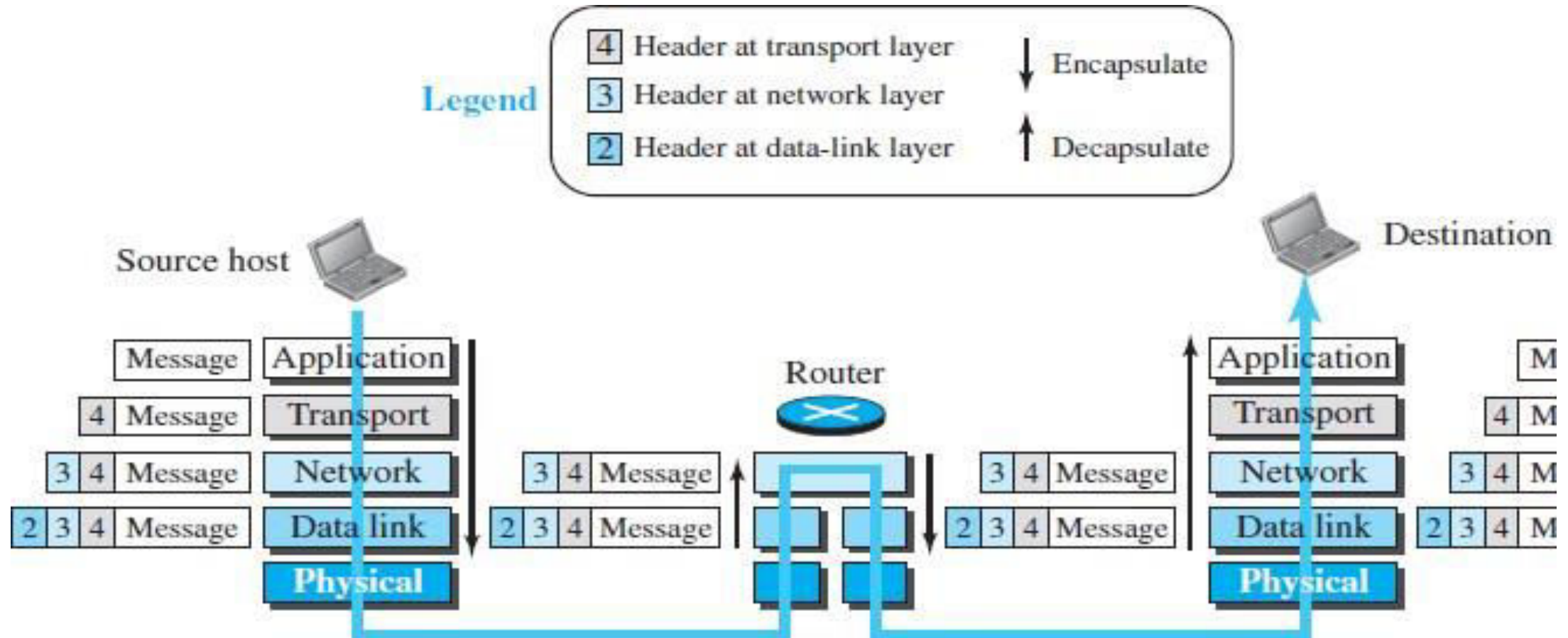
- The logical connection at the transport layer is also end-to-end. The transport layer at the source host gets the message from the application layer, encapsulates it in a transport layer packet (called a segment or a user datagram in different protocols) and sends it, through the logical (imaginary) connection, to the transport layer at the destination host.
- The transport layer is responsible for giving services to the application layer: to get a message from an application program running on the source host and deliver it to the corresponding application program on the destination host. (**process to process communication**)

# Application Layer

- The logical connection between the two application layers is end to-end. The two application layers exchange messages between each other as though there were a bridge between the two layers. However, communication is done through all the layers.
- Communication at the application layer is between two processes (two programs running at this layer). To communicate, a process sends a request to the other process and receives a response. Process-to-process communication is the duty of the application layer.



# Encapsulation and Decapsulation

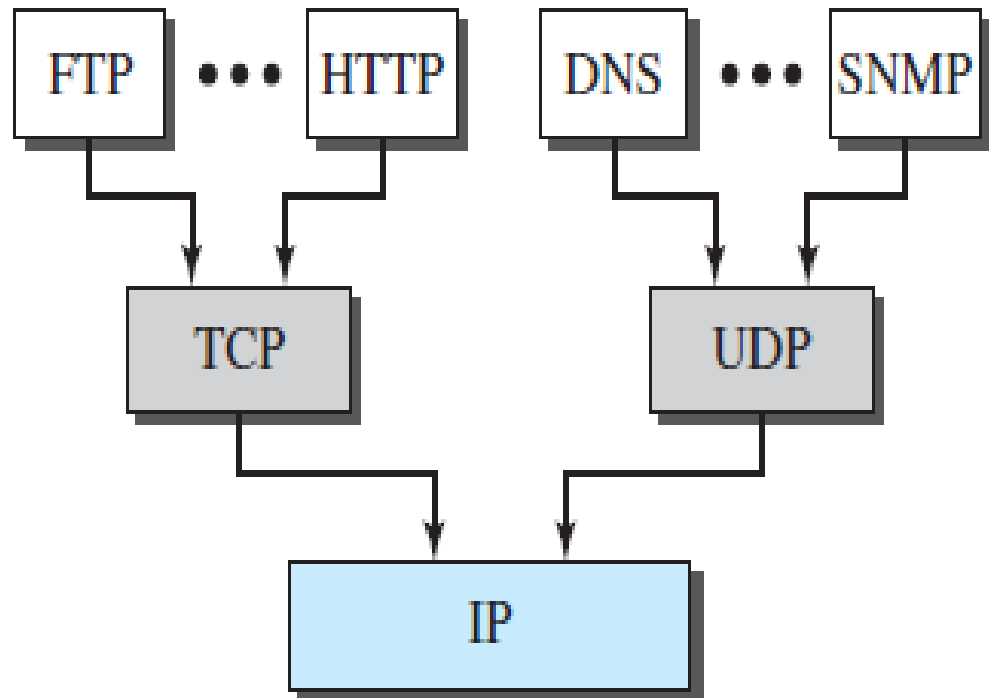


# Addressing

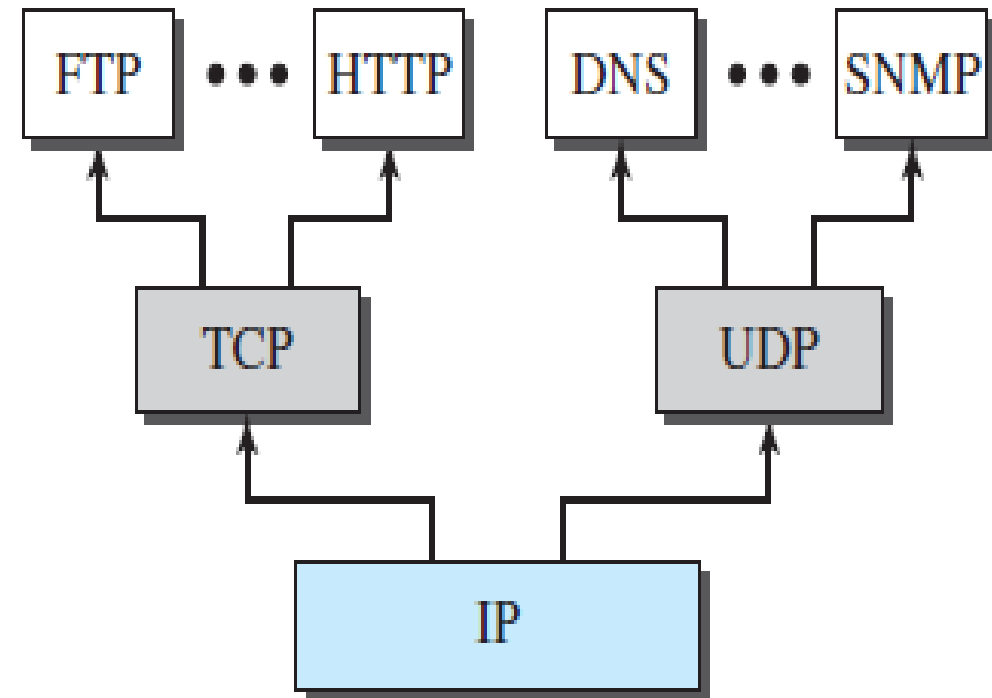
Packet names	Layers	Addresses
Message	Application layer	Names
Segment / User datagram	Transport layer	Port numbers
Datagram	Network layer	Logical addresses
Frame	Data-link layer	Link-layer addresses
Bits	Physical layer	



# Multiplexing and Demultiplexing



a. Multiplexing at source



b. Demultiplexing at destination

# THE OSI MODEL

- An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model. It was first introduced in the late 1970s. An open system is a set of protocols that allows any two different systems to communicate regardless of their underlying architecture.
- The purpose of the OSI model is to show how to facilitate communication between different systems without requiring changes to the logic of the underlying hardware and software. The **OSI model is not a protocol**; it is a model for understanding and designing a network architecture that is flexible, robust, and interoperable. The OSI model was intended to be the basis for the creation of the protocols in the OSI stack. The OSI model is a layered framework for the design of network systems that allows communication between all types of computer systems.

Layer 7

Application

Layer 6

Presentation

Layer 5

Session

Layer 4

Transport

Layer 3

Network

Layer 2

Data link

Layer 1

Physical

# OSI Model v/s TCP/IP

