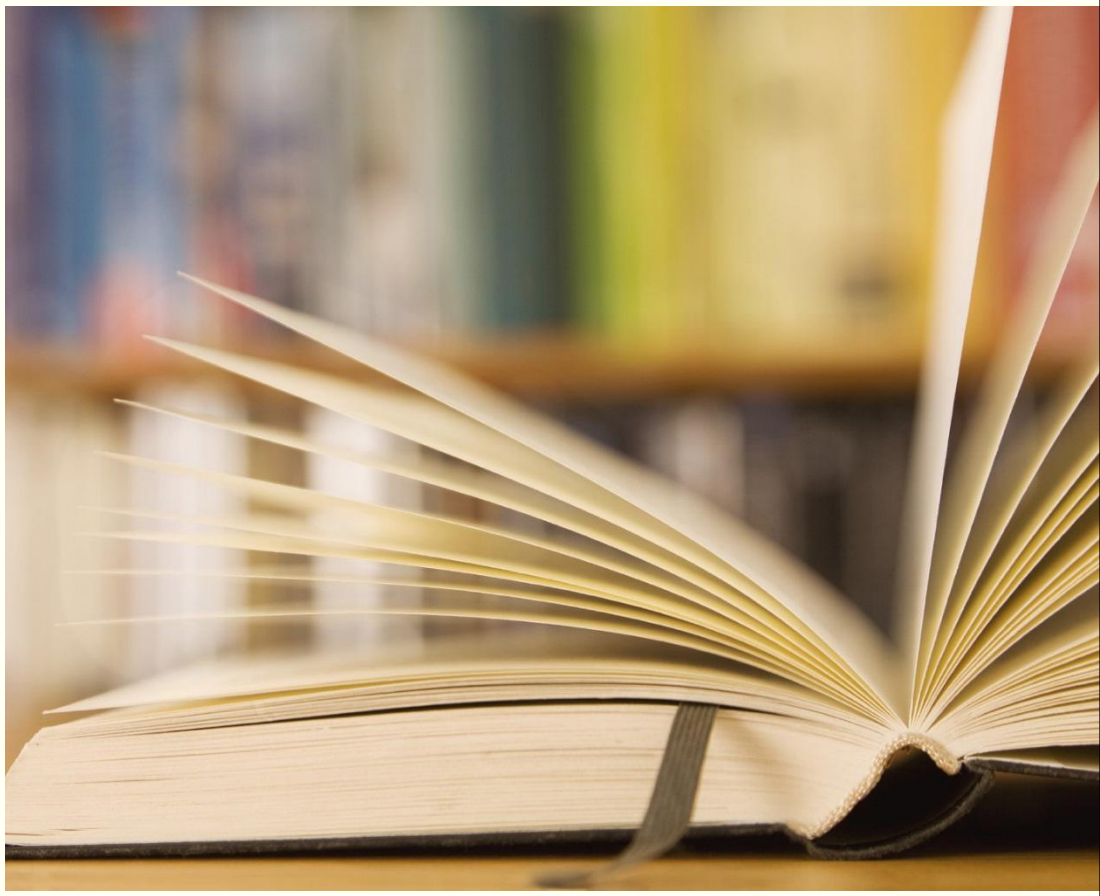
4. COMPUTER NETWORKS AND INTERNET



Content

- 4.1 Overview
  - LAN & WAN
  - TCP/IP protocol
- 4.2 Layers in netwoking

Objectives

After studying this chapter, the student should be able to:

- Describe local and wide area networks (LANs and WANs).
- Distinguish an Internet from the Internet.
- Describe the TCP/IP protocol suite as the network model in the Internet.
- Define the layers in the TCP/IP protocol suite and their relationship.
- Describe the applications in the Internet.
- Describe the different transmission media used in computer networking.

1-OVERVIEW

1. Introduction

- **A network is defined as the interconnection of a set of devices capable of communication.**
- A device can be a host (or an end system) such as a large computer, desktop, laptop, workstation, cellular phone, or security system.
- A device cab be also be a connecting device such as a **router** which connects the network to other networks, a switch which connects devices together, a modem that changes the form of data, and so on.
- These devices in a network are connected using wired or wireless transmission media such as cable or air. **Networks**

Figure 4.1 A simple network today

2. Local Area Network (LAN)

- **A LAN is usually privately owned and connects some hosts in a single office, building, or campus**.
- A LAN can be as simple as two PCs and a printer in someone's home office, or it can extend throughout a company and include audio and video devices.
- Each host in a LAN has an identifier, an address, that uniquely defines the host in the LAN.
- A packet sent by a host to another host carries both the source host's and the destination host's addresses.

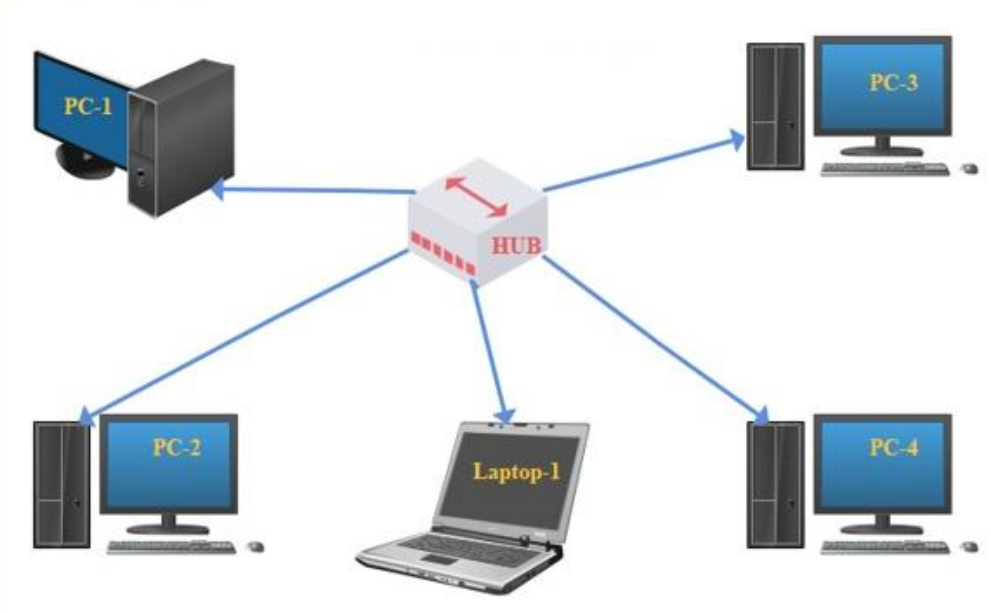


Figure 4.2 A LAN architecture

3. Wide Area Network (WAN)

- **A WAN is also an interconnection of devices capable of communication**.
- A WAN has a wider geographical span, spanning a town, a state, a country, or even the world, however, a LAN is normally limited in size, spanning an office, a building, or a campus.
- A WAN interconnects connecting devices such as switches, routers, or modems, however, a LAN interconnects hosts.
- A WAN is normally created and run by communication companies and leased by an organization that uses it, however, a LAN is normally privately owned by the organization that uses it.

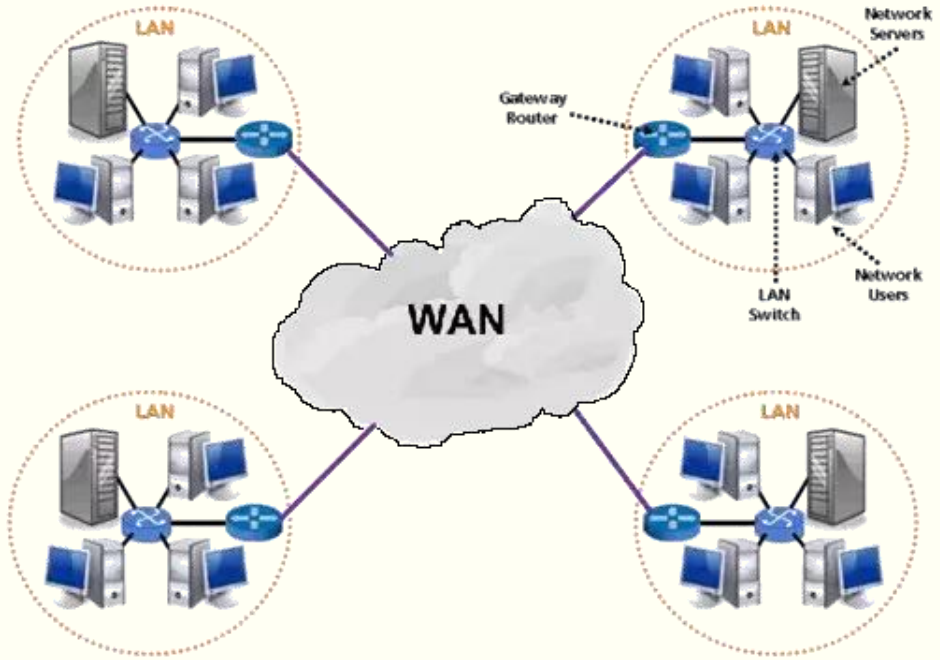


Figure 4.3 A WAN architecture

4. The Internet

- **An Internet is two or more networks that can communicate with each other and is composed of thousands of interconnected networks.**
- The Internet is as several backbones, provider networks, and customer networks. *Backbones* at top level are large networks owned by some communication companies. *Provider networks* at second level use the services of the backbones for a fee.
- *Customer networks* are networks at the edge of the Internet that actually use the services provided by the Internet. They pay fees to provider networks for receiving services. Backbones and provider networks are also called **Internet Service Providers (ISPs)**. The backbones are often referred to as international ISPs.

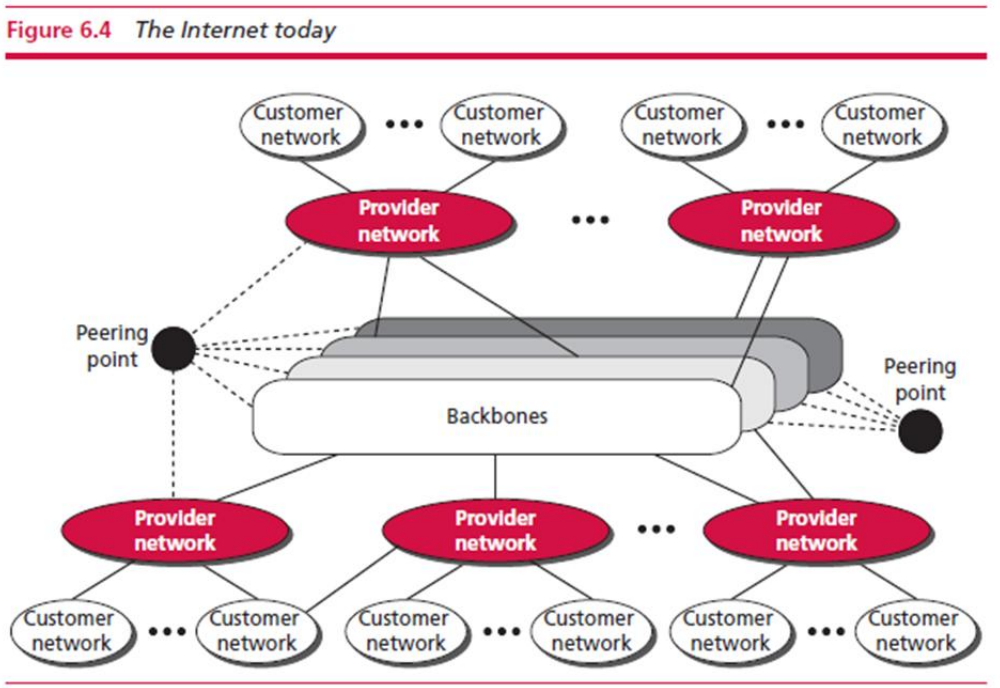


Figure 4.4 The internet today

5. TCP/IP

- **Protocol Layering A protocol defines the rules that both the sender and receiver and all intermediate devices need to follow to be able to communicate effectively in Internet.** we need a protocol at each layer, or protocol layering.

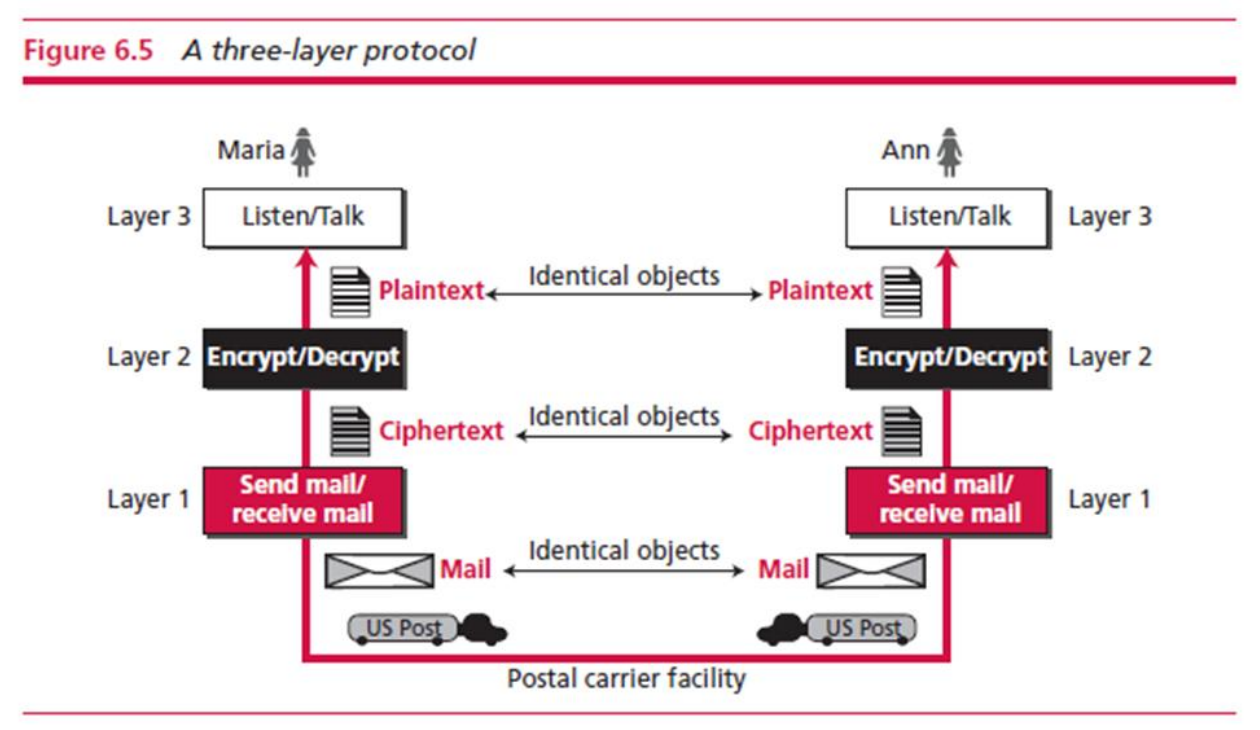


Figure 4.5 A three layer protocol

TCP/IP Protocol Suite

- The **TCP/IP (Transmission Control Protocol / Internet Protocol)** 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.

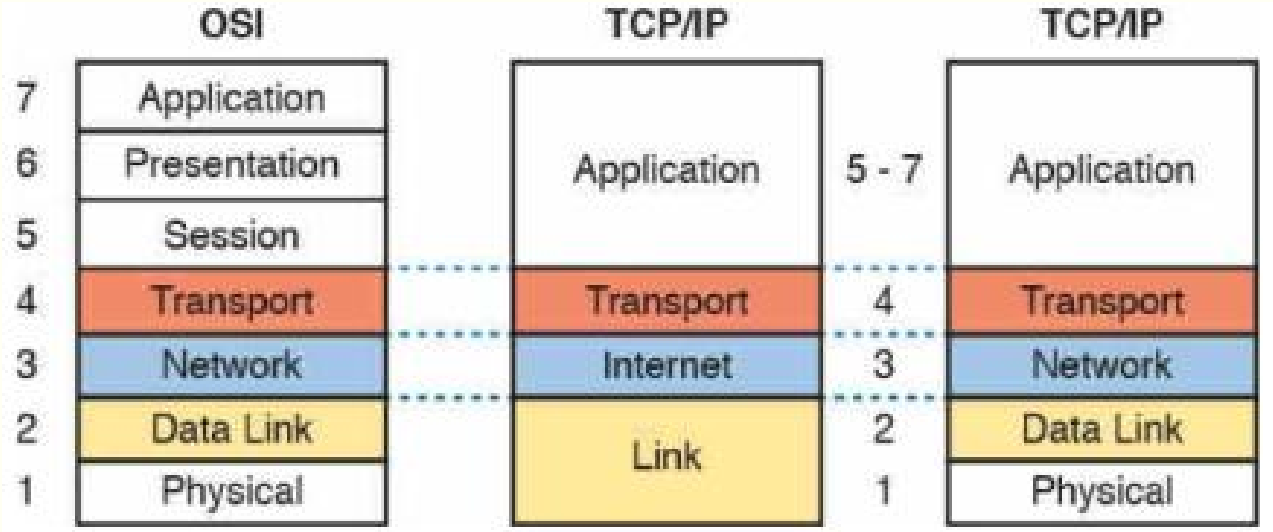
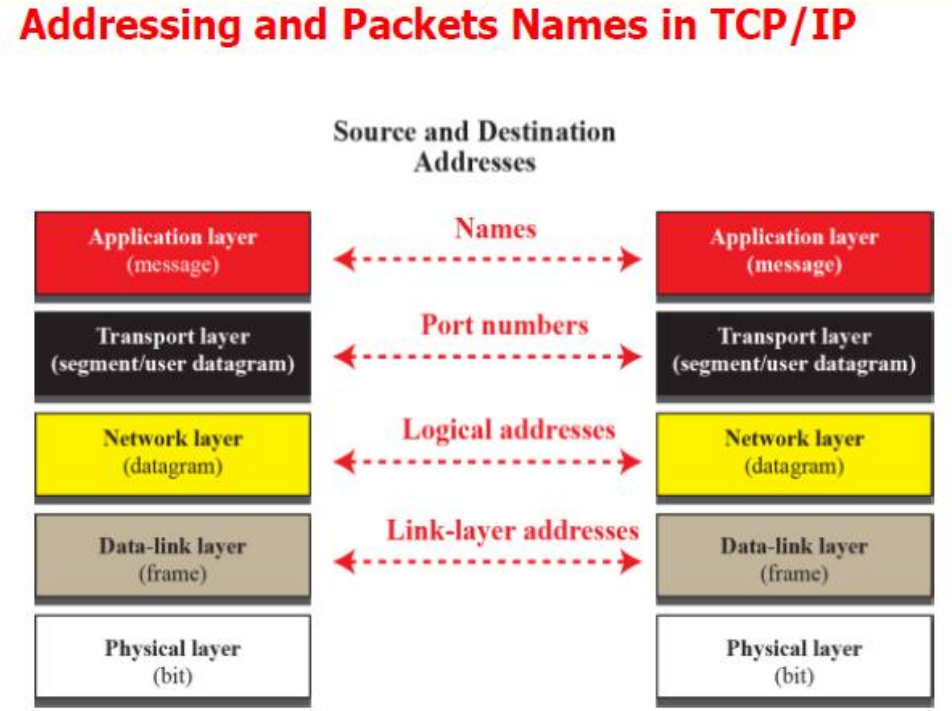


Figure 4.6 Layers in TCP/IP Protocol Suite

Addressing and Packet Names

- Any communication that involves two parties needs source and destination addresses. we normally have **only four because the physical layer (data exchange is a bit) does not need addresses**.
- There is a relationship between the layer, **the address used in that layer, and the packet name at that layer**.



2 - LAYERS IN NETWOKING

2.1 Application layer

- We start from the fifth layer and move to the first layer.
- **The fifth layer of the TCP/IP protocol is called the application layer.**
- The application layer provides services to the user. Communication is provided using a logical connection.

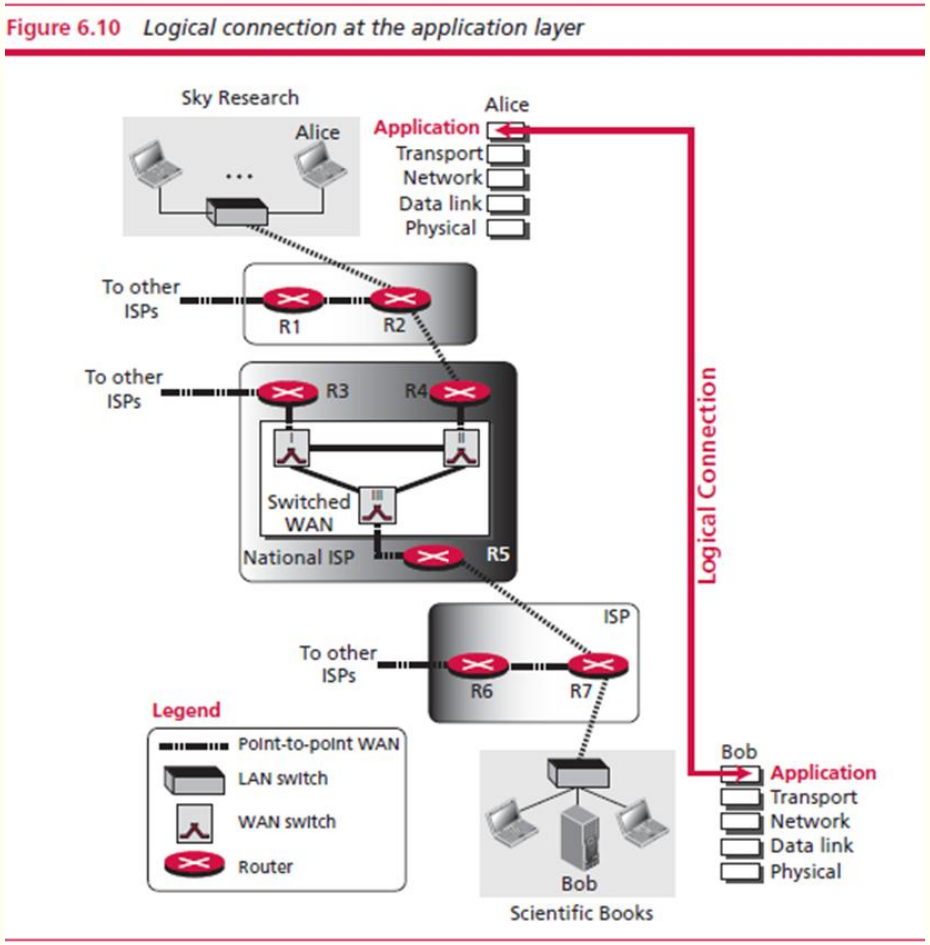
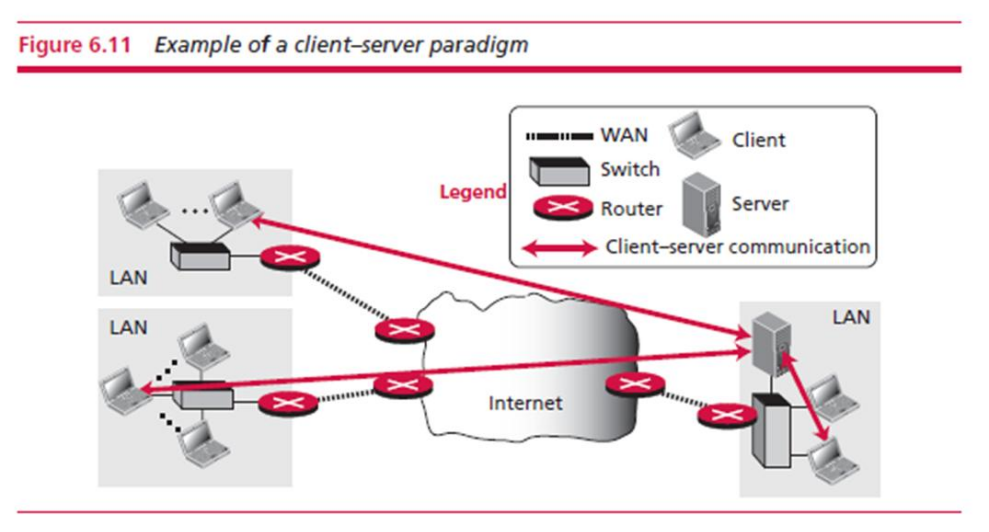


Figure 4.7 Logical Connection at Application Layer

Application-Layer Paradigms

- Using the Internet, we need two application programs to interact with each other: one running on a computer and the other running on another. Should both application programs be able to **request services** and/or **provide services**?
- Two paradigms have been developed during the lifetime of the Internet to answer this question: the ***client-server paradigm*** and the ***peer-to-peer paradigm***



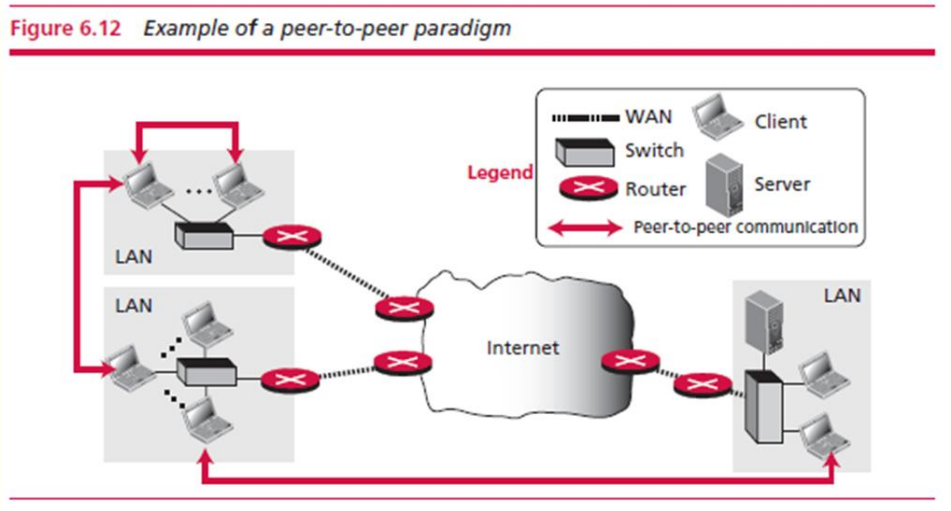
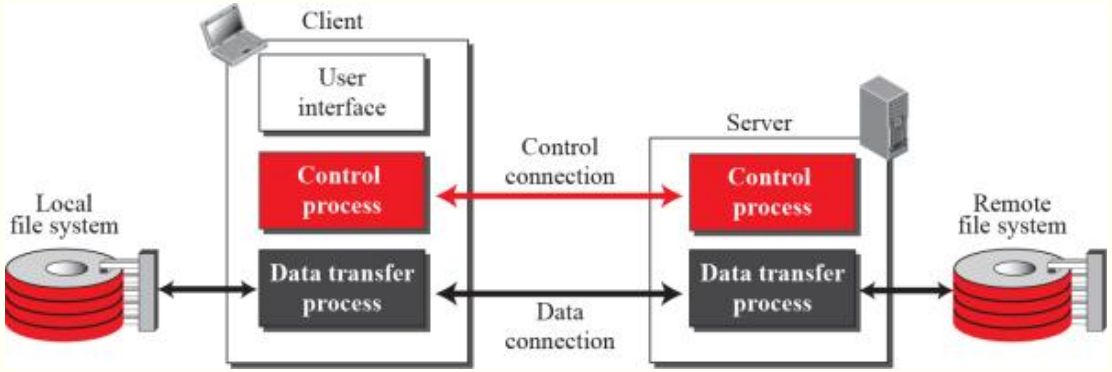


Figure 4.8 the client-server paradigm and the peer-to-peer paradigm

Applications of Standard Client-Server

- Several traditional services are still using this paradigm, including the **World Wide Web (WWW)** and its vehicle **HyperText Transfer Protocol (HTTP)**, **file transfer protocol** (FTP), **secure shell** (SSH), **email**, and so on.



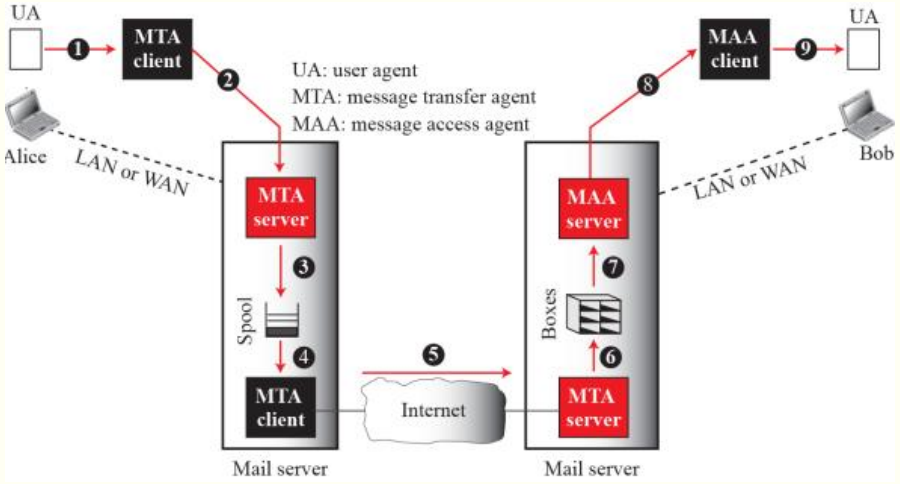
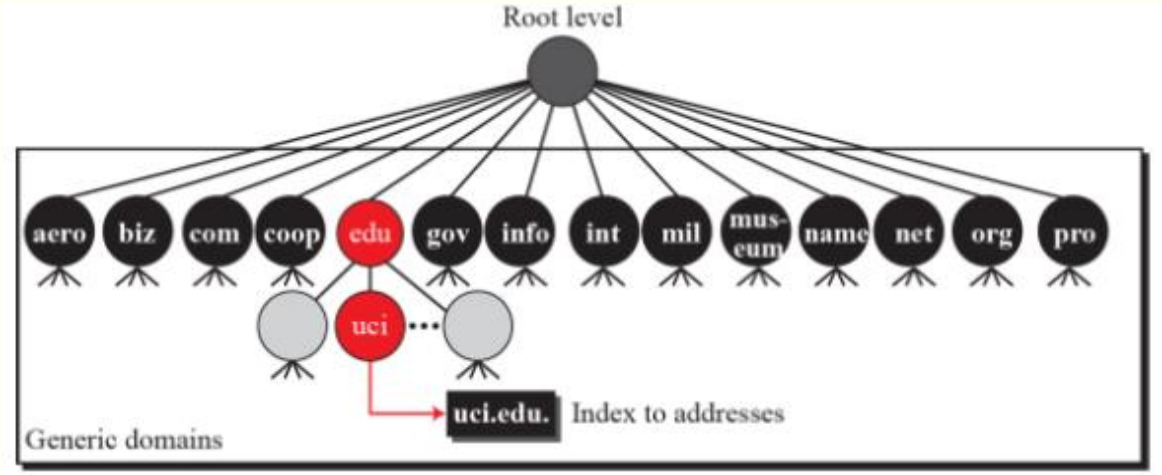


Figure 4.9 Several traditional services at Application Layer

DNS in the Internet

- DNS is a protocol that can be used in different platforms. The domain name space (tree) was originally divided into three different sections: **generic domains, country domains, and the inverse domain**. However, the inverse domains are now deprecated.
- **Generic Domains :** define registered hosts



2.2 TRANSPORT LAYER

- The transport layer in the TCP/IP suite is located between the application layer and the network layer. It provides services to the application layer and receives services from the network layer.
- **The transport layer acts as a liaison between a client program and a server program**.

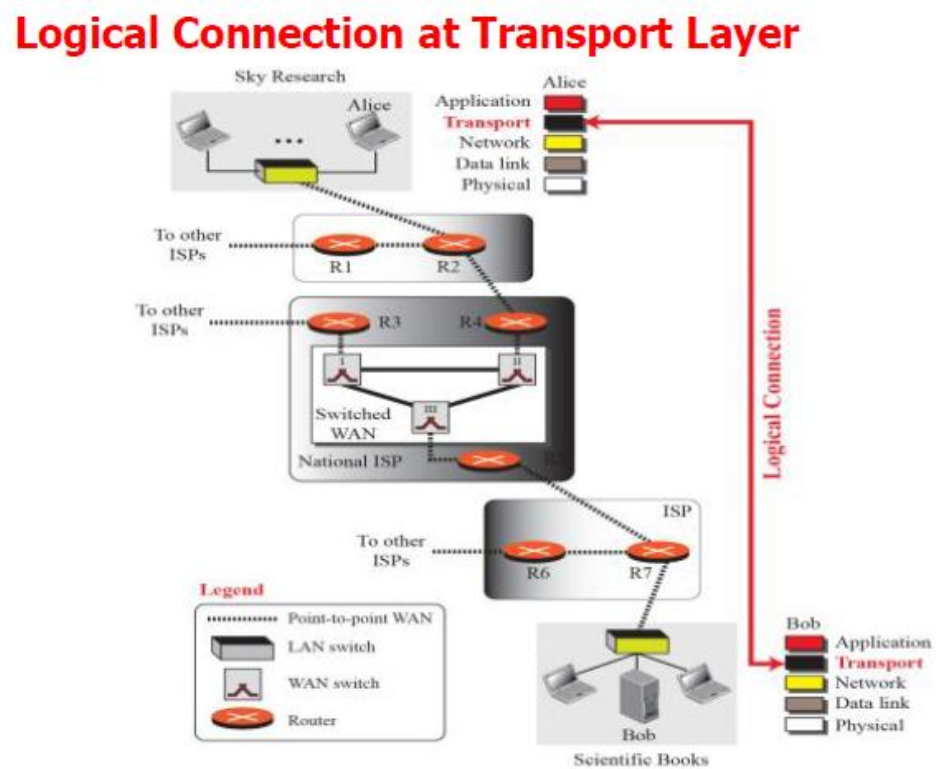


Figure 4.10 Logical Connection at Transport Layer

Process-to-Process Communication

- The Transport-layer protocol provides process-to-process communication . A process is an application-layer entity (running program) that uses the services of the transport layer.
- The network layer is responsible for communication at the computer level and can deliver the message only to the destination computer. A transport-layer protocol is responsible for delivery of the message to the appropriate process.

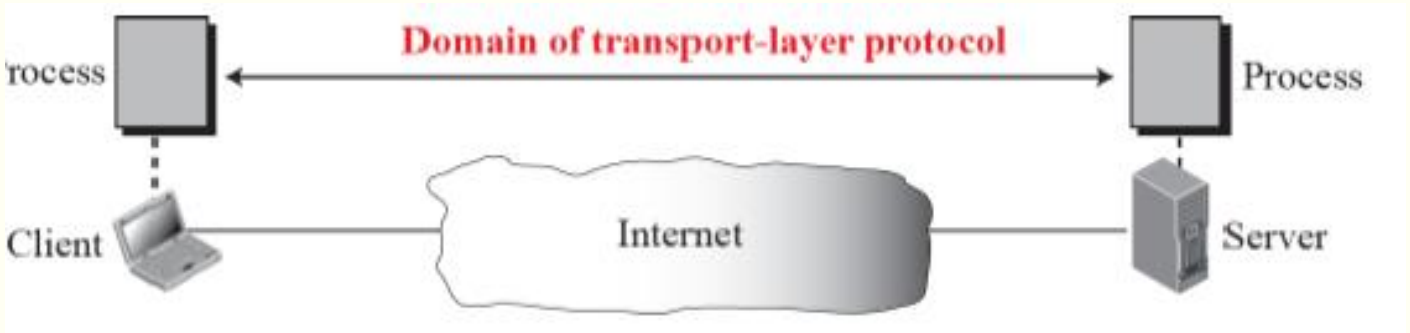


Figure 4.11 Network Layer versus Transport Layer

Addressing: Port Numbers

- For communication, we must define the local host (IP), local process, remote host (IP), and remote process. To define the processes, we need second identifiers called port numbers. In the TCP/IP protocol suite, the port numbers are integers between 0 and 65,535 (16 bits).
- The **client program** defines itself with an ephemeral port number that is recommended to be **greater than 1023** for some client/server programs to work properly. The **server process** must also define **itself with a port number**.

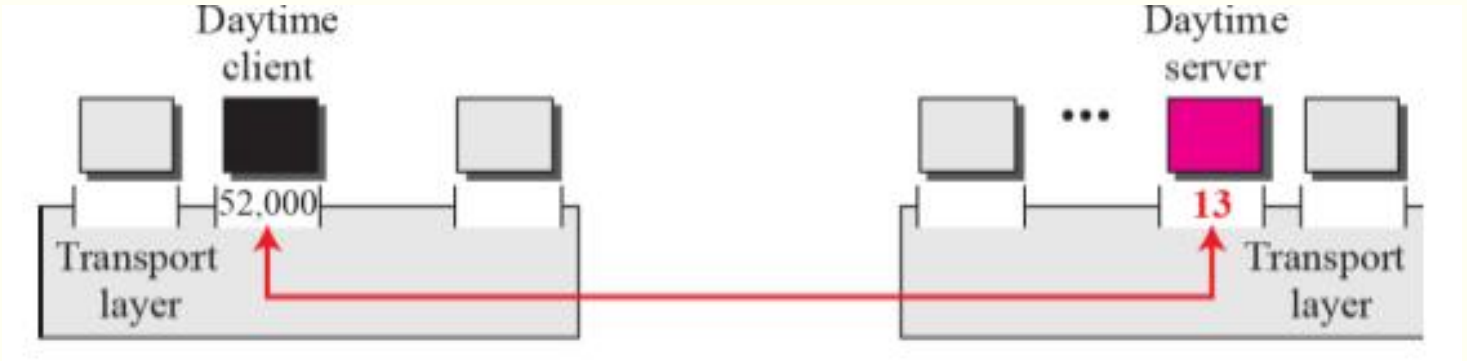
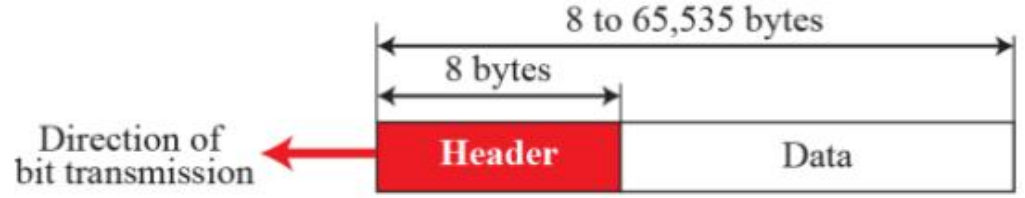


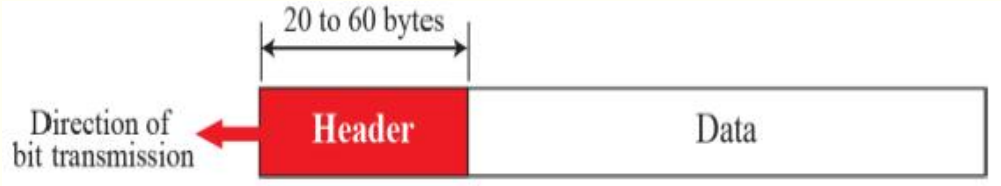
Figure 4.12 Addressing: Port Numbers

Translayer-Layer Protocols

- The **User Datagram Protocol (UDP)** is a connectionless, unreliable transport protocol. UDP is a very simple protocol using a minimum of overhead. If a process wants to send a small message and does not care much about reliability, it can use UDP. Sending a small message using UDP takes much less interaction between the sender and receiver than using TCP.
- UDP packets, called *user datagrams* (format as below), have a fixed-size header of 8 byte and the total length needs to be less 65 535 bytes.



- **Transmission Control Protocol (TCP)** is a connection-oriented, reliable protocol. TCP explicitly defines connection establishment, data transfer, and connection teardown phases to provide a connection-oriented service. At the transport layer, TCP groups a number of bytes together into a packet called a segment.
- TCP adds a header to each segment (for control purposes) and delivers **the segment** (format as below) to the network layer for transmission. The segments are encapsulated in an IP datagram and transmitted.



2.3 NETWORK LAYER

- The network layer in the TCP/IP protocol suite is responsible for the host-to-host delivery of messages.
- **The network layer accepts a packet from a transport layer, encapsulates the packet in a datagram, and delivers the packet to the data-link layer.**
- At the destination host , the datagram is de-capsulated, the packet is extracted and delivered to the corresponding transport layer.

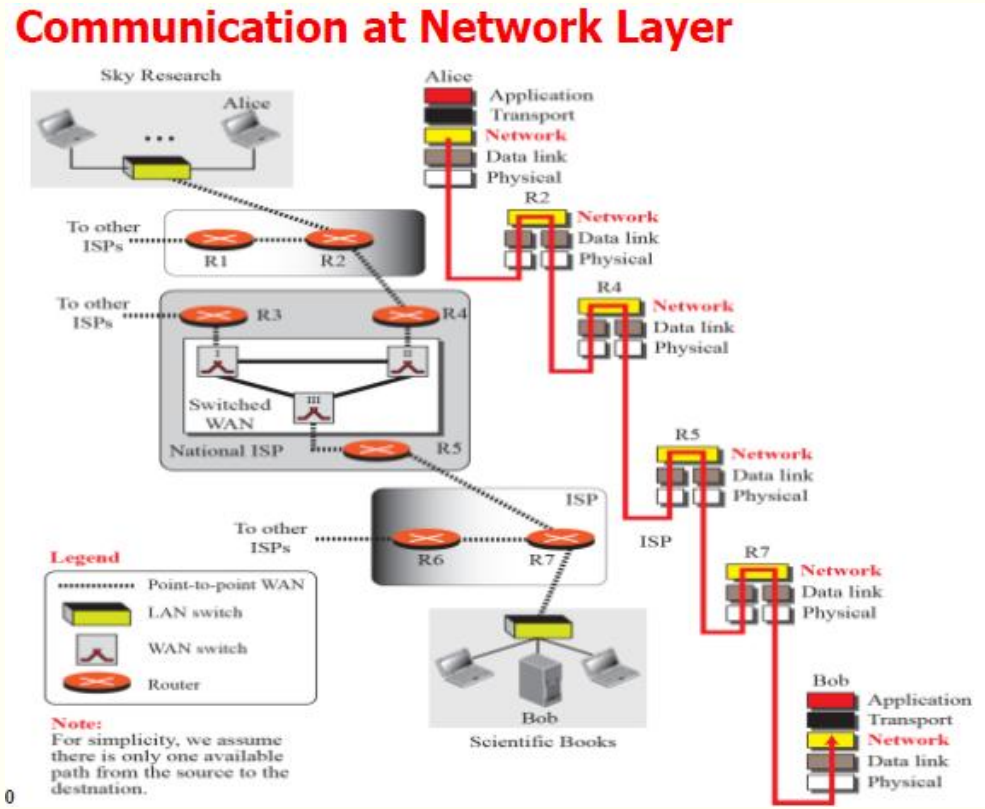
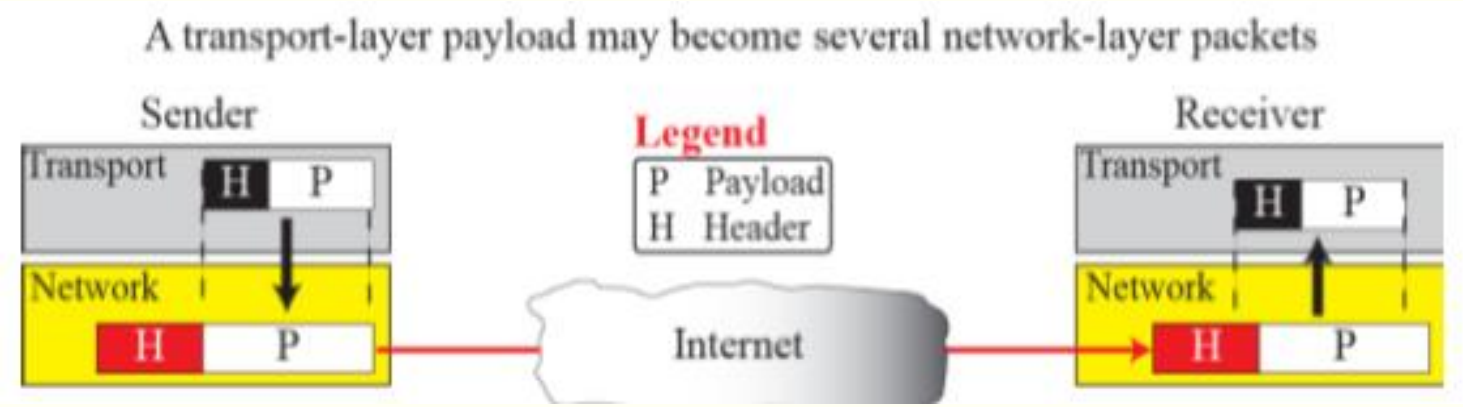


Figure 4.13 Communication at Network Layer

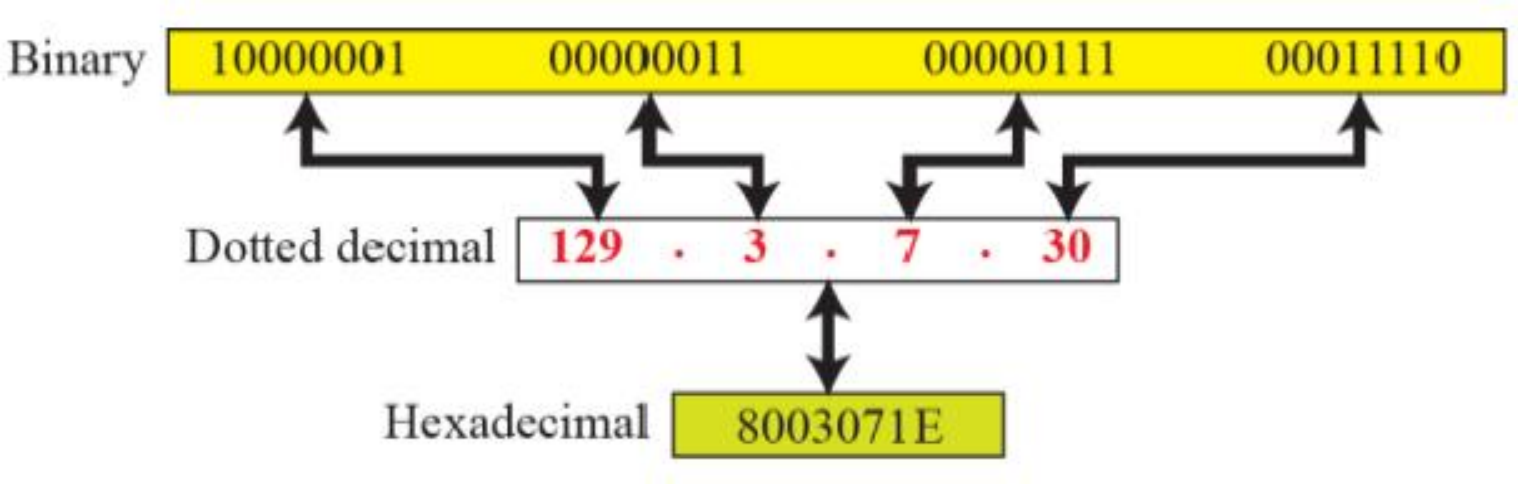
Packetizing at Network Layer

- Packetizing: encapsulating the payload (data received from upper layer) in a network-layer packet at the source and decapsulating the payload from the network-layer packet at the destination.
- *1. The source network-layer receives a packet from transport- layer, adds a header that contains source and destination addresses and some other information.*
- *2. The network layer then logically delivers the packet to the network-layer protocol at the destination.*
- *3. The destination host receives the network-layer packet, decapsulate the payload and deliver to the upper-layer protocol.*



Network-Layer Protocols

- The main protocol is called the Internet Protocol (IP) . IPv4 and IPv6 are in use today.
- There are three common notations to show an IP address: **binary notation** (base 2), **dotted-decimal notation** (base 256), and **hexadecimal notation** (base 16).



2.4 DATA-LINK LAYER

- The TCP/IP suite does not define any protocol in the data-link layer. This layer is the territories of networks that when connected make up the Internet. These networks, wired or wireless, receive services and provide services to the network layer.

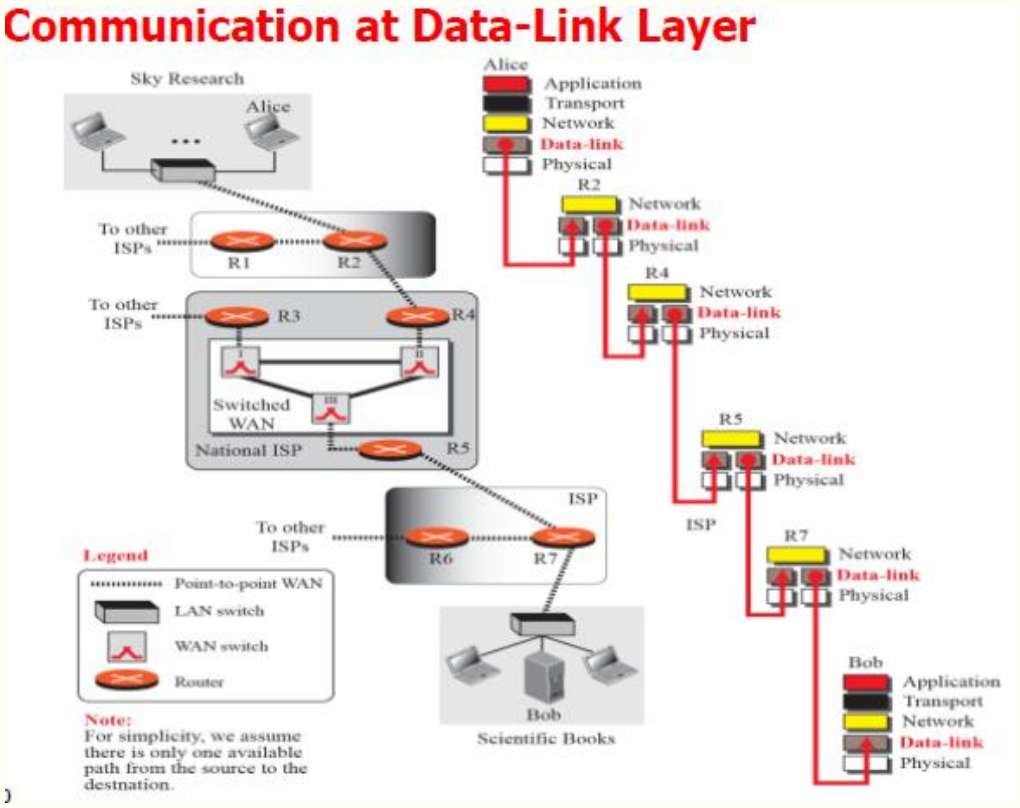
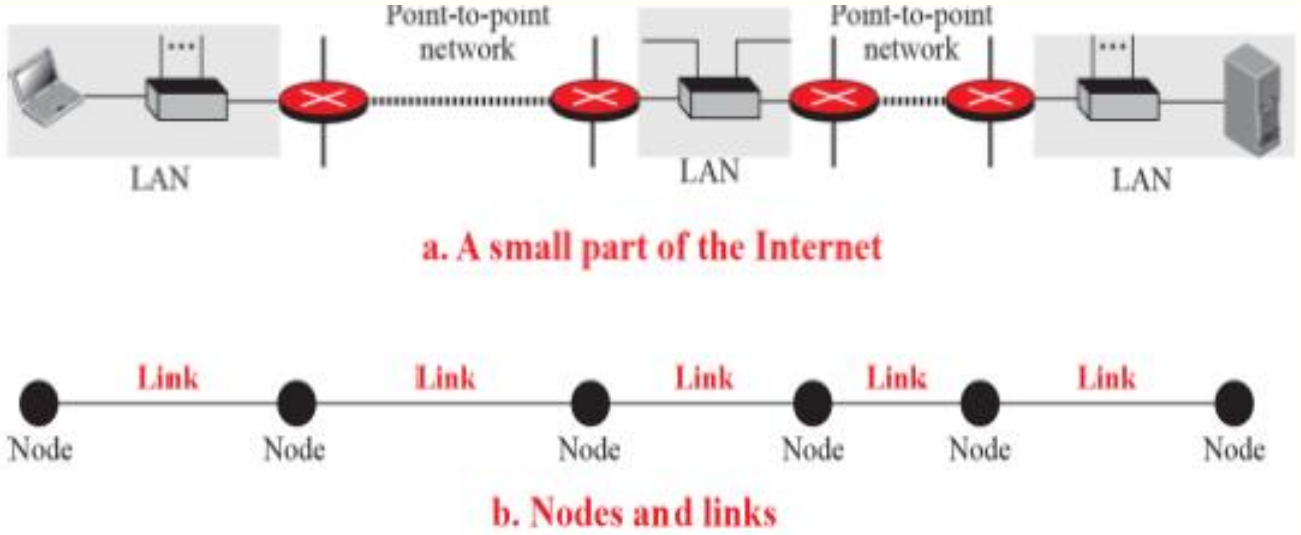


Figure 4.14 Communication at Data-Link Layer

Nodes and Links

- Communication at the data-link layer is ***node-to-node*** .Data unit from one point in the Internet needs to pass through many networks (LANs and WANs) to reach another point. Theses LANs and WANs are connected by routers.

- It is customary to **refer to the two end hosts and the routers as *nodes*** and **the networks in between as *links*** .



Wred LANs: Ethernet

- **Ethernet LAN** was developed in 1970s by Robert Metcalfe and David Boggs. Standard Ethernet (10 Mbps), Fast Ethernet (100 Mbps), Gigabit Ethernet (1 Gbps), and 10 Gigabit Ethernet (10 Gbps).
- **A frame** carries some information such as the source address (48 bits), the destination address (48 bits), the type of data, the actual data, and some other control bits as a guard to help checking the integrity of data during transition.

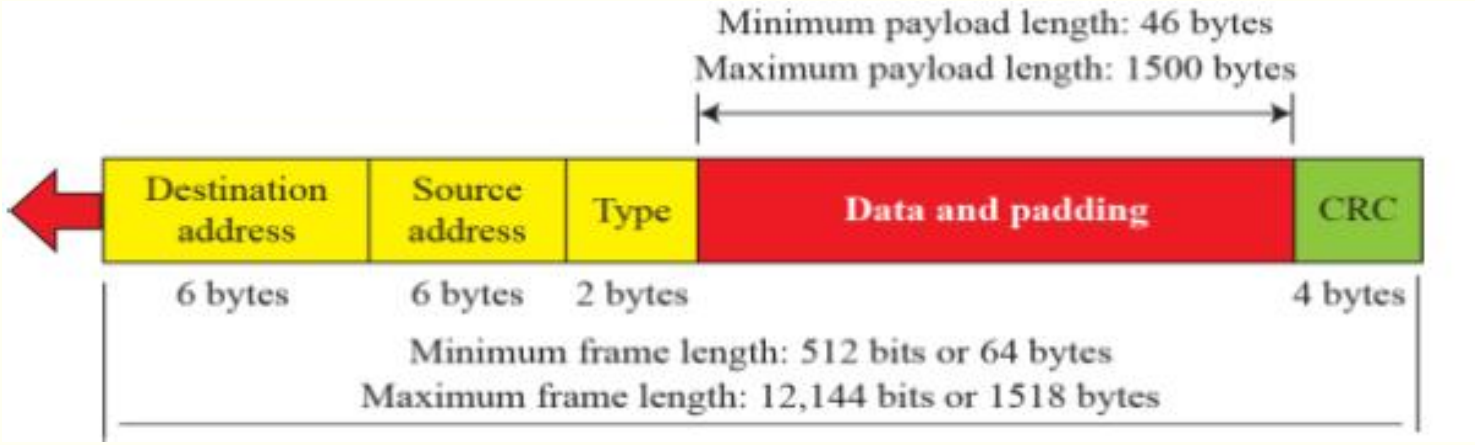


Figure 4.15 Ethernet LAN and the Frame Format

Wireless Ethernet

- **Wireless Ethernet or *WiFi* is a wireless LAN**. Two kinds of services: the **basic service set (BSS)** and the **extended service set (ESS).** The second service uses an extra device (access point or AP) that serves as a switch for connection to other LANs or WANs.

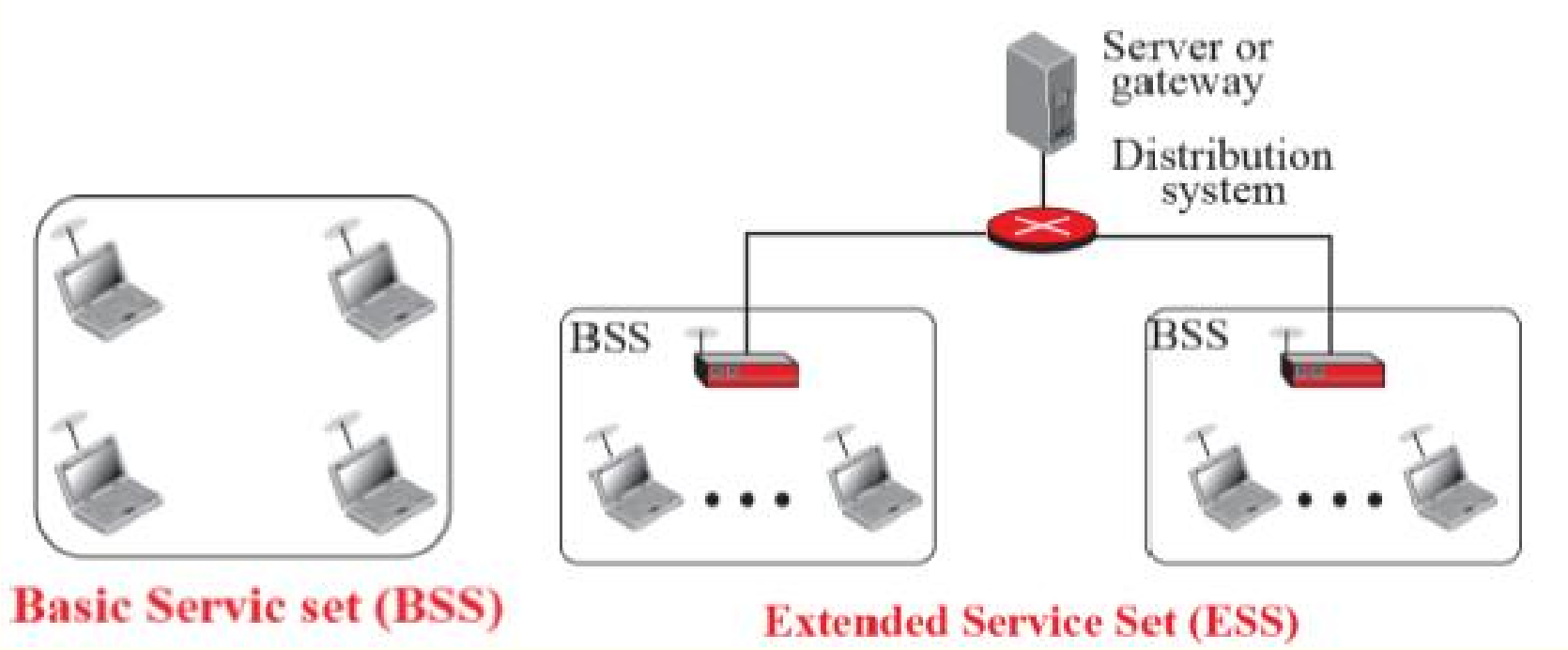


Figure 4.16 the basic service set (BSS) and the extended service set (ESS).

Cable Service

- **Cable networks** were originally created to provide access to TV programs. Cable TV network can also support DSL technology that provides high-data-rate connections for residential subscribers over the local loop.

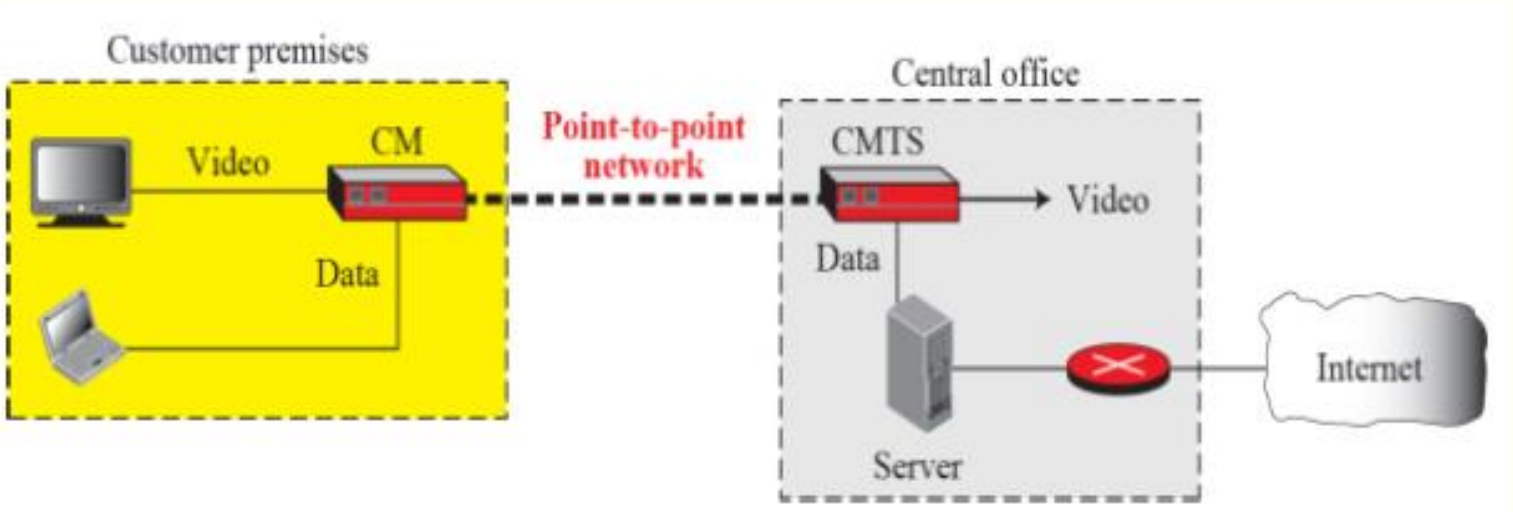


Figure 4.17 the cable networks of cable service

Wireless WAN:WiMax

- The **worldwide Interoperability Access (WiMax)** is the wireless version of DSL or Cable connection to the Internet. It provide two types of services (fixed WiMax) to connect the main station to fixed station or to mobile stations such as cellular phones

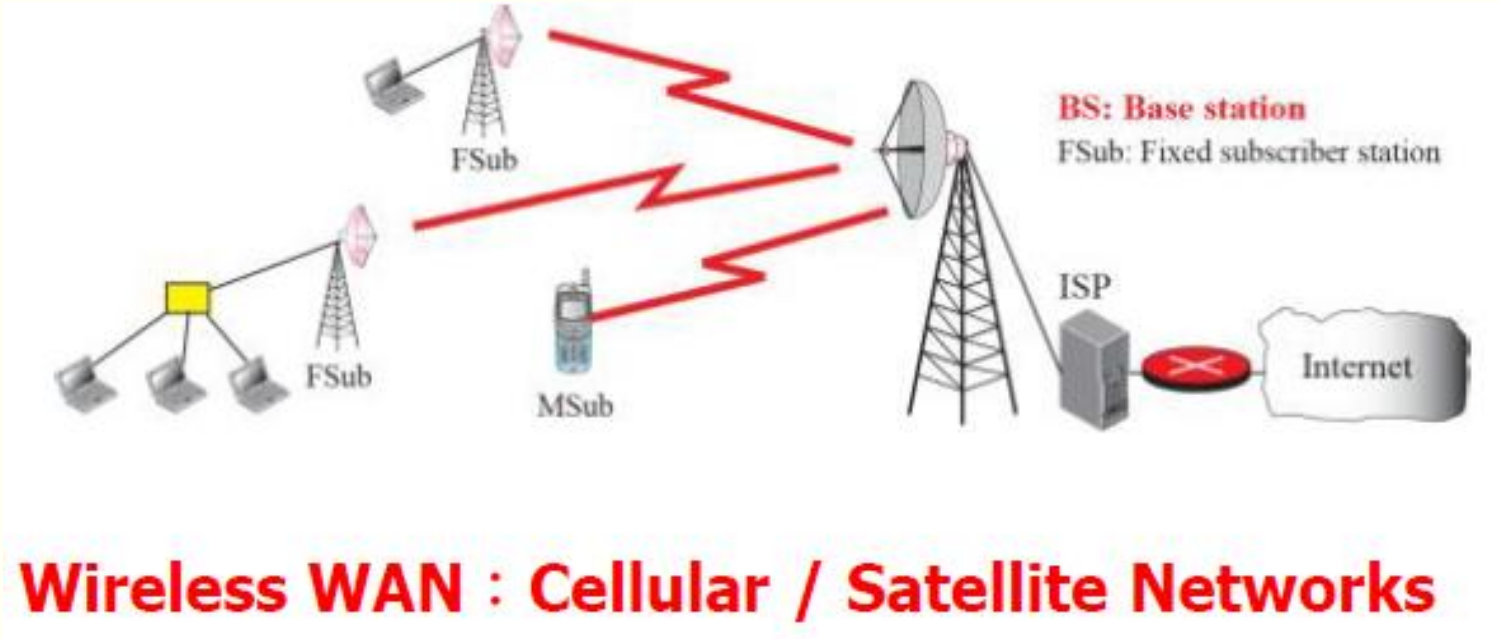


Figure 4.17 The worldwide Interoperability Access (WiMax)

2.5 PHYSICAL LAYER

- The role of the physical layer is to transfer the bits received from the data-link layer and convert them to electromagnetic signals for transmission.
- After the bits are converted to signals, the signals are delivered to the transmission media.

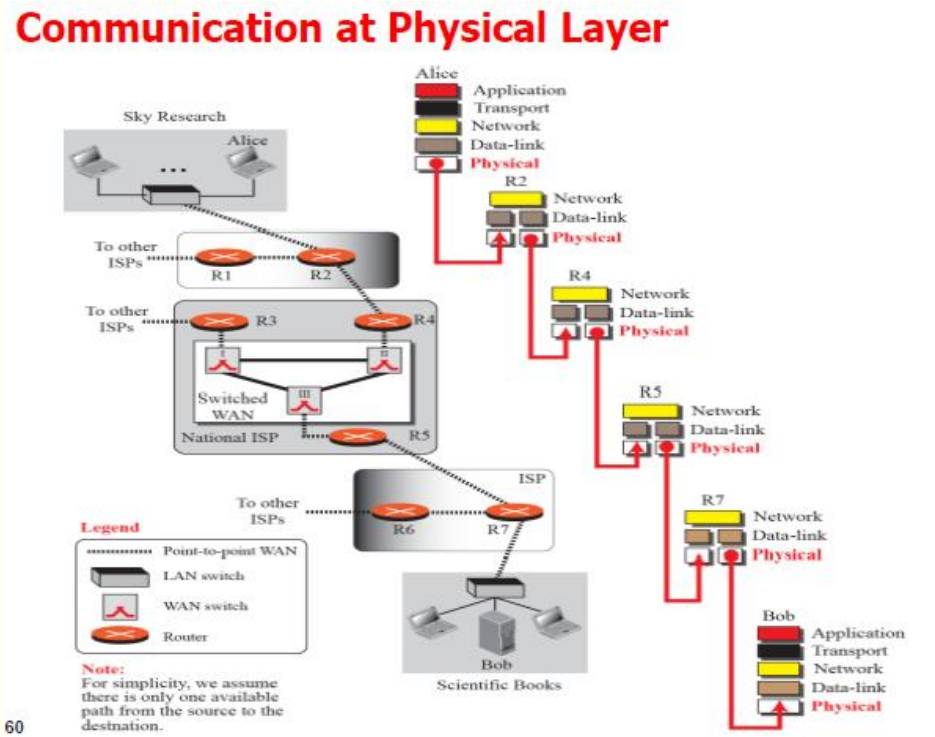
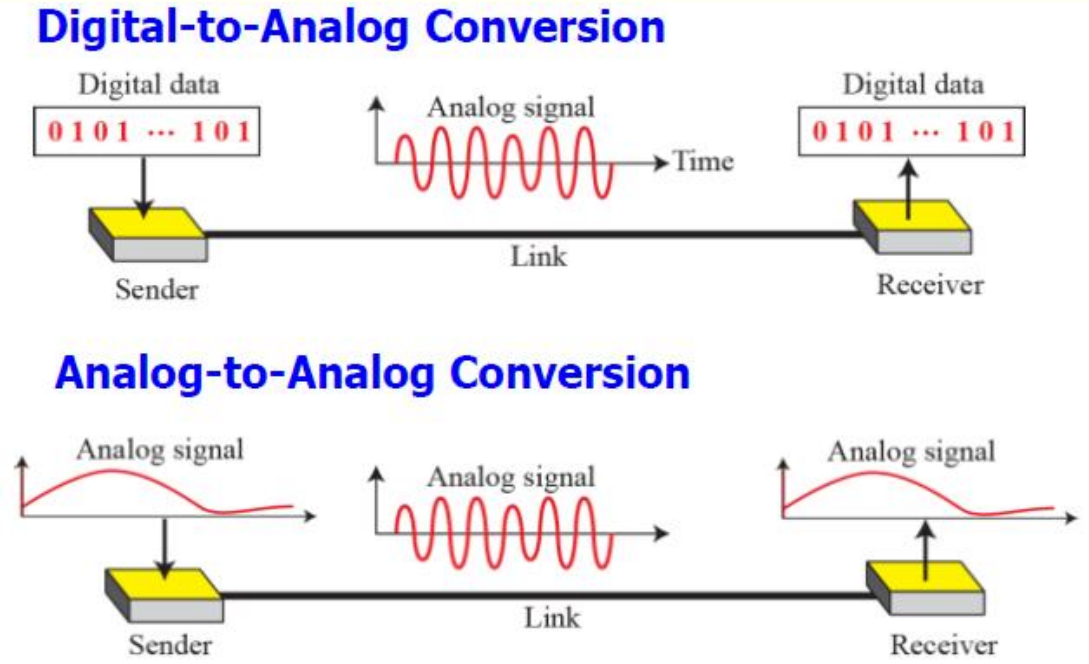


Figure 4.19 Communication at Physical Layer

Analog and Digital Transmission

- **Analog Transmission**



- **Digital Transmission**

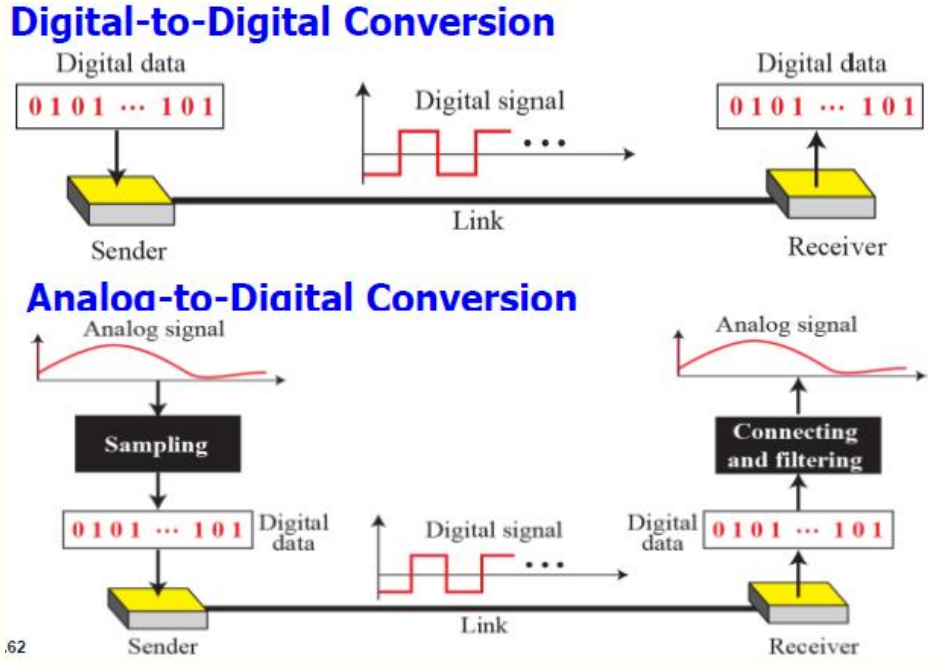


Figure 4.19 Analog and Digital Transmission

Summary of TCP/IP Protocol Layers

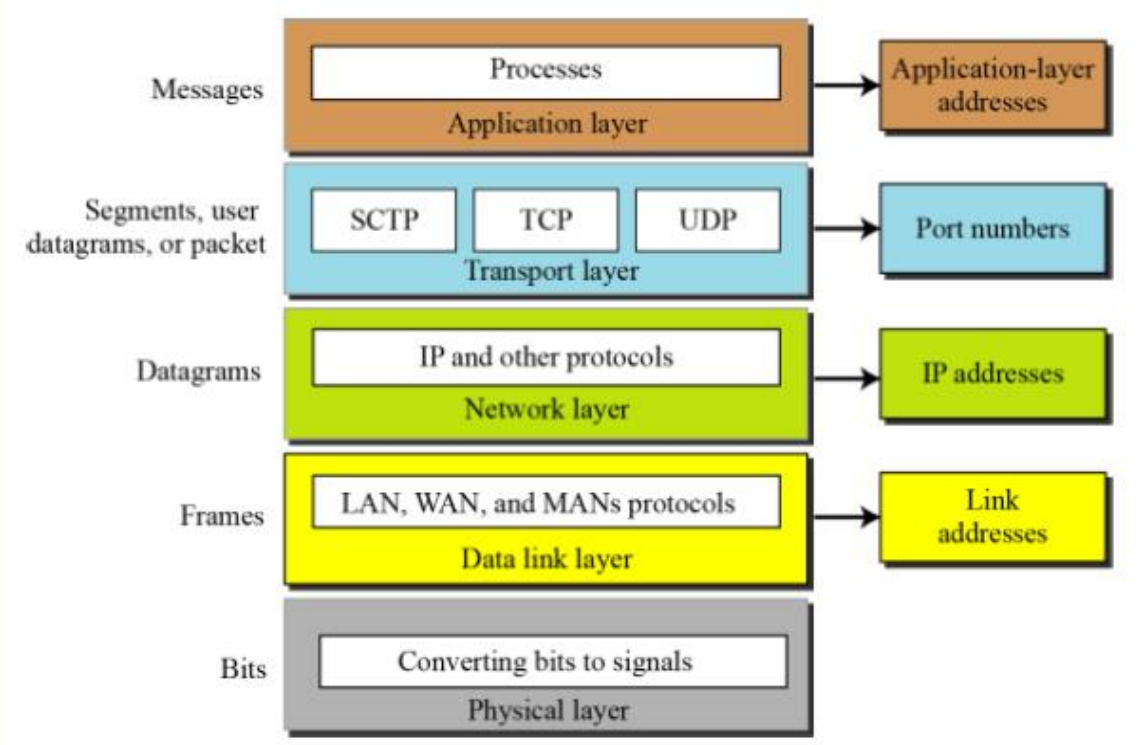


Figure 4.20 TCP/IP Protocol Layers