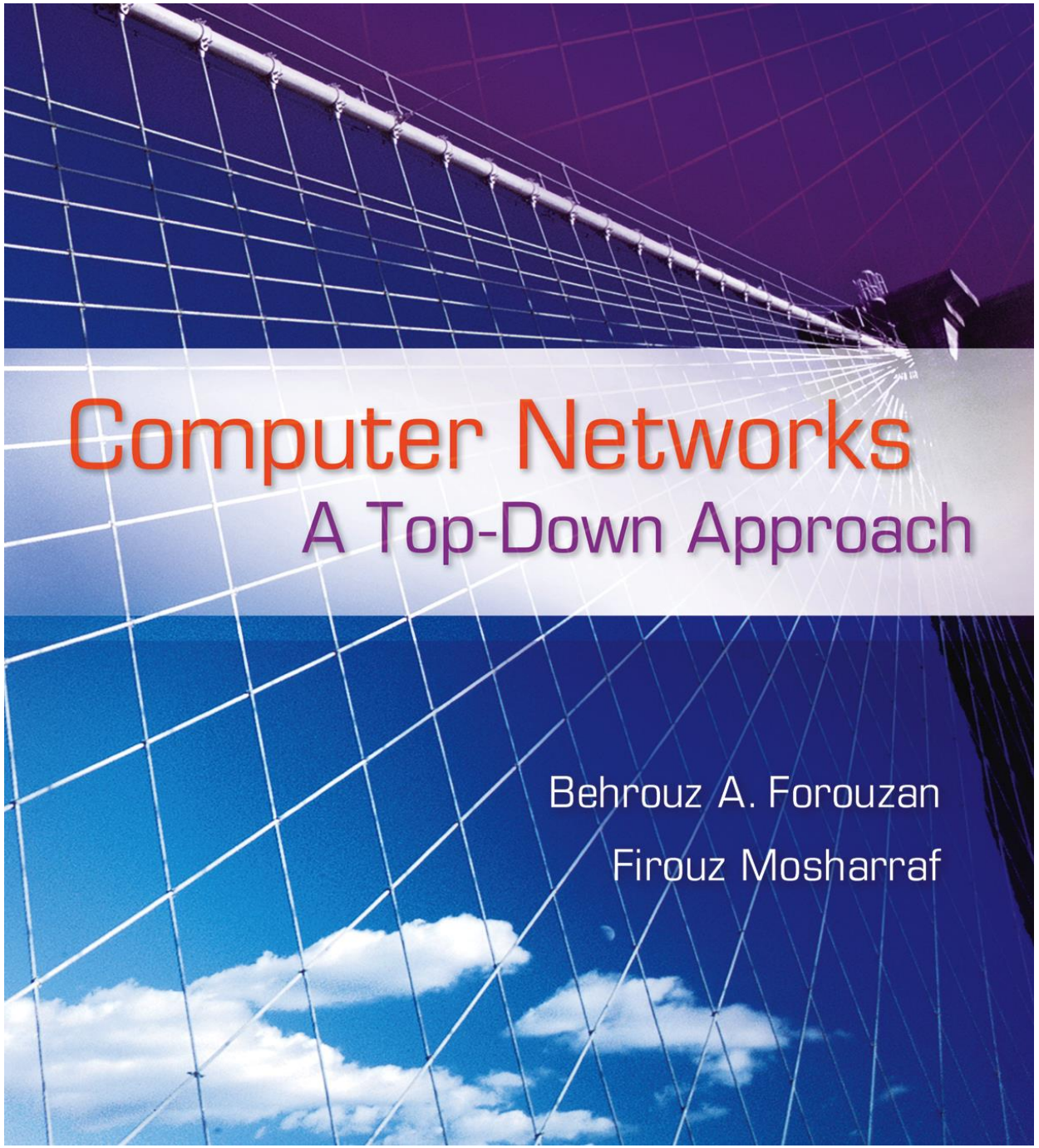


Module - 1

Introduction

Contents

Objective

- Brief history of the Internet
- Introduction to local area networks (LANs) and wide area networks (WANs) and show that an internet or the Internet is a combination of these networks.
- Introduction to the concept of protocol layering (how the task to be done by divided into smaller tasks).
- Discussion of TCP/IP protocol suite.

1.1. OVERVIEW OF THE INTERNET

- The Internet, has more than one billion users (wired and wireless transmission media for connecting to systems)
- Allows users to share an enormous amount of information across

1.1.1. Networks

- “A network is the interconnection of a set of devices capable of communication”

Note: Internet not as a single network, but as an internetwork, a combination of networks.

- Devices can be:
    1. Host(End system) such as a large computer, desktop, laptop, workstation, cellular phone, or security system
    2. Can also be connecting device such as Router, Switch, hub, etc..

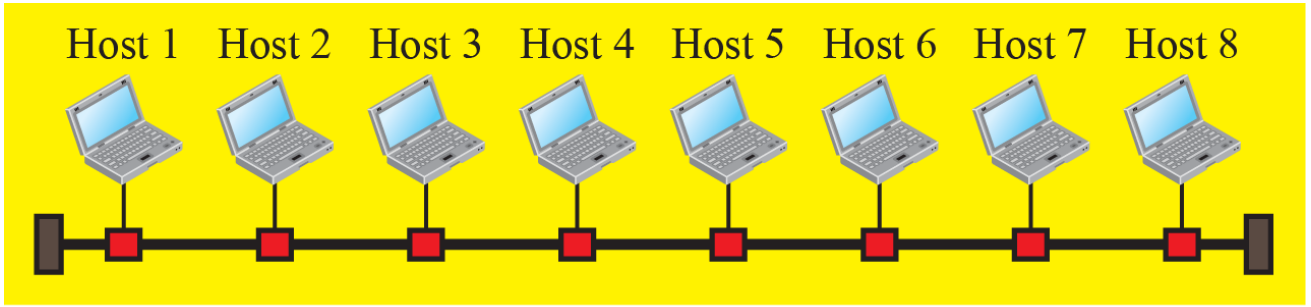
Router: connects the network to other networks

Switch: which connects devices together

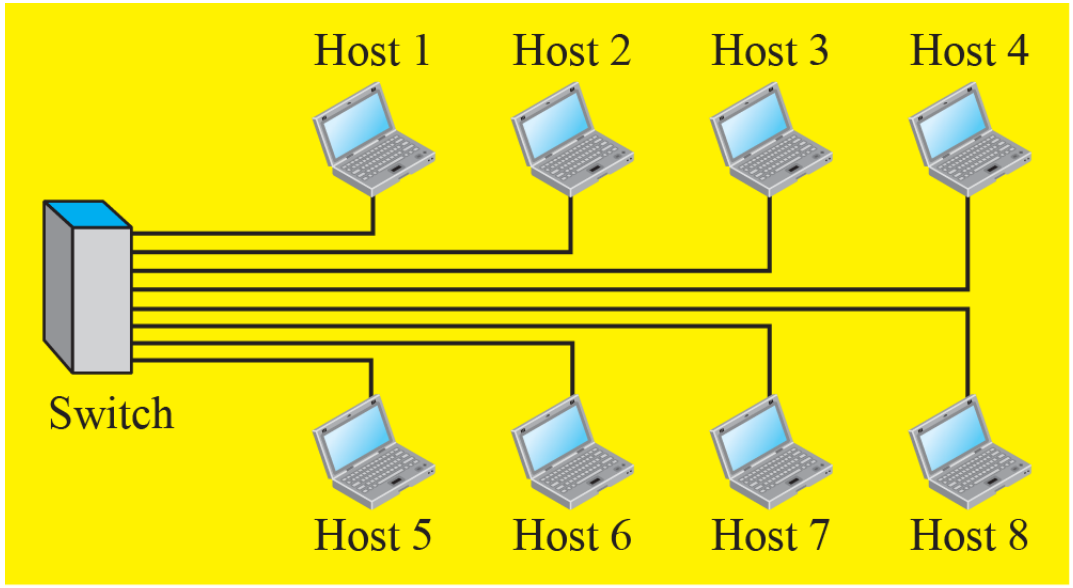
modem (modulator-demodulator): that changes the form of data, and so on

Local Area Network

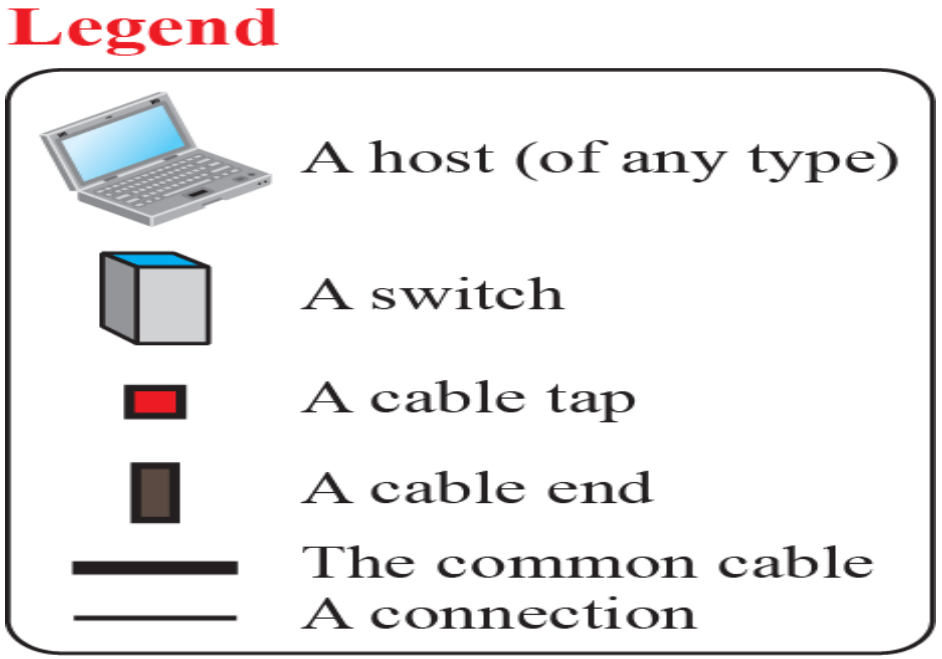
- Collection of devices connected together in one physical location, such as a building, office, or home
- comprises cables, access points, switches, routers, and other components that enable devices to connect to internal servers, web servers, and other LANs via wide area networks.
- Example: in an office with multiple departments, such as accounting, IT support, and administration, each department's computers could be logically connected to the same switch but segmented to behave as if they are separate.
- Advantages: The devices can use a single Internet connection, share files with one another, print to shared printers, and be accessed and even controlled by one another.



a. LAN with a common cable (past)



b. LAN with a switch (today)

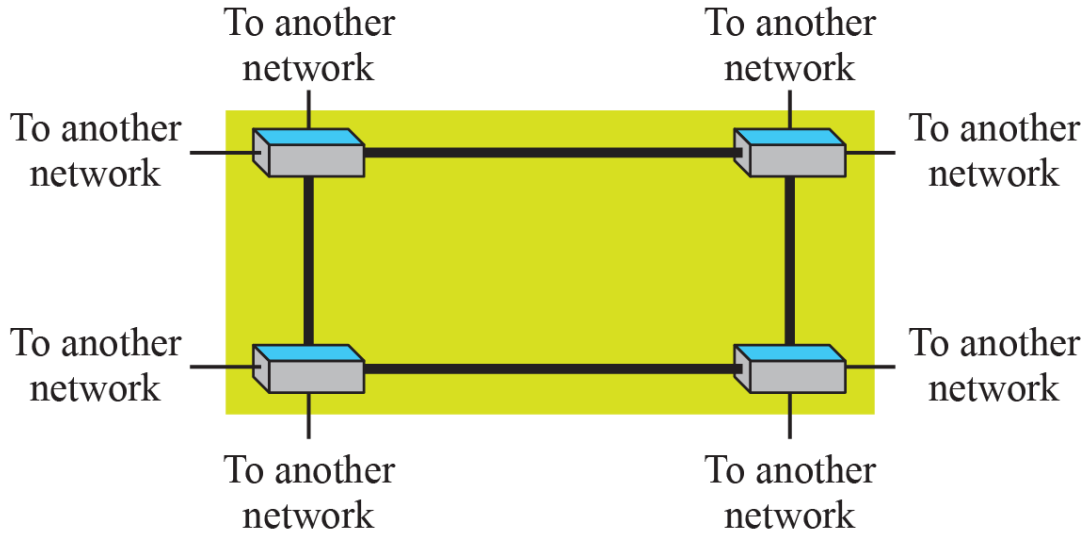


Wide-Area Network

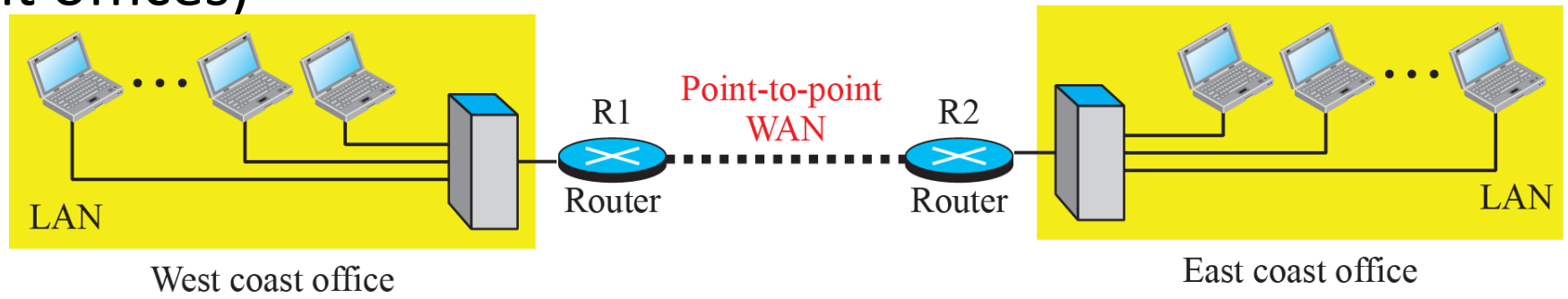
- collection of local-area networks (LANs) or other networks that communicate with one another/Connects groups of computers over large distances.
- WAN is essentially a **network of networks**, with the Internet the world's largest WAN.
- Limitations of LAN: limited in size, spanning an office, a building, or a campus

- Point-to-Point WAN: connects two communicating devices through a transmission media

- **A Switched WAN:** switched WAN is a network with more than two ends. switched WAN is a combination of several point-to-point WANs that are connected by switches.

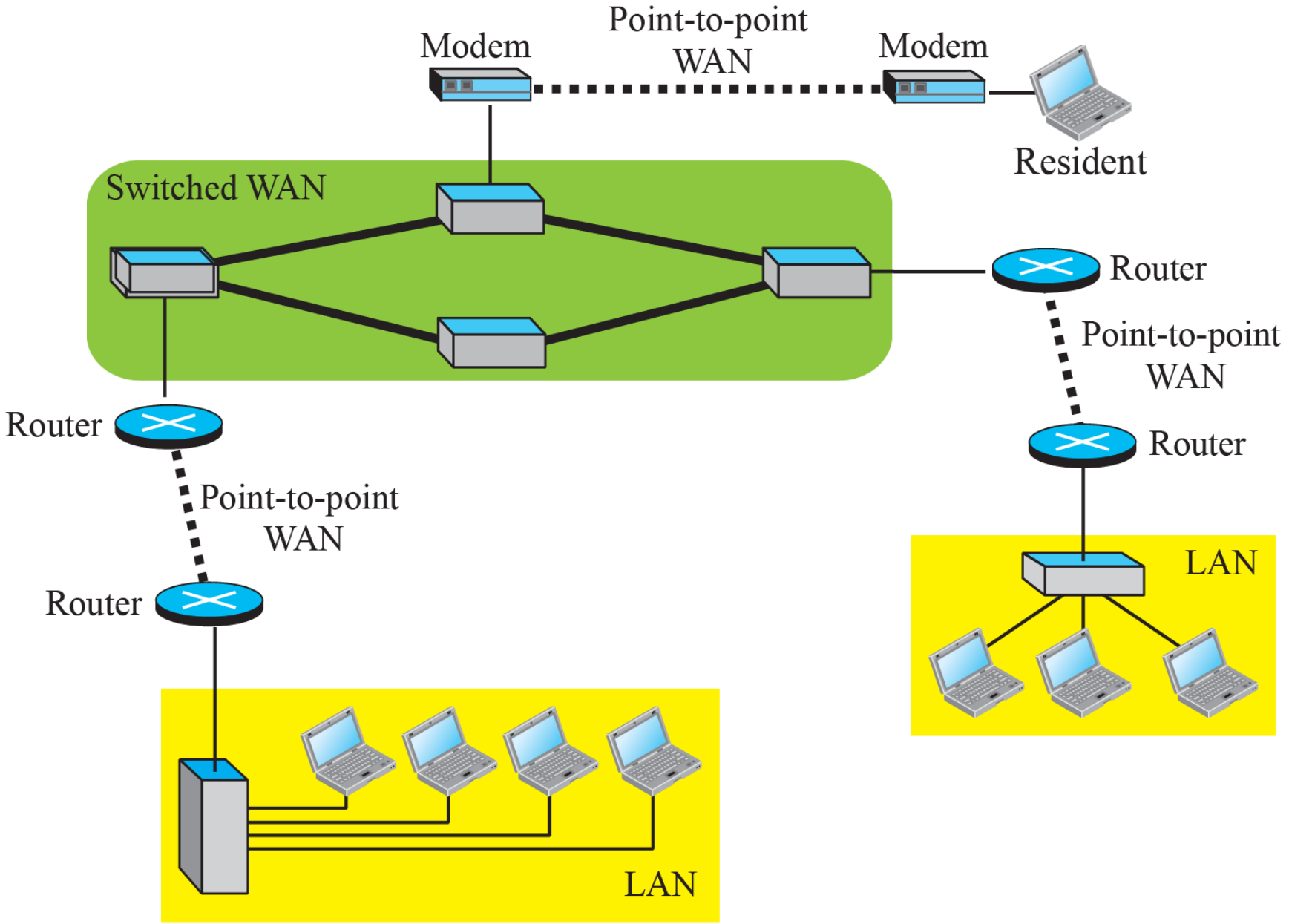


- Internetwork: connection of two or more networks that they make an internetwork, or internet.
- Ex: organization has two offices (make the communication between different offices)



- Heterogeneous network: internet with several LANs and WANs

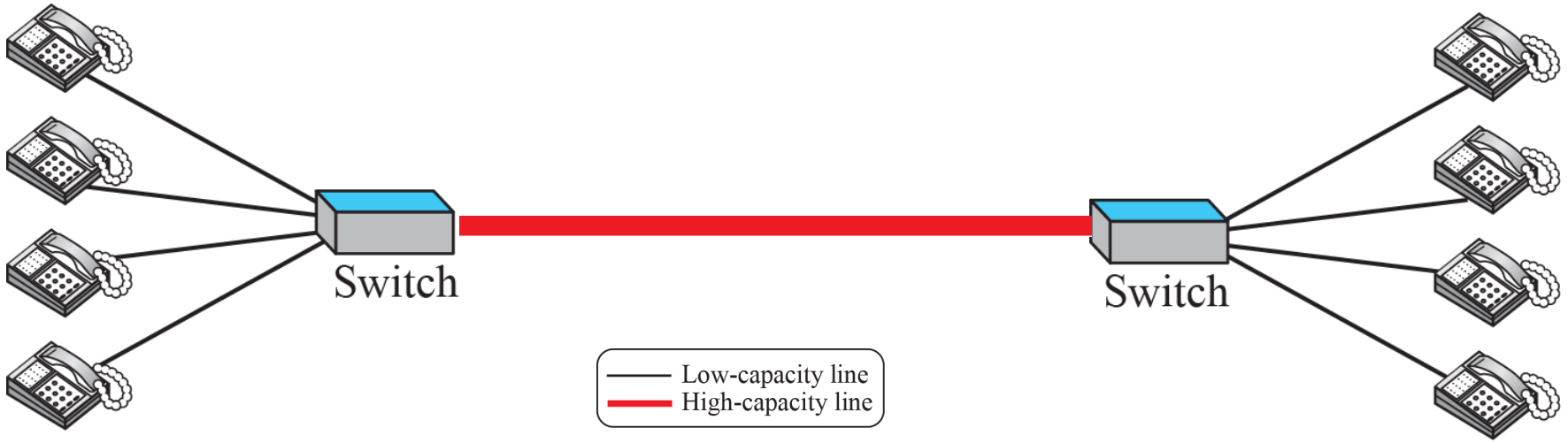
Heterogeneous Networks: A heterogeneous network made of WANs and LANs



1.1.2. Switching

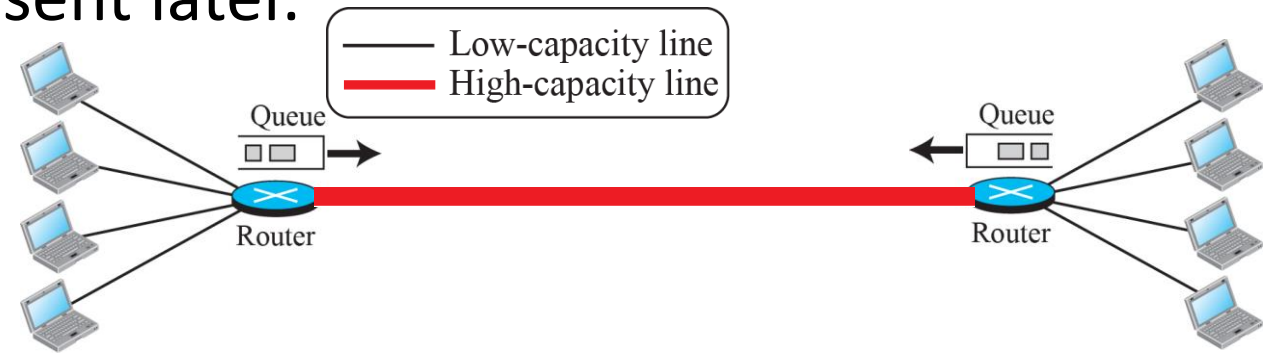
- An internet is a switched network in which a switch connects at least two links together.
- A switch needs to forward data from a link to another link when required.
- Types: Circuit-Switched Network , Packet-Switched Network

- Circuit Switched network: a dedicated connection, called a circuit, is always available between the two end systems; the switch can only make it active or inactive



- high-capacity communication line that can handle four voice communications at the same time
- **Note: switches used here has forwarding tasks but no storing capability**. Efficient when used in full capacity
- Consider all 4 telephones are busy then the capacity of the thick line is fully used, whereas if any one is used the only ¼ of its capacity is used – indicates circuit-switched network is efficient only when it is working at its full capacity

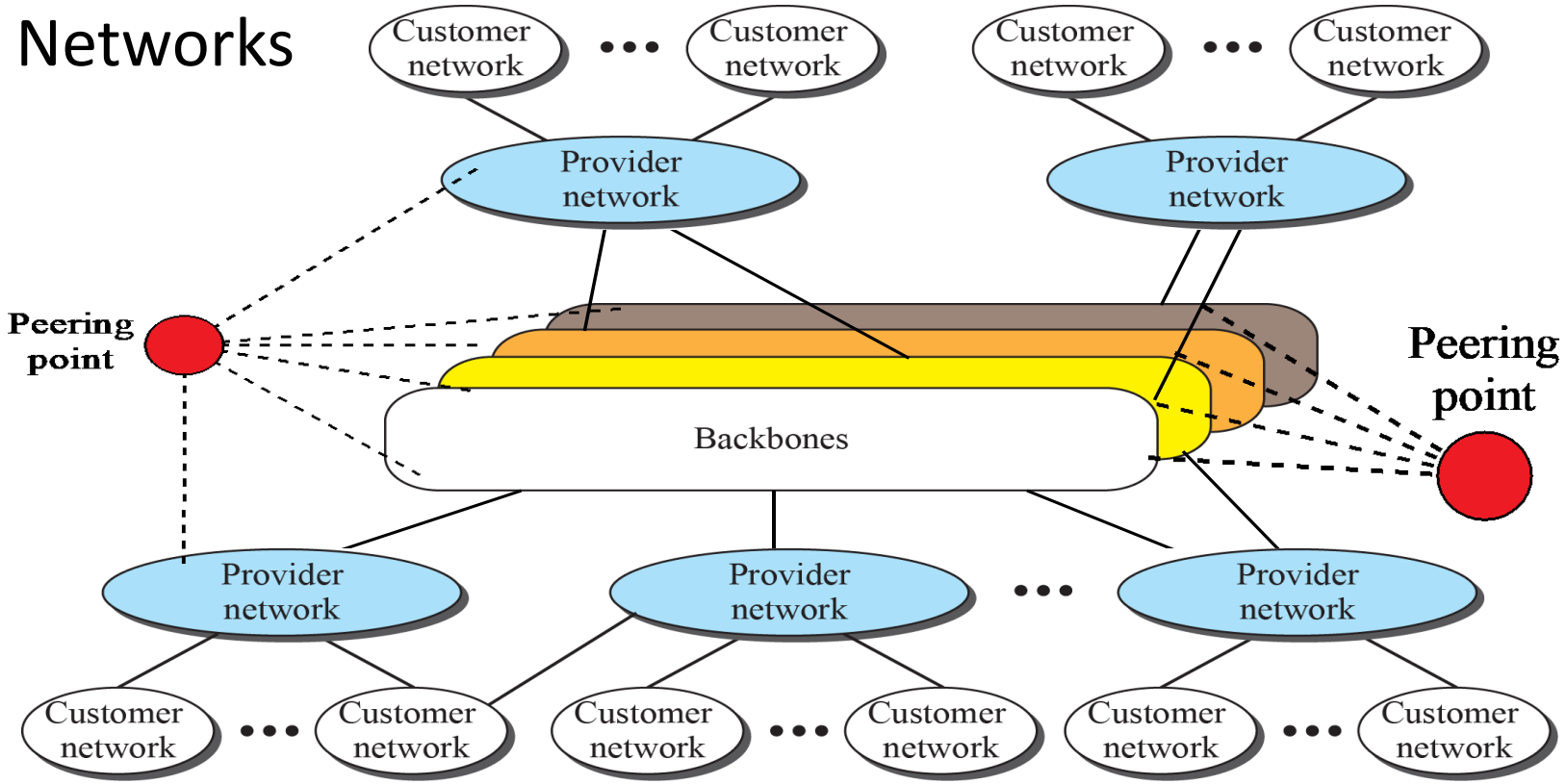
- A packet-switched network: Communication between the two ends is done in blocks of data called packets
- Exchange of individual data packets between the two computers allows us to make the switches functional for both storing and forwarding because a packet is an independent entity that can be stored and sent later.



- A router in a packet-switched network has a queue that can store and forward the packet.

1.1.3. The Internet

- The most notable internet is called the Internet and is composed of thousands of inter-connected networks.
- Its an internetwork that allows any user to become part of it. The user, however, needs to be physically connected to an ISP.
- Ex: Telephone Networks



1.1.4. Accessing the Internet

- Using Telephone Networks: Dial-up Service (add to the telephone line a modem that converts data to voice - dial-up service is slow), DSL

❖ Using Cable Networks

❖ Using Wireless Networks

❖ Direct Connection: become a local ISP

1.1.5. Hardware and Software

- For communication to happen, we need both hardware and software

1.2 PROTOCOL LAYERING

- "A protocol defines the rules that both the sender, receiver and all intermediate devices needs to follow – to communicate effectively".
- ***It determines what is communicated, how it is communicated and when it is communicated. The key elements of a protocol are syntax, semantics and timing***
- Why Protocol Layering ?
  - Simple communication - may need Single protocol
  - Complex - divide task between different layers
- Advantages:

  1. Allows us to separate the services from the implementation (ie. Service and implementation layers are separate)

  2. communication does not always use only two end systems; there are intermediate systems that need only some layers for **not** to make whole system more expensive

1.2.1 Scenarios - need for protocol layering

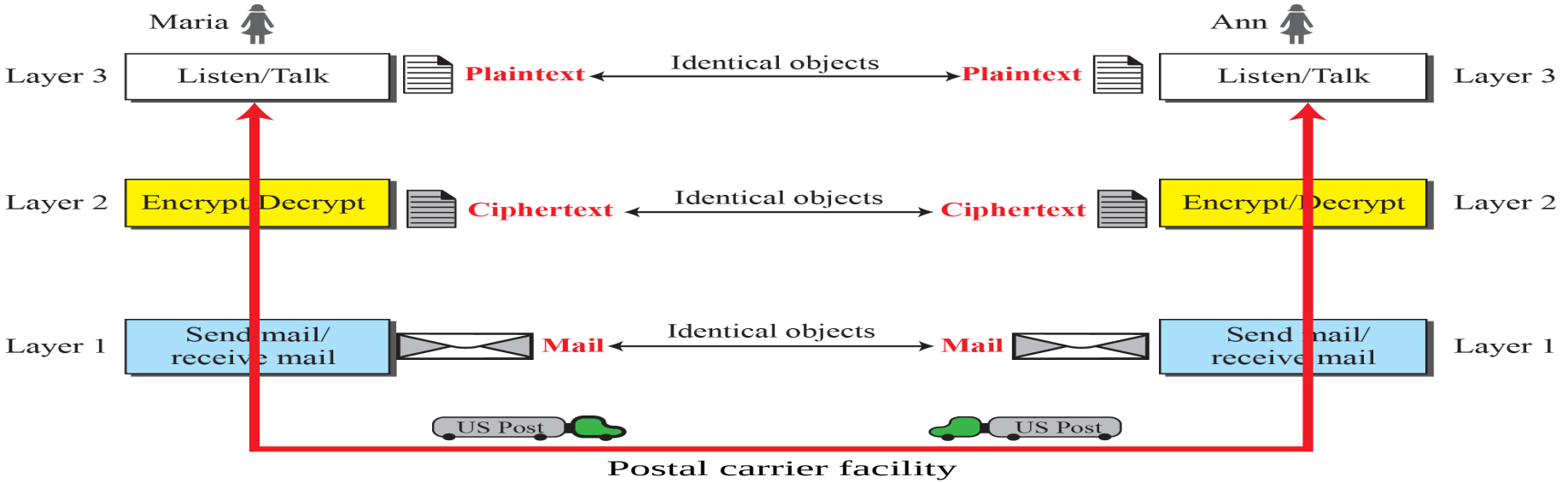
Scenario -1

- Figure 1.9: A single-layer protocol (Simple Communication)

- Note: 1. set of rules needs to be followed
  2. Steps: a. Both needs greet each other
     b. confine their vocabulary to the level of their friendship
     c. Refrain from speaking when the other party is speaking
     d. each party knows that the conversion (completely)
     e. exchange some nice words when they leave
-

Scenario -2

- Figure 1.10: A three-layer protocol



- Main focus on layering – exchange of Email done through layering using encrypt and decrypt techniques for secure communication.
- Protocol layering enables us to divide a complex task into several smaller and simpler tasks
- **Modularity:** Indicates as independent layers for maintaining secrecy (Ex: Ann and Maria has decided to have new layer instead of believing layer 2 – they buy one dedicated machine to do the same)

Principle of Protocol Layering

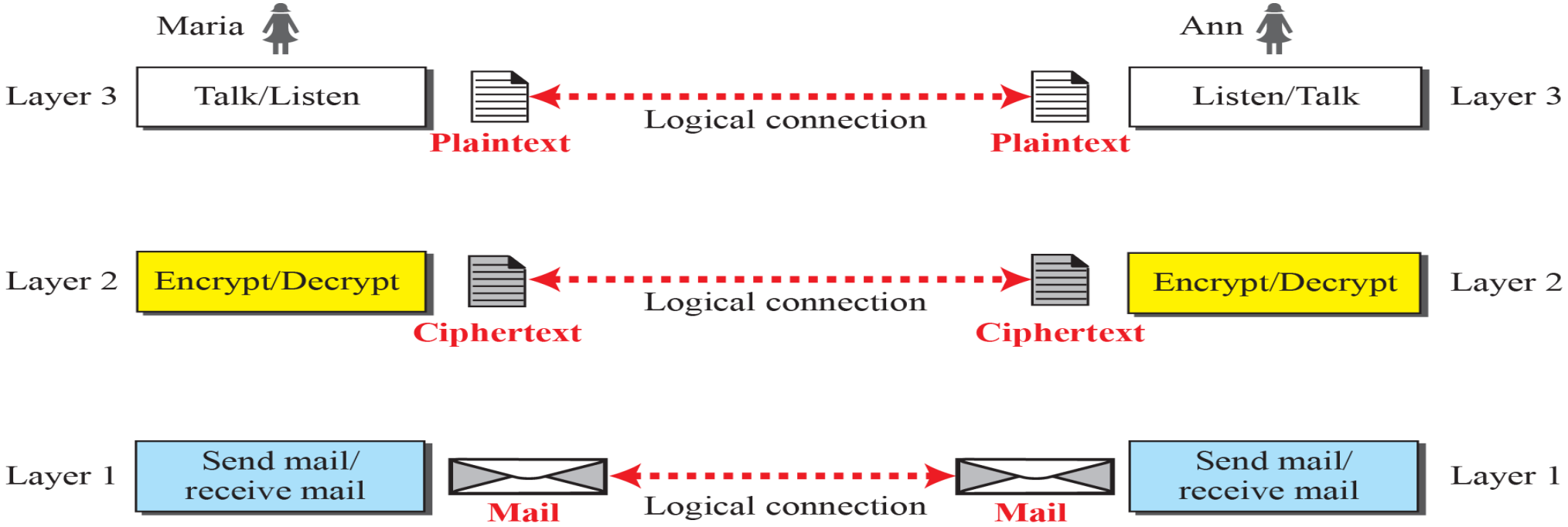
- For Bidirectional communication - make each layer able to perform two opposite tasks (one in each direction)

Ex: Third layer task is to listen (in one direction) and talk (in the other direction

- Two objects under each layer at both sites should be identical

  Ex: Layer 3 at both sites should be a plaintext letter.

Figure 1.11: Logical connection between peer layers

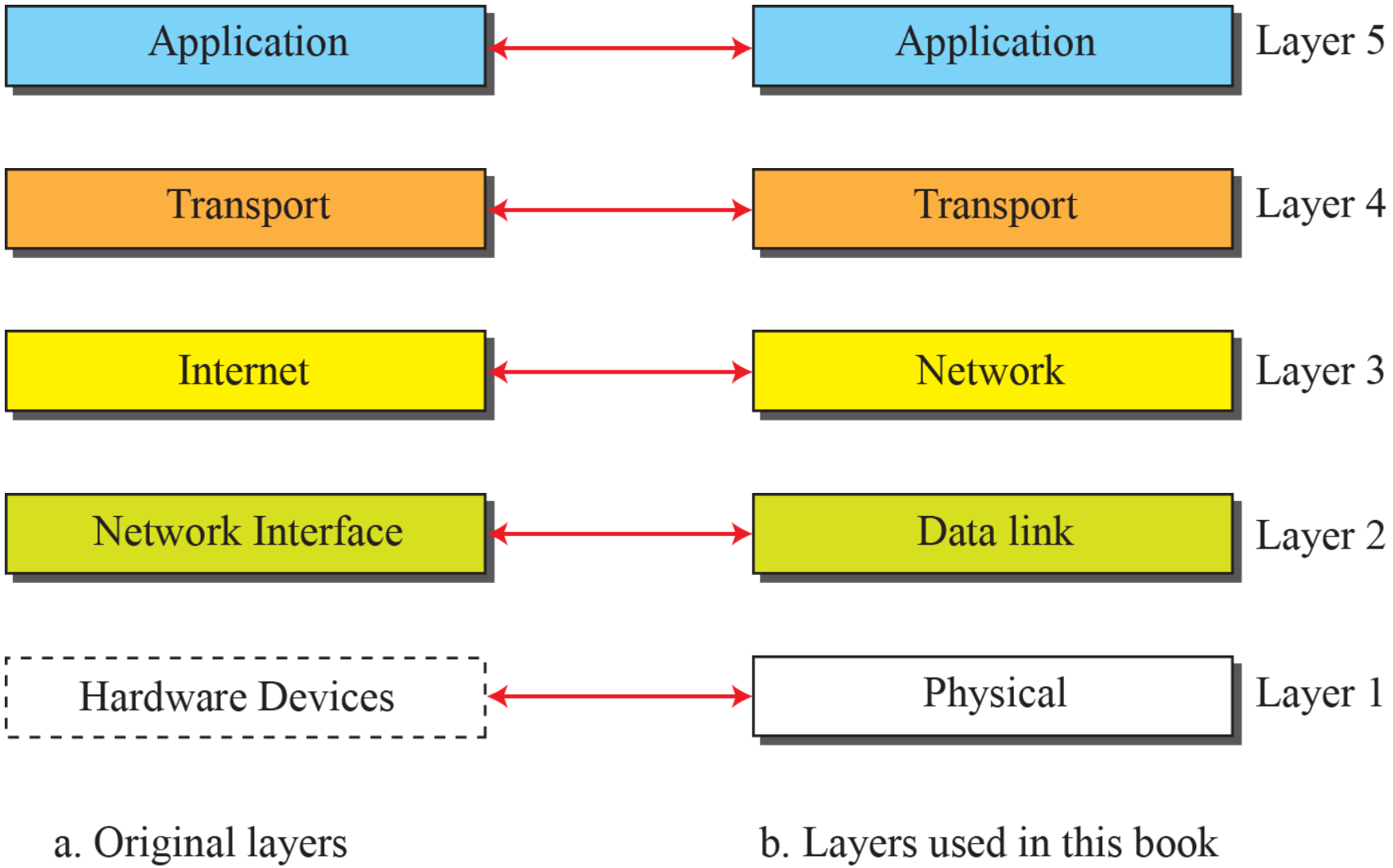


- layer-to-layer communication.
- Maria and Ann can think that there is a logical (imaginary) connection at each layer through which they can send the object created from that layer

1.2.2 TCP/IP Protocol Suite

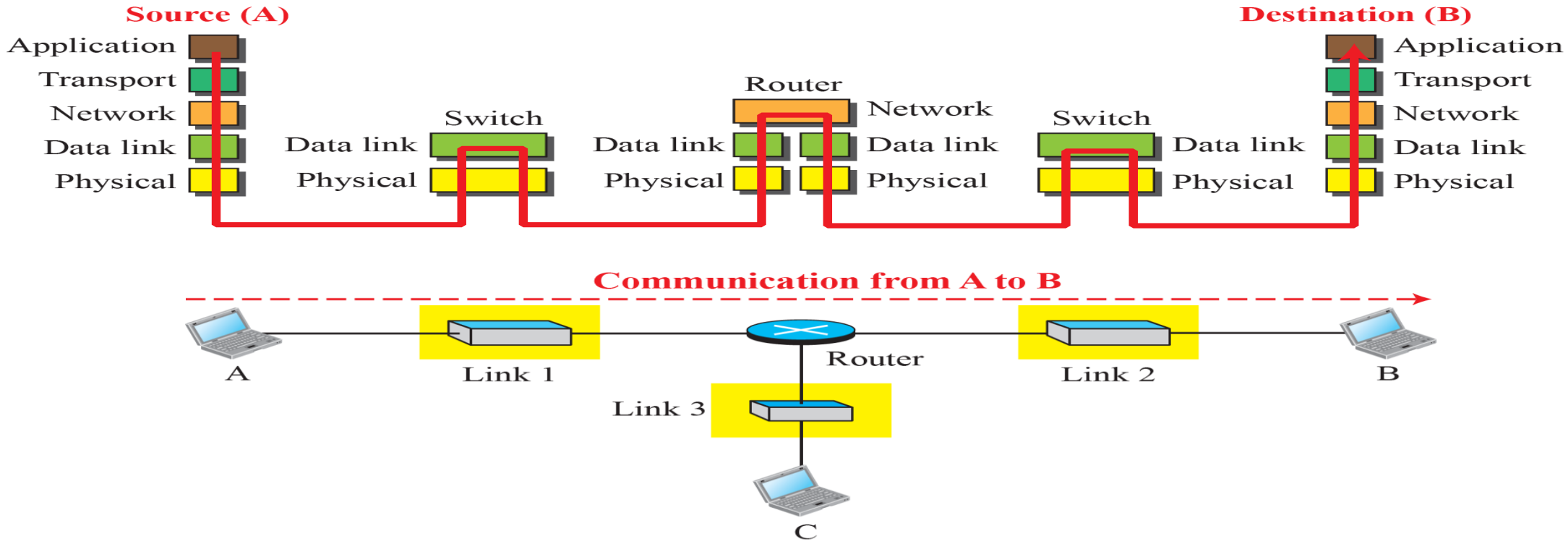
- It is a hierarchical protocol made up of interactive modules, each provides a specific functionality
- The term hierarchical means that each upper level protocol is supported by the services provided by one or more lower level protocols
- original TCP/IP protocol suite was defined as four software layers built upon the hardware. TCP/IP is thought of as a five-layer model.

- Figure 1.12: Layers in the TCP/IP protocol suite



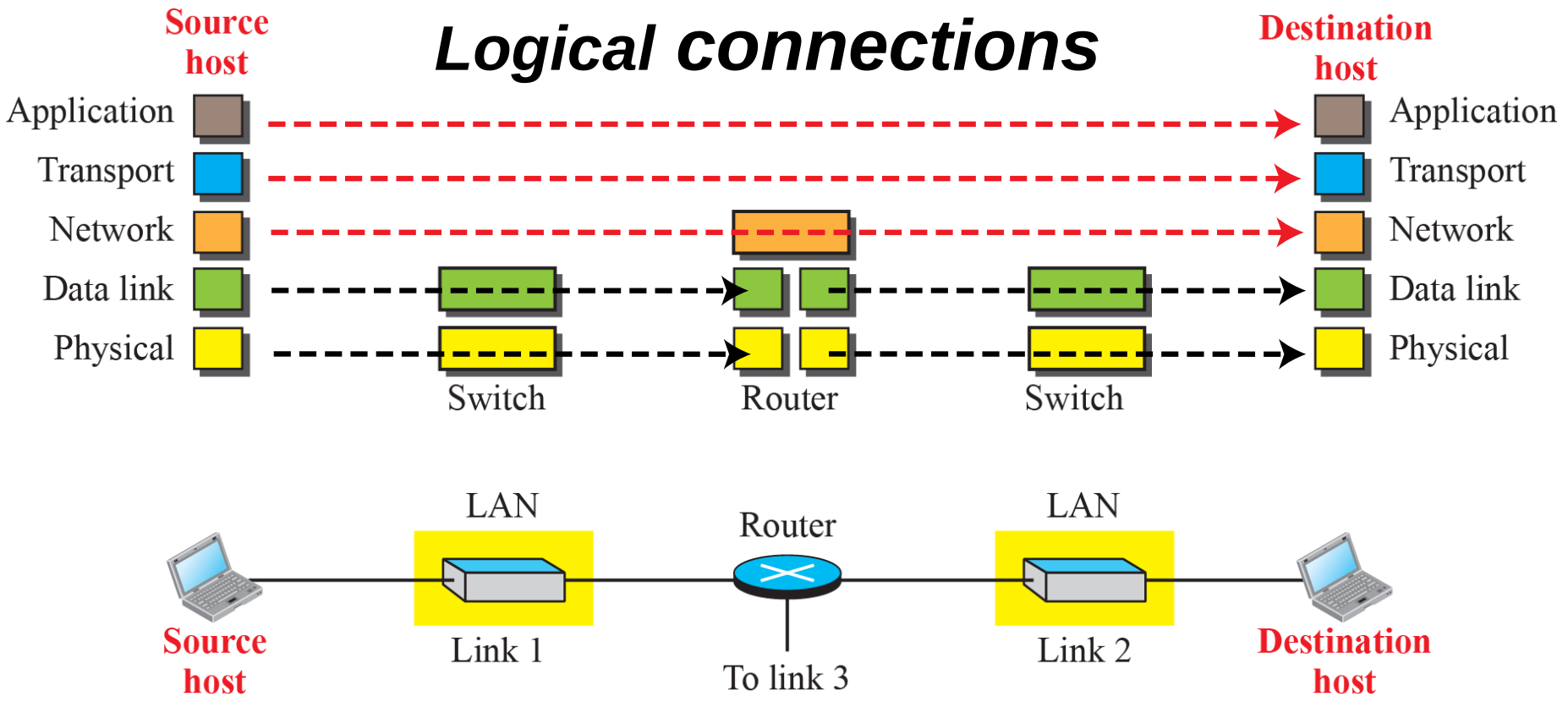
- *Layered Architecture*

Figure 1.13: **Communication through an internet**



- Shows the communication between two hosts
- Scenario: "Src A" communicates with computer "Destination B" - five communicating devices –

Figure 1.14: Logical connections between layers in TCP/IP



- shows logical connections between layers

Advantage: easier to think about the duty of each layer.

Functions of TCP/IP

- Transmission Control Protocol/Internet Protocol (TCP/IP) are two different communication protocols
- TCP splits a message to packets which were transmitted across the internet whereas the IP is accountable to address of every packet hence a chance to forward the exact destination
- Therefor main function of TCP/IP is to govern how the information is sent and received in the form of packets between source and destination.
- Layers functionality:
  1. Application layer:
     - Top most layer
     - Acts as an interface between the application programs
     - Uses protocols like SMTP, HTTP, HTTPS, FTP, NTP, SSH, Telnet SNMP

2. Internet Layer:

- main responsibility of the internet layer is to send the packets from any network, and they arrive at the destination irrespective of the route they take.

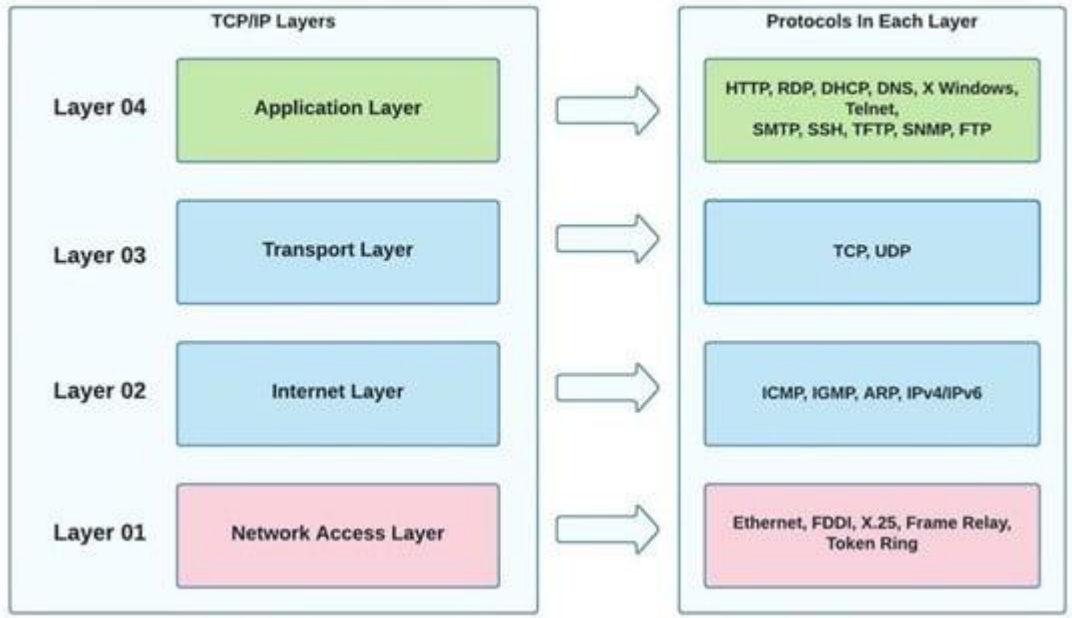
3. Network Layer:

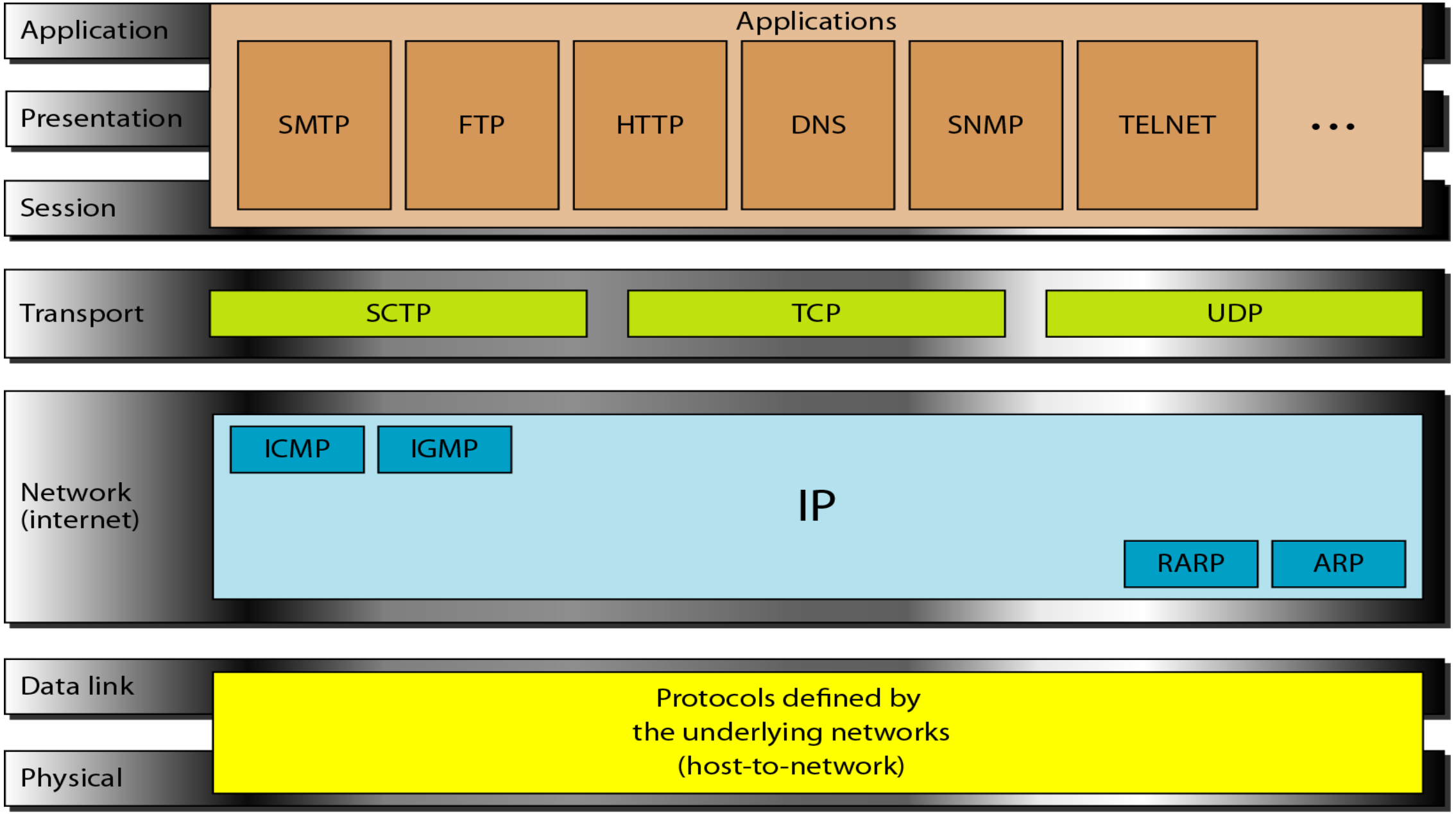
- Hardware addressing is done at this layer
- defines protocols for physical transmission of data.
- Ethernet is the most important protocol used at this layer.

4. Transport Layer:

  - responsible for the reliability, flow control, and correction of data which is being sent over the network.
  - The two protocols used in the transport layer are **User Datagram protocol and Transmission control protocol**.
  - **User Datagram Protocol (UDP):** It provides connectionless service and end-to-end delivery of transmission.
  - **Transmission Control Protocol (TCP):**provides a full transport layer services to applications. creates a virtual circuit between the sender and receiver, and it is active for the duration of the transmission.

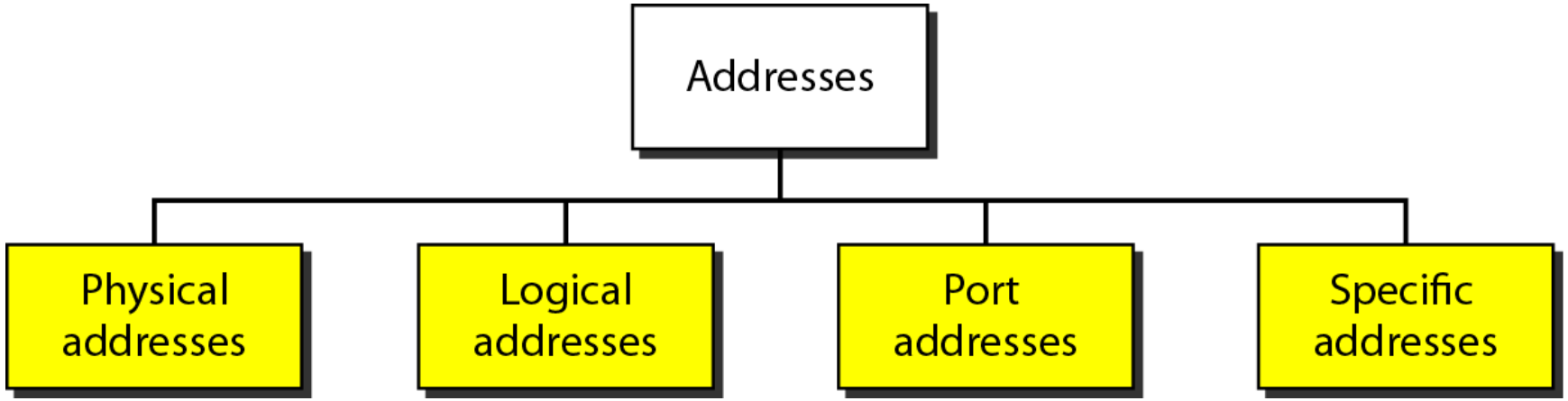
TCP/IP Model


TCP/IP Layers
Protocols In Each Layer
Layer 04
Application Layer
HTTP, RDP, DHCP, DNS, X Windows, Telnet,
SMTP, SSH, TFTP, SNMP, FTP
Layer 03
Transport Layer
TCP, UDP
Layer 02
Internet Layer
ICMP, IGMP, ARP, IPv4/IPv6
Layer 01
Network Access Layer
Ethernet, FDDI, X.25, Frame Relay, Token Ring

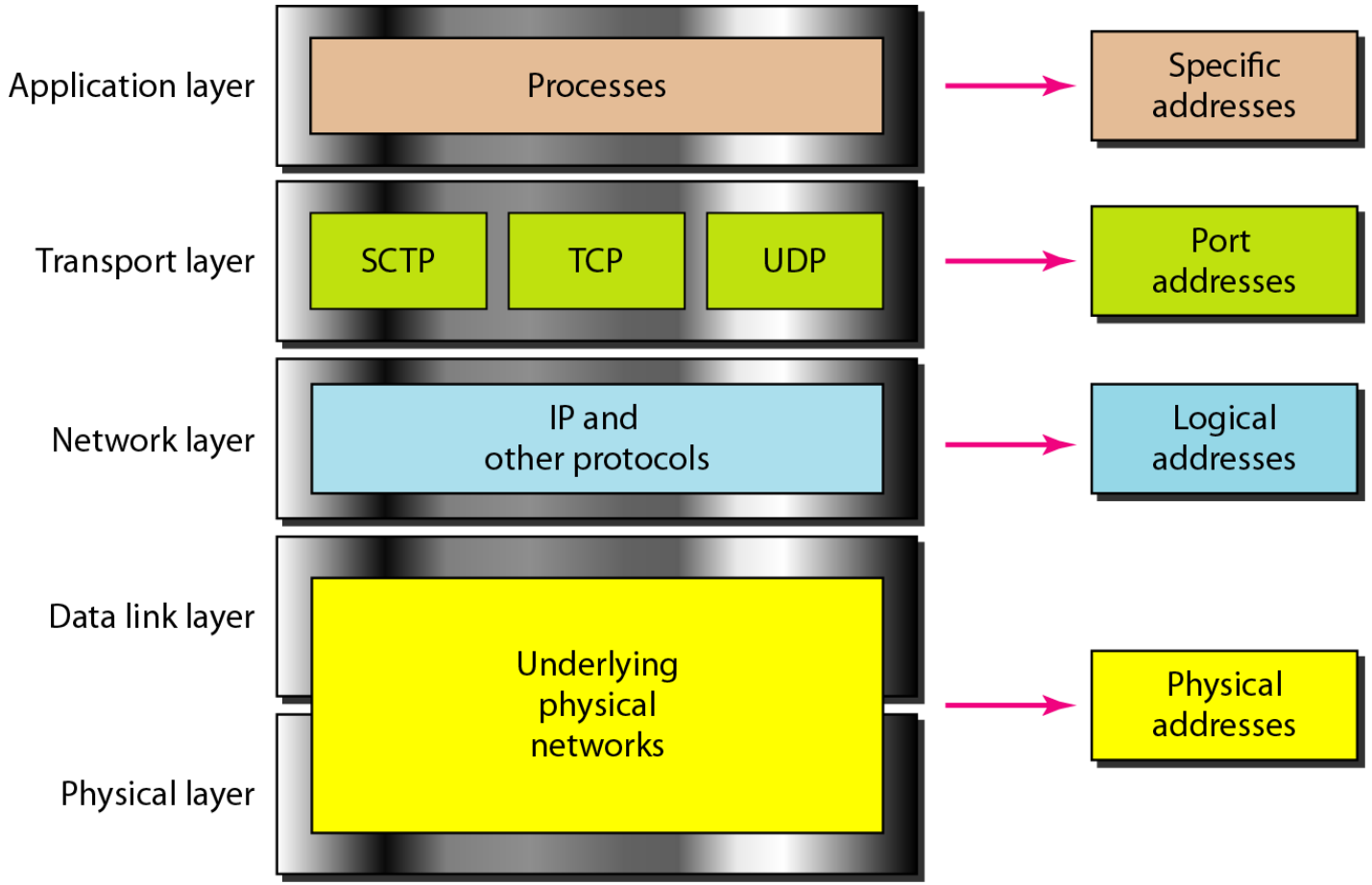

Application
Presentation
Session
Applications
SMTP
FTP
HTTP
DNS
SNMP
TELNET
• • •
Transport
SCTP
TCP
UDP
Network
(internet)
ICMP
IGMP
IP
RARP
ARP
Data link
Physical
Protocols defined by
the underlying networks
(host-to-network)

ADDRESSING

- ***Four levels of addresses are used in an internet employing the TCP/IP protocols: physical, logical, port, and specific.***
-



Relationship of layers and addresses in TCP/IP



1.2.2 TCP/IP Protocol Suite (continued)

- Encapsulation and Decapsulation
  - Encapsulation at the Source Host
  - Decapsulation and Encapsulation at Router
  - Decapsulation at the Destination Host
- Addressing
- Multiplexing and Demultiplexing

Figure 1.16: Encapsulation / Decapsulation

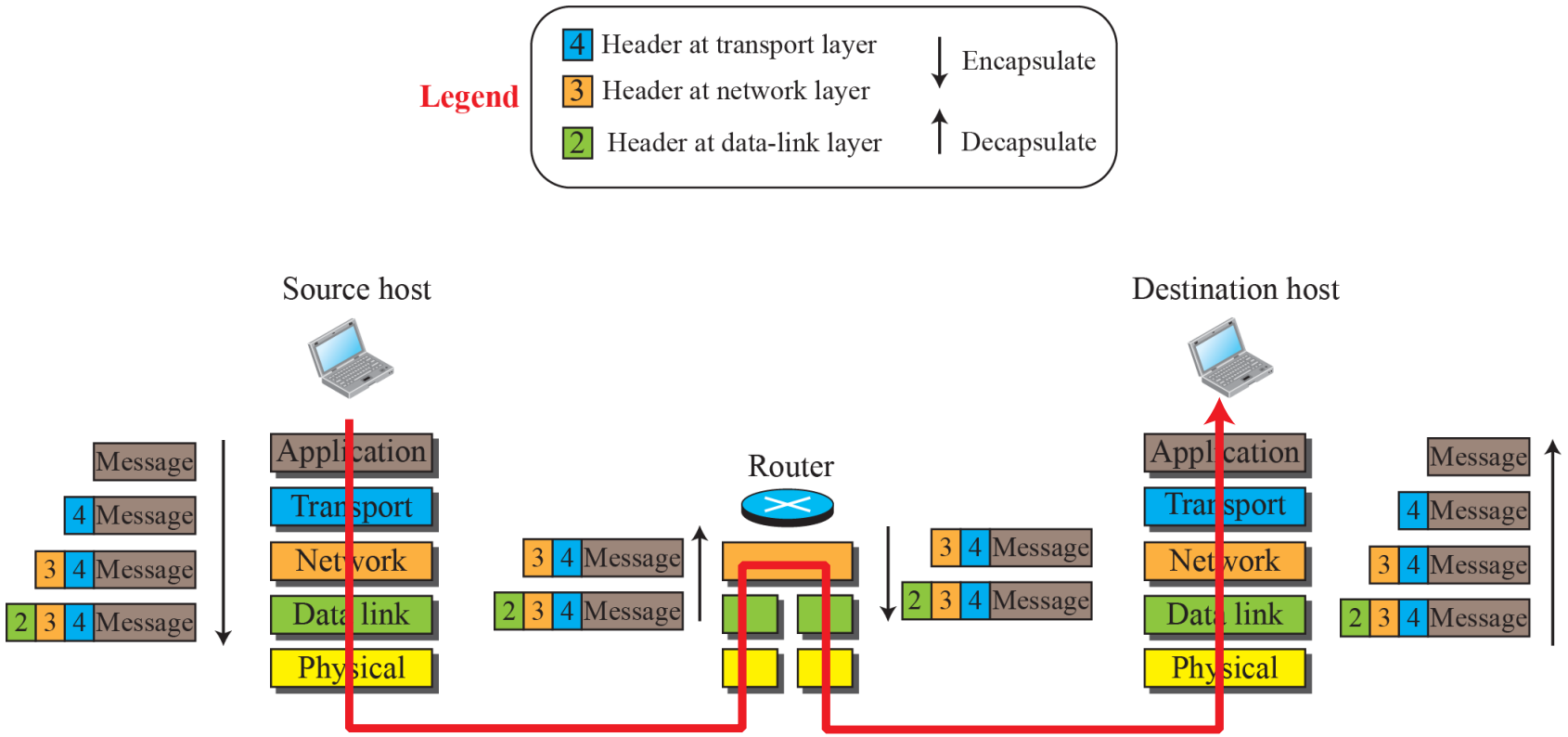


Figure 1.17: Addressing in the TCP/IP protocol suite

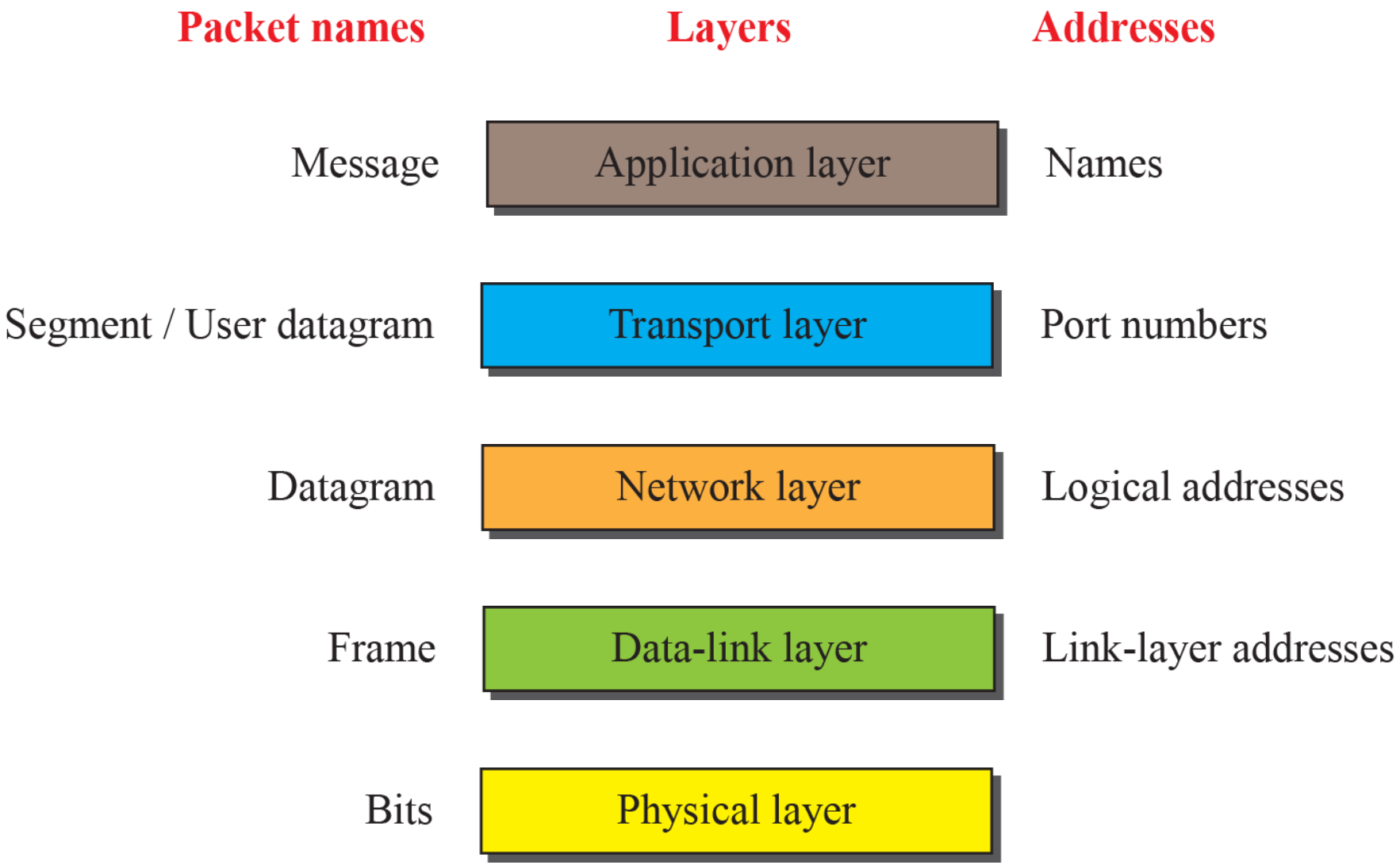
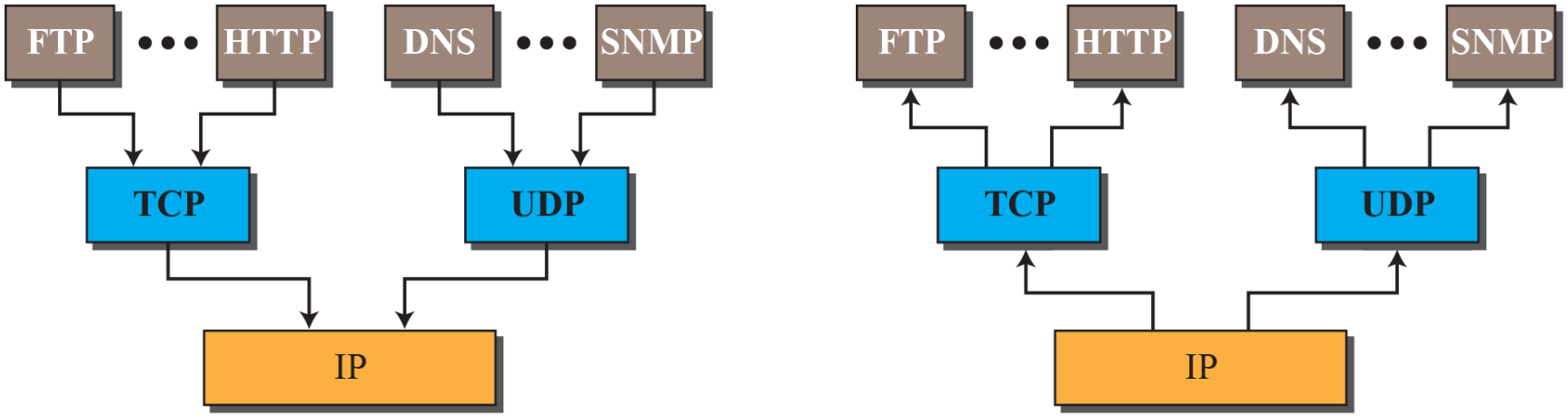


Figure 1.18: Multiplexing and demultiplexing



a. Multiplexing at source

b. Demultiplexing at destination

1.2.2 The OSI Model

Established in 1947, ISO is a multinational body dedicated to worldwide agreement on international standards. 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.

- OSI versus TCP/IP

- Lack of OSI Model's Success

Figure 1.19: ***The OSI model***

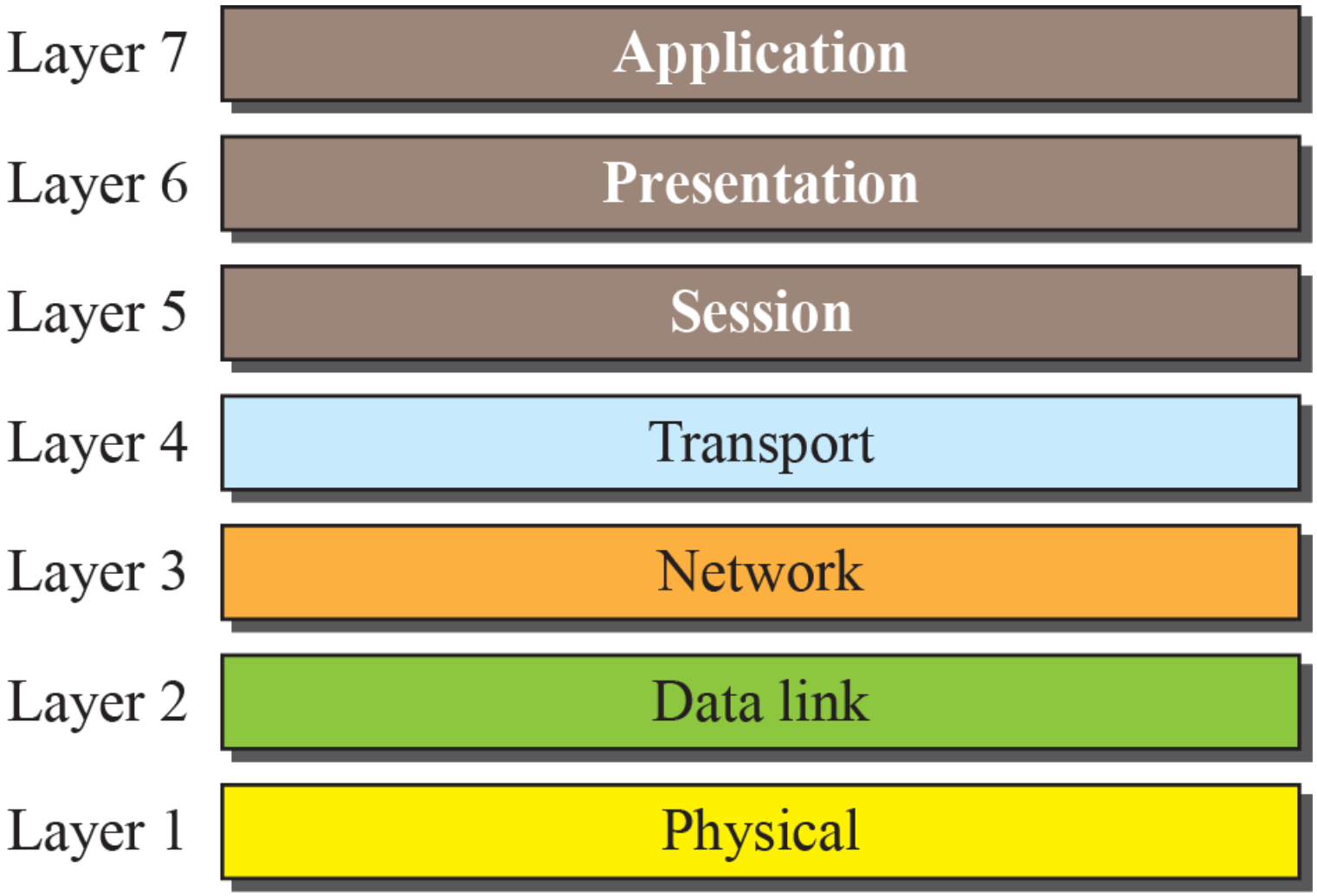
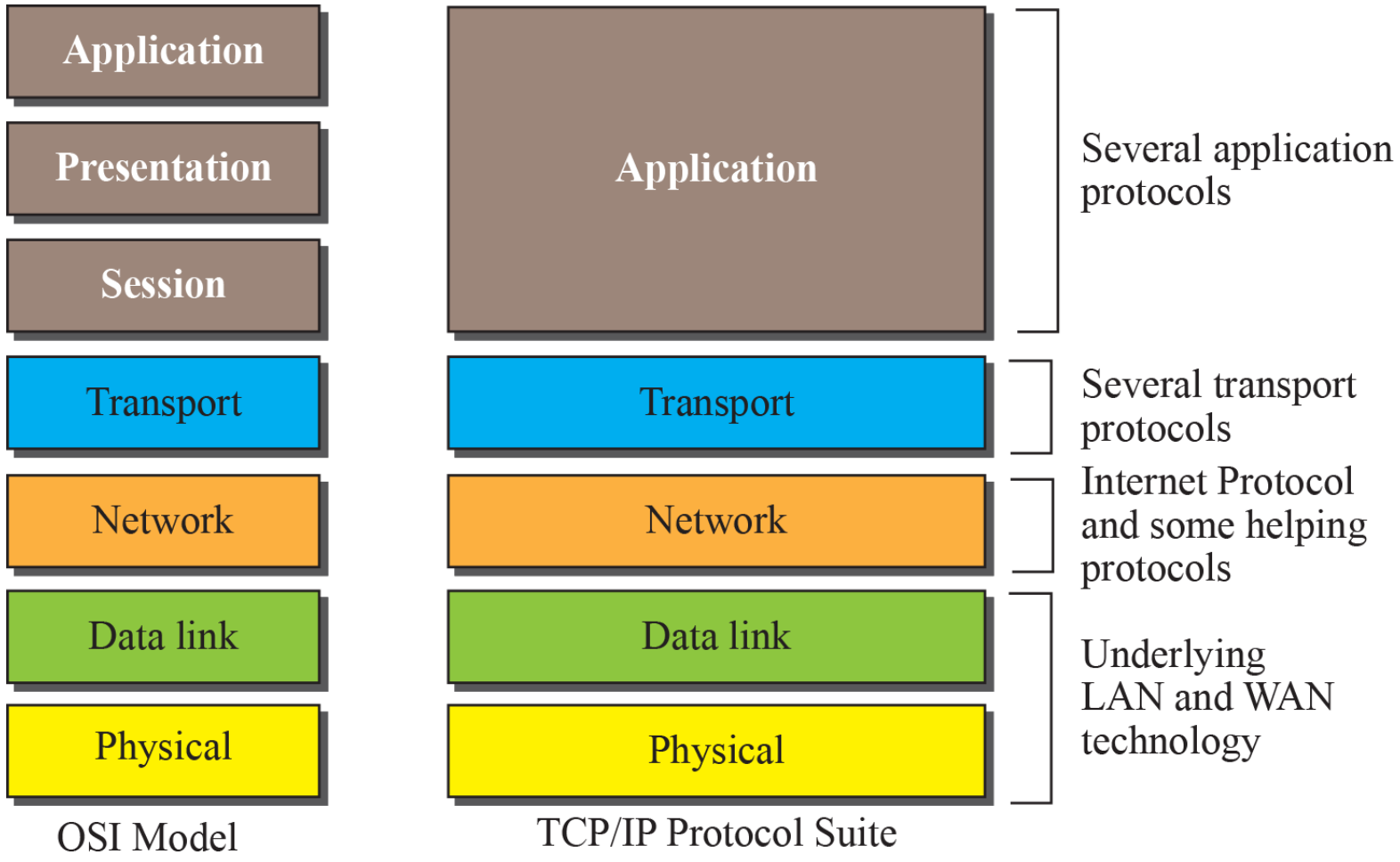


Figure 1.20: TCP/IP and OSI model



1-3 INTERNET HISTORY

Now that we have given an overview of the Internet and its protocol, let us give a brief history of the Internet. This brief history makes it clear how the Internet has evolved from a private network to a global one in less than forty years.

1.3.2 Early History

There were some communication networks, such as telegraph and telephone networks, before 1960. These networks were suitable for constant-rate communication at that time, which means that after a connection was made between two users, the encoded message (telegraphy) or voice (telephony) could be exchanged.

- Birth of Packet-Switched Networks

- ARPANET

1.3.3 Birth of the Internet

In 1972, Vint Cerf and Bob Kahn, both of whom were part of the core ARPANET group, collaborated on what they called the Internetting Project. They wanted to link dissimilar networks so that a host on one network could communicate with a host on another. There were many problems to overcome: diverse packet sizes, diverse interfaces, and diverse transmission rates, as well as differing reliability requirements.

1.3.3 Birth of the Internet (continued)

- TCP/IP
- MILNET
- CSNET
- NSFNET
- ANSNET

1.3.3 Internet Today

Today, we witness a rapid growth both in the infrastructure and new applications. The Internet today is a set of pier networks that provide services to the whole world. What has made the Internet so popular is the invention of new applications.

- World Wide Web
- Multimedia
- Peer-to-Peer Applications

1-4 STANDARDS AND ADMINISTRATION

In the discussion of the Internet and its protocol, we often see a reference to a standard or an administration entity. In this section, we introduce these standards and administration entities for those readers that are not familiar with them; the section can be skipped if the reader is familiar with them.

1.4.1 Internet Standards

An Internet standard is a thoroughly tested specification that is useful to and adhered to by those who work with the Internet. It is a formalized regulation that must be followed. There is a strict procedure by which a specification attains Internet standard status. A specification begins as an Internet draft.

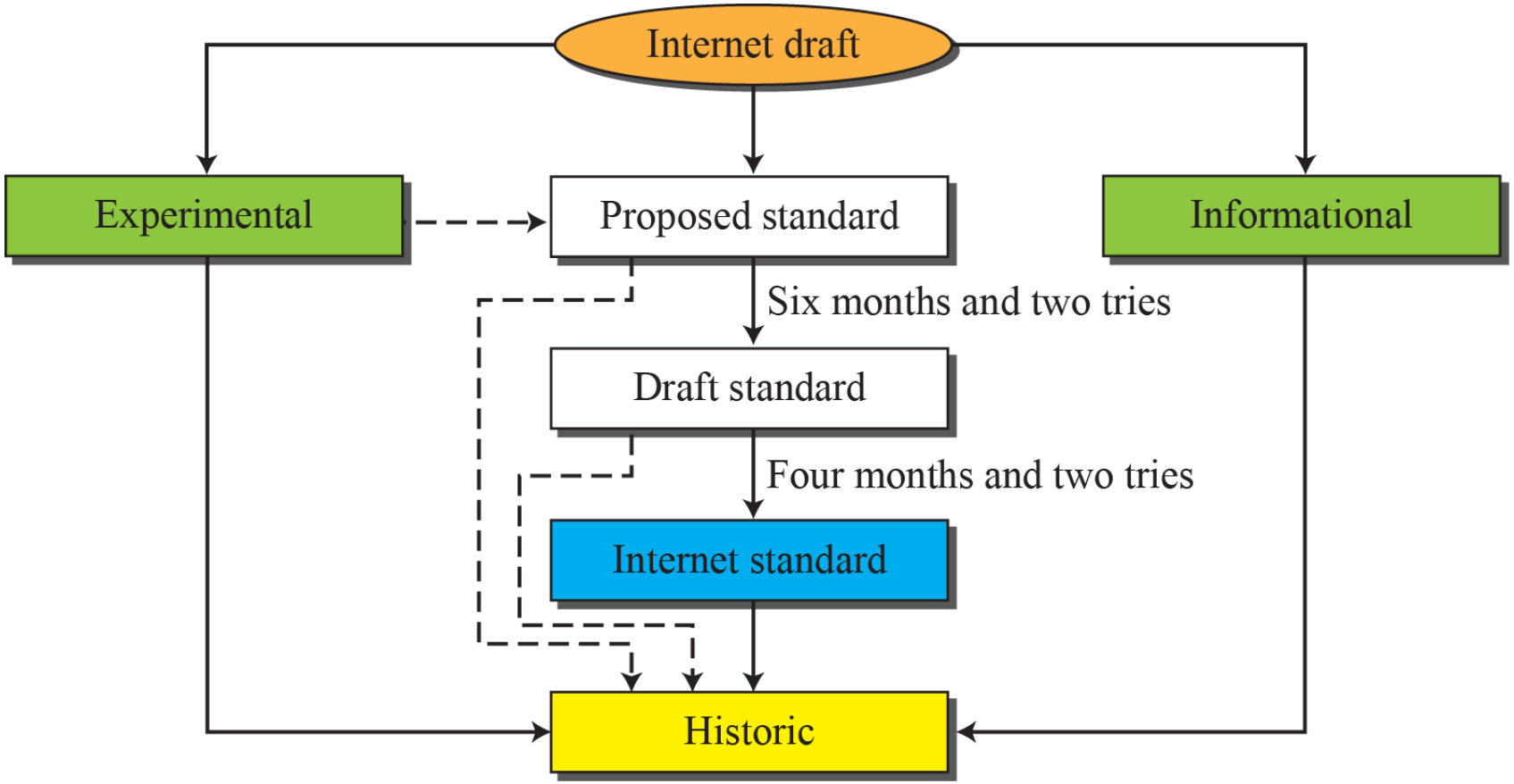
1.4.1 Internet Standards (Continued)

- Maturity Levels
  - Proposed Standard
  - Draft Standard
  - Internet Standard
  - Historic
  - Experimental
  - Informational

1.4.1 Internet Standards (Continued)

- Requirement Levels
  - Required
  - Recommended
  - Elective
  - Limited Use
  - Not Recommended

Figure 1.21: Maturity levels of an RFC



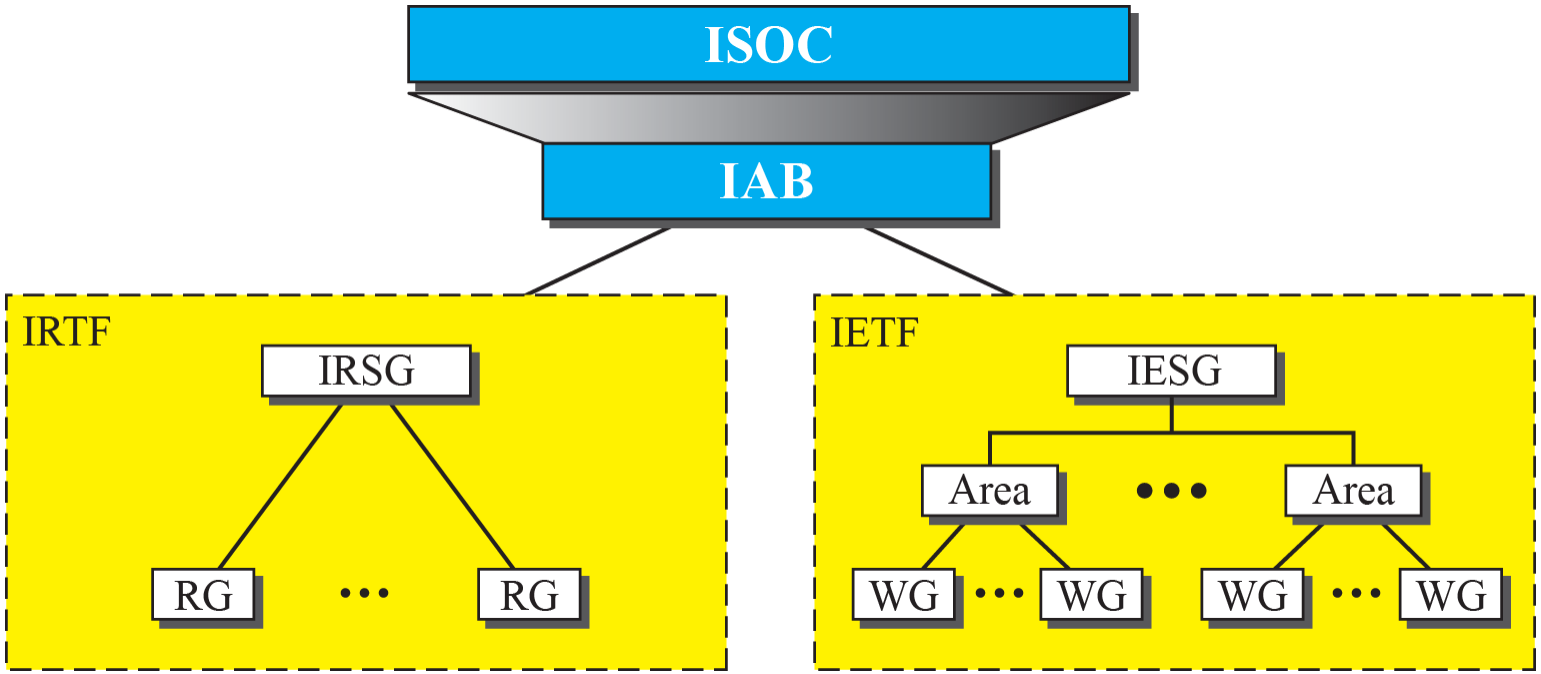
1.4.2 Internet Administration

The Internet, with its roots primarily in the research domain, has evolved and gained a broader user base with significant commercial activity. Various groups that coordinate Internet issues have guided this growth and development. Appendix D gives the addresses, e-mail addresses, and telephone numbers for some of these groups.

1.4.2 Internet Administration (continued)

- ISOC
- IAB
- IETF
- IANA and ICANN
- Network Information Center (NIC)

Figure 1.22: Internet administration



Chapter 1: Summary

- ***A network is a set of devices connected by communication links. The Internet today is made up of many wide and local area networks joined by connecting devices and switching stations. Most end users who want Internet connection use the services of Internet service providers (ISPs). There are backbone ISPs, regional ISPs, and local ISPs.***

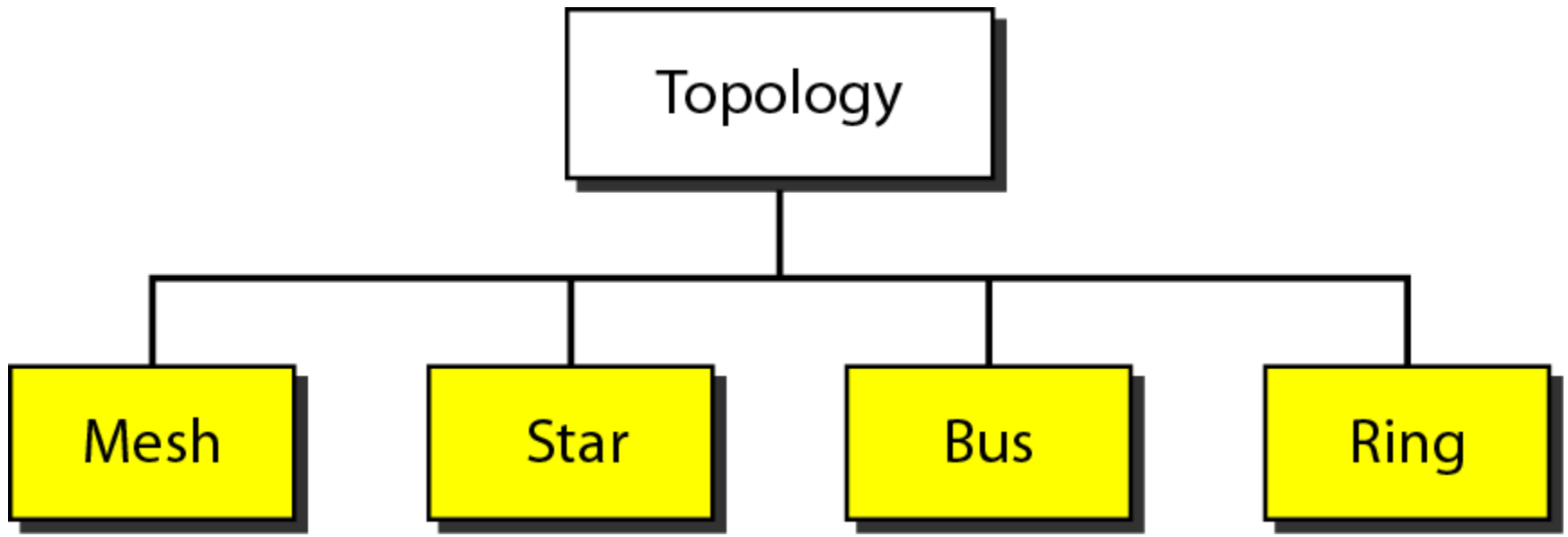
- ***A protocol is a set of rules that governs communication. In protocol layering, we need to follow two principles to provide bidirectional communication. First, each layer needs to perform two opposite tasks. Second, two objects under each layer at both sides should be identical. TCP/IP is a hierarchical protocol suite made of five layers: application, transport, network, data-link, and physical.***

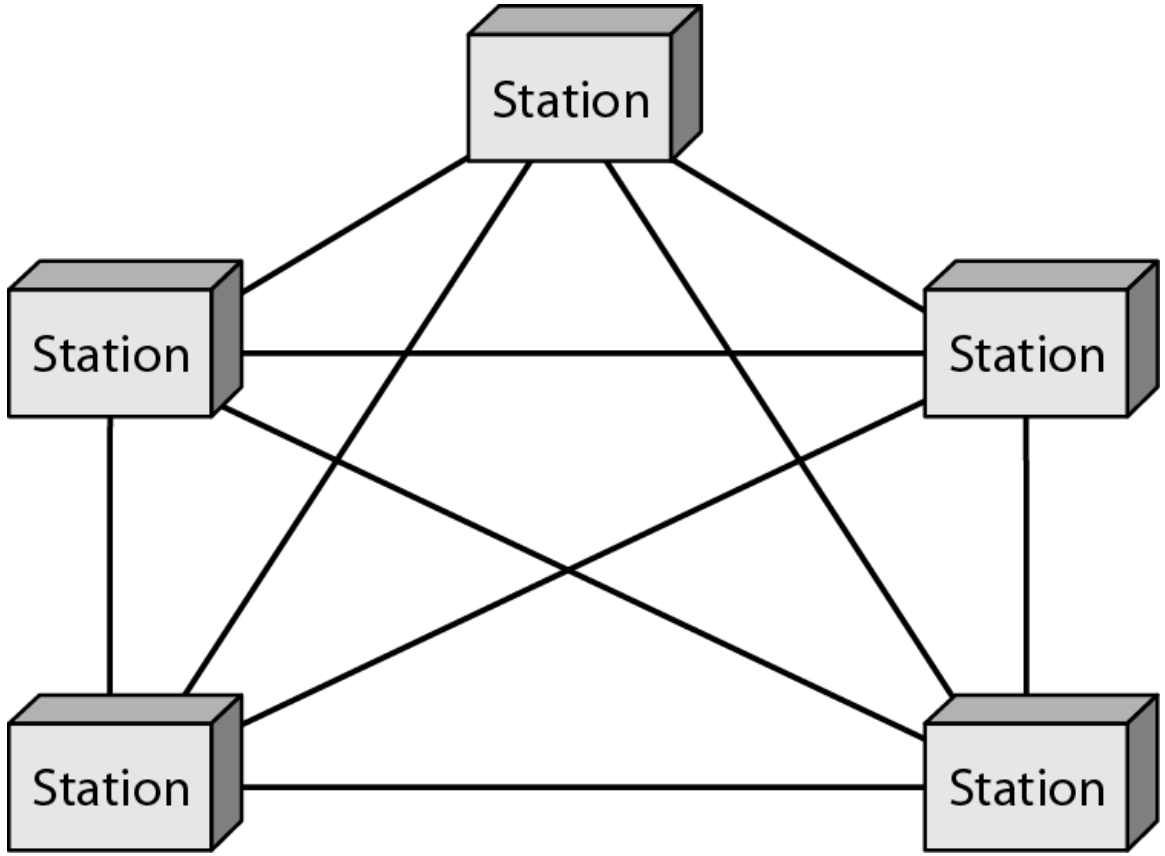
Chapter 1: Summary (continued)

- ***The history of internetworking started with ARPA in the mid-1960s. The birth of the Internet can be associated with the work of Cerf and Kahn and the invention of a gateway to connect networks. The Internet administration has evolved with the Internet. We discussed ISOC, IAB, IETF, IRTF, ICANN, and NIC.***

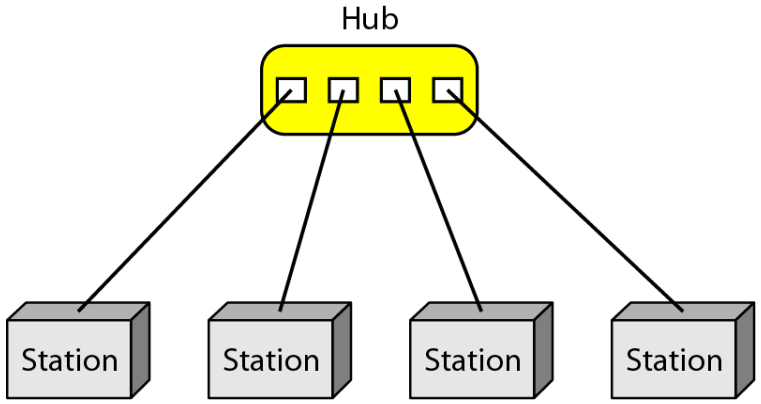
- ***An Internet standard is a thoroughly tested specification. An Internet draft is a working document with no official status and a six-month lifetime. A draft may be published as a Request for Comment (RFC). RFCs go through maturity levels and are categorized according to their requirement level.***

Categories of topology

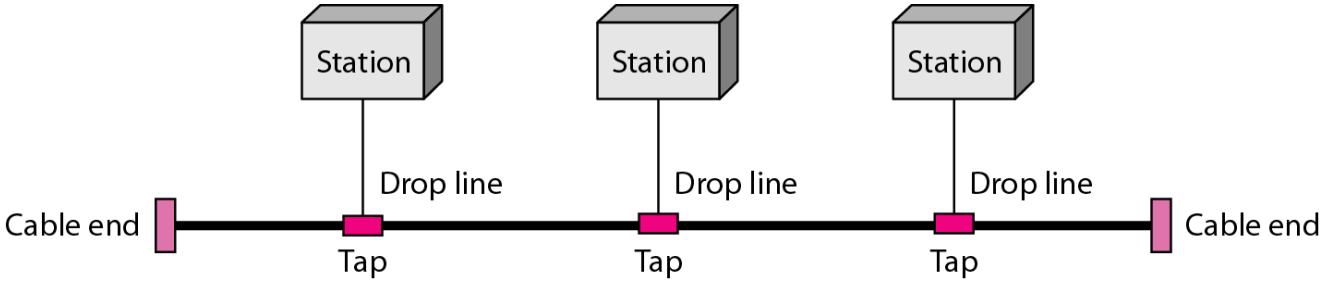




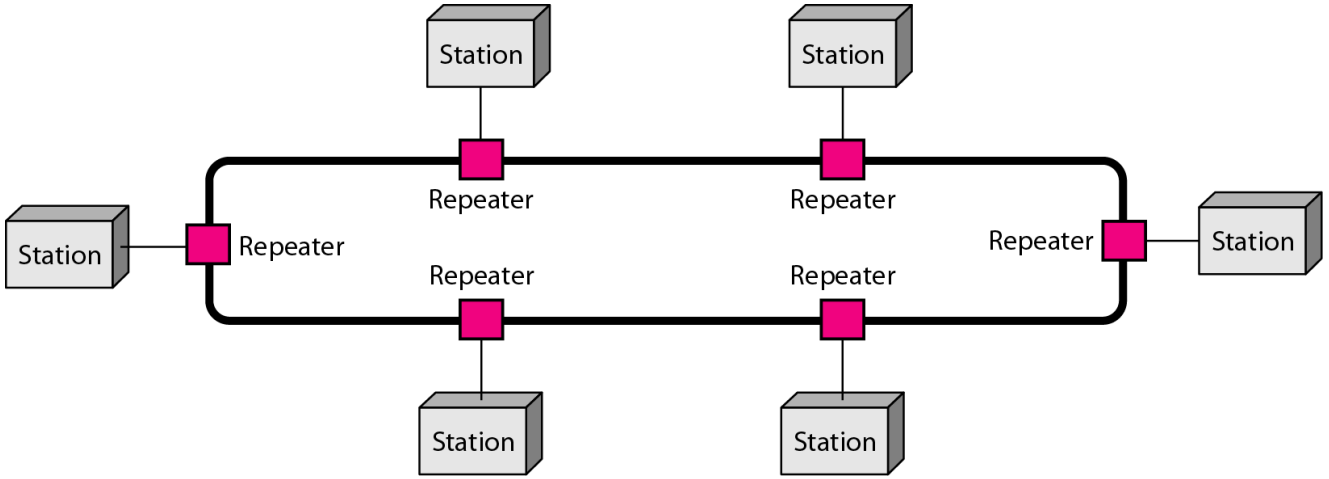
fully connected mesh topology (five devices)



A star topology connecting four stations



bus topology connecting three stations



Ring topology connecting six stations