SEOULTECH

Lecture 02
Introduction & Network Models

09/12/2022 & 09/15/2022

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Course Schedule (Tentative)

- FL: Flipped learning
- **Rec: Recorded video for makeup class**

No	Topics	Date-M		Date-Th	
1	Introduction to course and data communications (Ch1)	09/05	FL (**Zoom**)	09/08	FL
2	Intro. to data communications (Ch1) & Network models (Ch2)	09/12	**Rec**	09/15	FL
3	Intro. to physical layer (Ch3)	09/19	FL	09/22	FL
4	Digital transmission (Ch4)	09/26	FL	09/29	FL
5	Analog transmission (Ch5) & Bandwidth utilization: multiplexing (Ch6.1)	10/03	**Rec**	10/06	**Rec**
6	Bandwidth utilization: spread spectrum (Ch6.2) Transmission Media (Ch7)	10/10	**Rec**	10/13	FL
7	Switching (Ch8) Introduction to Data-Link Layer (Ch9)	10/17	FL	10/20	FL
8	**Midterm exam**	**10/24**	**Evening**	**10/24**	**Evening**
9	Error detection and correction (Ch10)	10/31	FL	11/03	FL
10	Data link control (Ch11)	11/07	FL	11/10	FL
11	Media Access Control (Ch12)	11/14	FL	11/17	**Rec**
12	Wired LAN (Ethernet) (Ch13) & Other wired network (Ch14)	11/21	**Rec**	11/24	FL
13	Wireless LAN (Ch15)	11/28	FL	12/01	FL
14	Other wireless networks (Ch16) Connecting devices and virtual LANs (Ch17)	12/05	FL	12/08	FL
15	**Final exam**	**12/12**	**Evening**	**12/12**	**Evening**

OUTLINES

- Chapter 1
  - Data Communications
  - Networks
  - Network Types
  - Internet History
  - Standards and Administration
- Chapter 2
  - Data Communications
  - Protocol Layering
  - TCP/IP Protocol Suite
  - OSI Model
- Summary & Next class

Ch 1 Introduction

: Data Communications, Networks, Network Types, Internet History, Standards and Administration

- Ch 1 Introduction
- Ch 2 Network models
- Summary & Next Class

Ch 1 Objective

- The first section: Data Communications
  - Introduces data communications and defines their components and the types of data exchanged. It also shows how different types of data are represented and how data is flowed through the network.

- The second section: Networks
  - Introduces networks and defines their criteria and structures. It introduces four different network topologies that are encountered throughout the book.

- The third section: Network Types
  - Discusses different types of networks: LANs, WANs, and internetworks (internets). It also introduces the Internet, the largest internet in the world. The concept of switching is also introduced in this section to show how small networks can be combined to create larger ones.

Ch 1 Objective

- The fourth section: Internet History
  - Covers a brief history of the Internet. The section is divided into three eras: early history, the birth of the Internet, and the issues related to the Internet today. This section can be skipped if the reader is familiar with this history.

- The fifth section: Standards and Administration
  - Covers standards and standards organizations. The section covers Internet standards and Internet administration. We refer to these standards and organizations throughout the book

1-2 Networks

- A network is the interconnection of a set of devices capable of communication.
  - In this definition, a device can be a host such as a large computer, desktop, laptop, workstation, cellular phone, or security system.
  - A device in this definition can also be a connecting device such as a router a switch, a modem that changes the form of data, and so on.

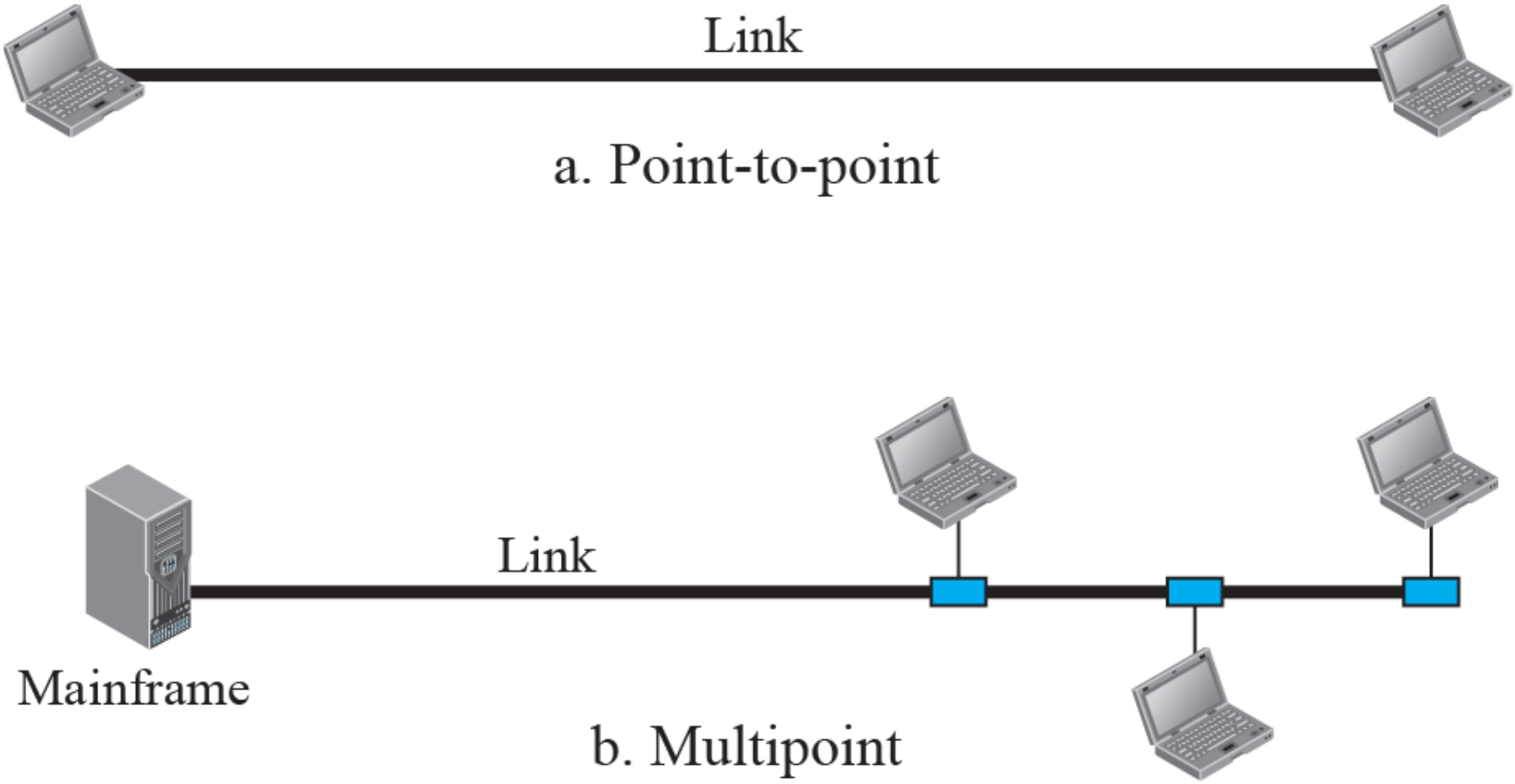
1.2.1 Network Criteria

- A network must be able to meet a certain number of criteria. The most important of these are performance, reliability, and security.
  - Performance: measured by
    - Transit time: the amount of time required for a message to travel from one device to another
    - Response time: the elapsed time between an inquiry and a response
    - Metrics: Throughput & Delay
  - Reliability: measured by
    - The frequency of failure
    - The time it takes a link to recover from a failure
    - The network's robustness in a catastrophe
  - Security
    - Protecting data from unauthorized access
    - Protecting data from damage and development
    - Implementing policies and procedures for recovery from breaches and data losses

1.2.2 Physical Structures

- A network is two ore more devices connected through links
  - Link: a communications pathway that transfers data from one device to another
- Two possible types of connections
  - Point-to-point connection:
    - A dedicated link between two devices
    - Using an actual length of wire or cable, microwave or satellite links
  - Multipoint (also called multidrop) connection
    - More than two specific devices share a single link

1.2.2 Physical Structures



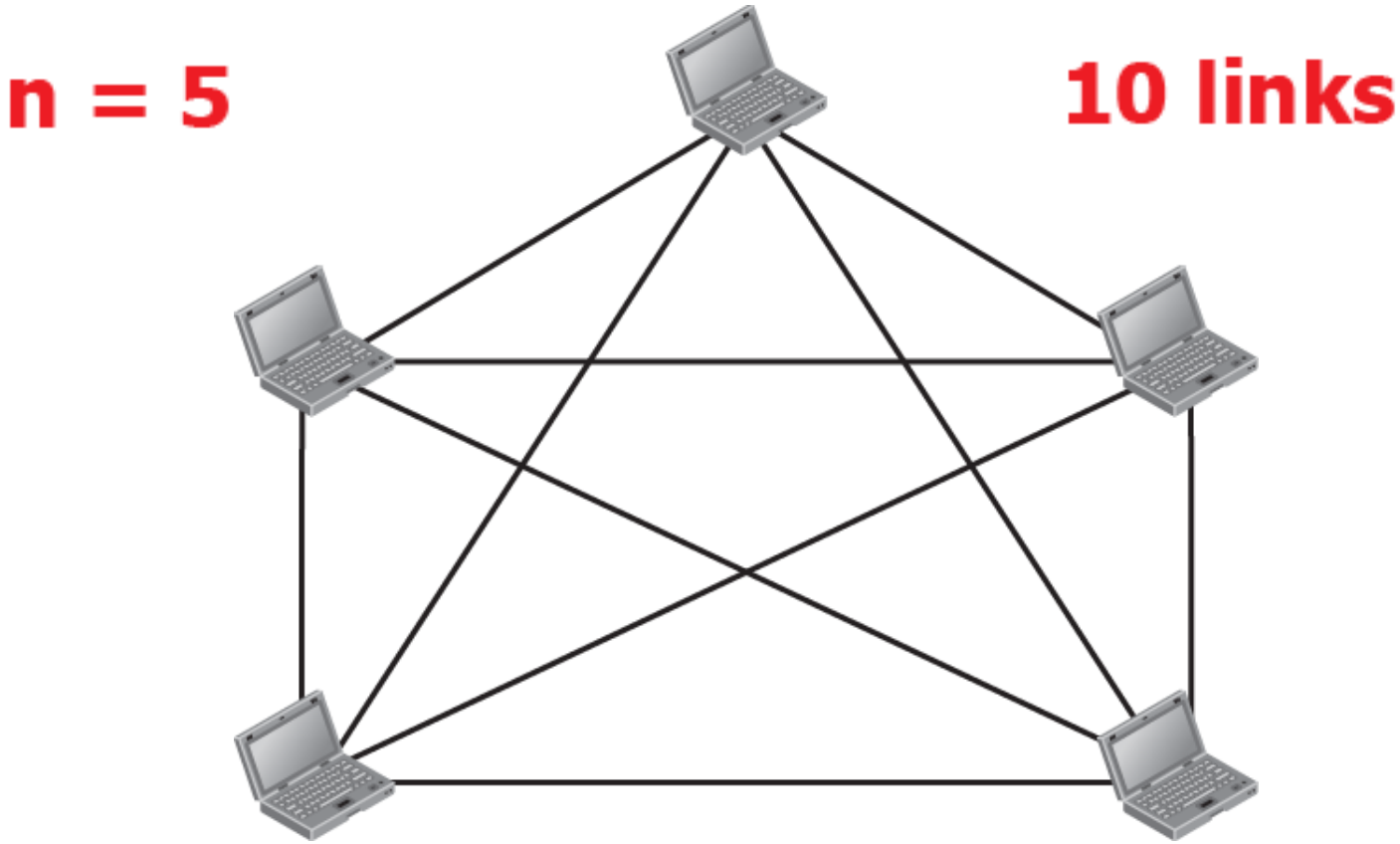
1.2.2 Physical Structures

- Physical topology
  - The way in which a network is laid out physically
  - The topology of a network: the geometric representation of the relationship of all the links and linking devices (usually called nodes) to one another
  - Mesh, star, bus, and ring topologies

1.2.2 Physical Structures

- Mesh topology
  - Every device has a dedicated point-to-point link to every other device
  - The number of physical links in a fully connected mesh network with n nodes: n(n-1)
    - In duplex mode: n(n-1)/2
  - Advantages
    - Eliminating the traffic problems, Robust, Secure, Easy fault identification & isolation
  - Disadvantages
    - The amount of cabling and number of I/O ports
  - Practical example
    - The connection of telephone regional offices

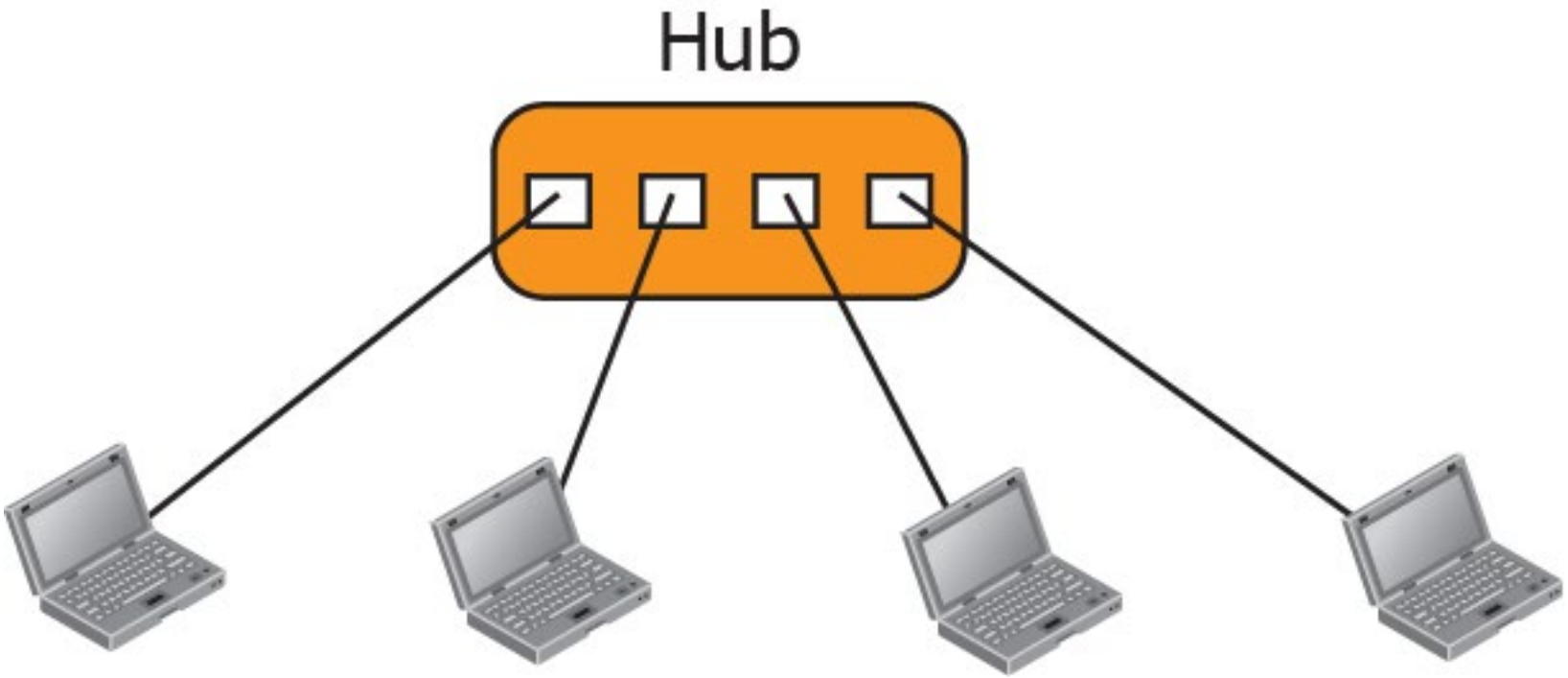
1.2.2 Physical Structures



1.2.2 Physical Structures

- Star topology
  - Each device has a dedicated point-to-point link only to a central controller, usually called a hub
  - Advantages
    - Less expensive than a mesh topology
    - Robustness
  - Disadvantages
    - Dependency of the whole topology on one single point, the hub
    - More cabling compared with ring and bus
  - Used in local-area networks (LANs)

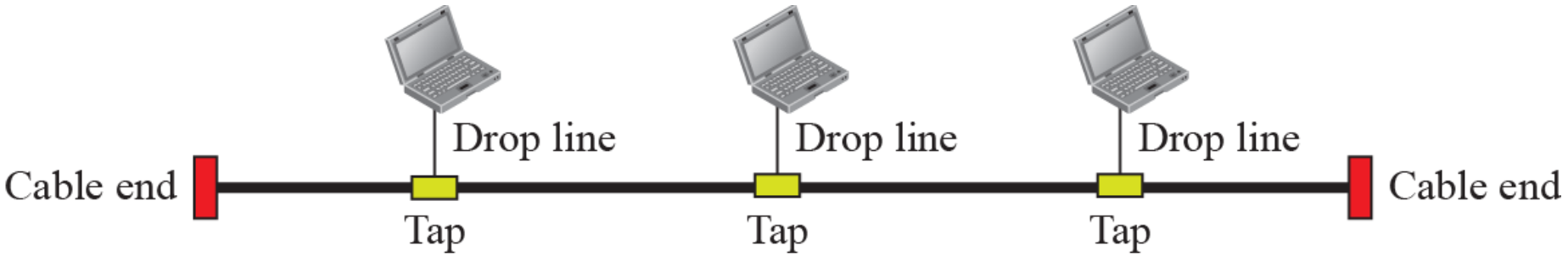
1.2.2 Physical Structures



1.2.2 Physical Structures

- Bus topology
  - Connected to the bus cable by drop lines (connection) and taps (connector)
  - The energy becomes weaker and weaker as it travels farther and farther → a limit on the number of taps a bus
  - Advantages
    - Ease of installation: only the backbone cable stretches through the entire facility
  - Disadvantages
    - Difficult reconnection and fault isolation
  - One of the first topologies used in the design of early local area networks
    - Traditional Ethernet LANs
    - Less popular now

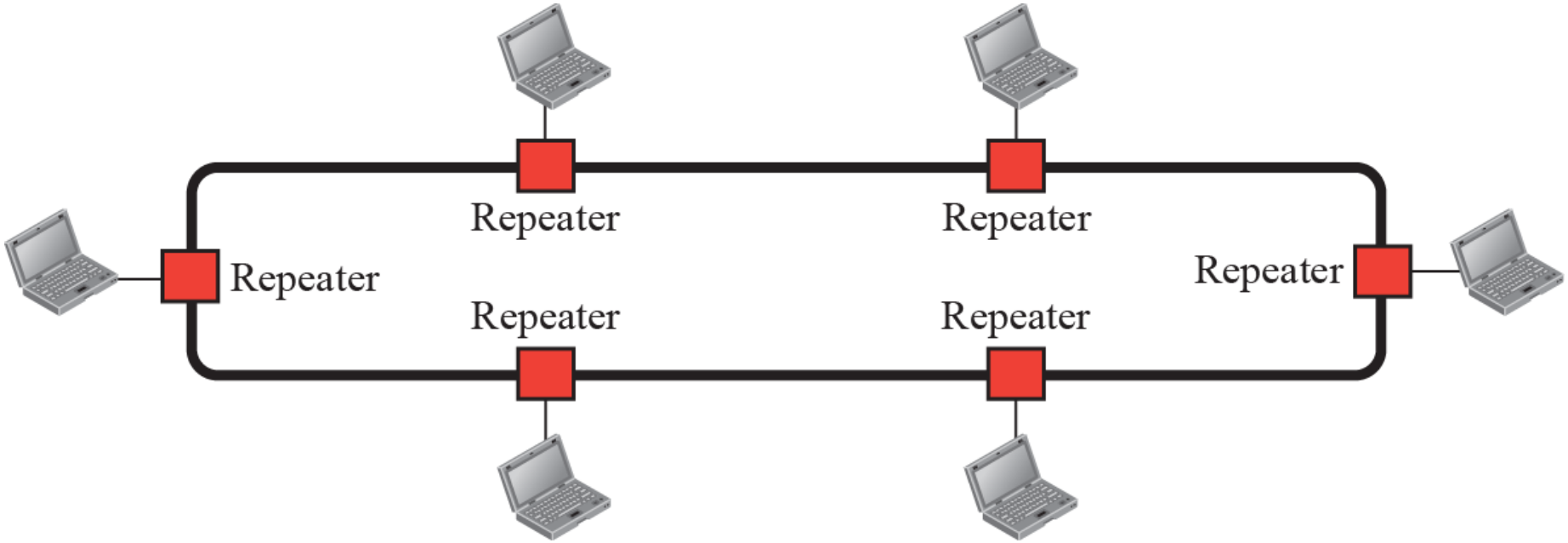
1.2.2 Physical Structures



1.2.2 Physical Structures

- Ring topology
  - Each device has a dedicated point-to-point connection with only the two devices on either side of it
  - Each device in the ring incorporates a repeater
  - Advantages
    - Relatively easy to install and reconfigure
    - Simple fault identification and isolation
  - Disadvantages
    - Unidirectional traffic
    - A break in the ring can disable the entire network → dual ring or a switch capable of closing off the break
  - IBM local-area network, i.e., Token Ring
    - Now, less popular

1.2.2 Physical Structures



1.3 Network Types

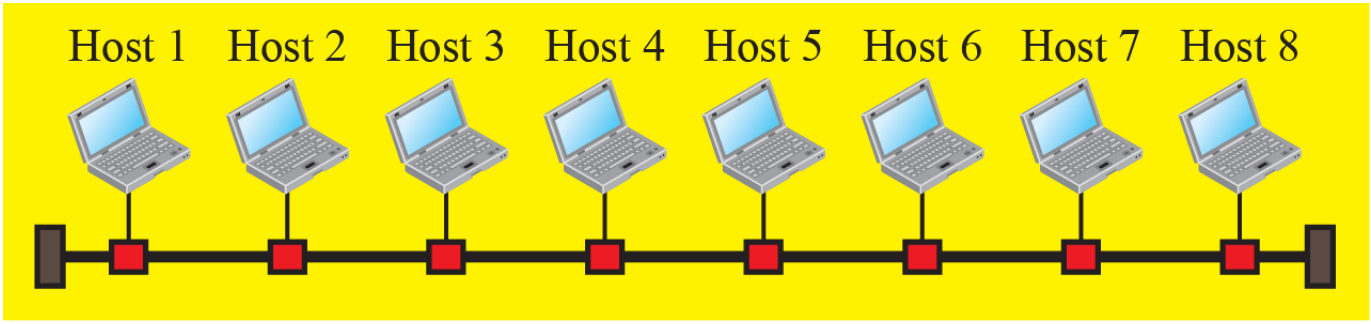
- Different types of networks in the world today
- The criteria of distinguishing one type of network from another is difficult and sometimes confusing.
- We use a few criteria such as size, geographical coverage, and ownership to make this distinction.

1.3.1 Local Area Network

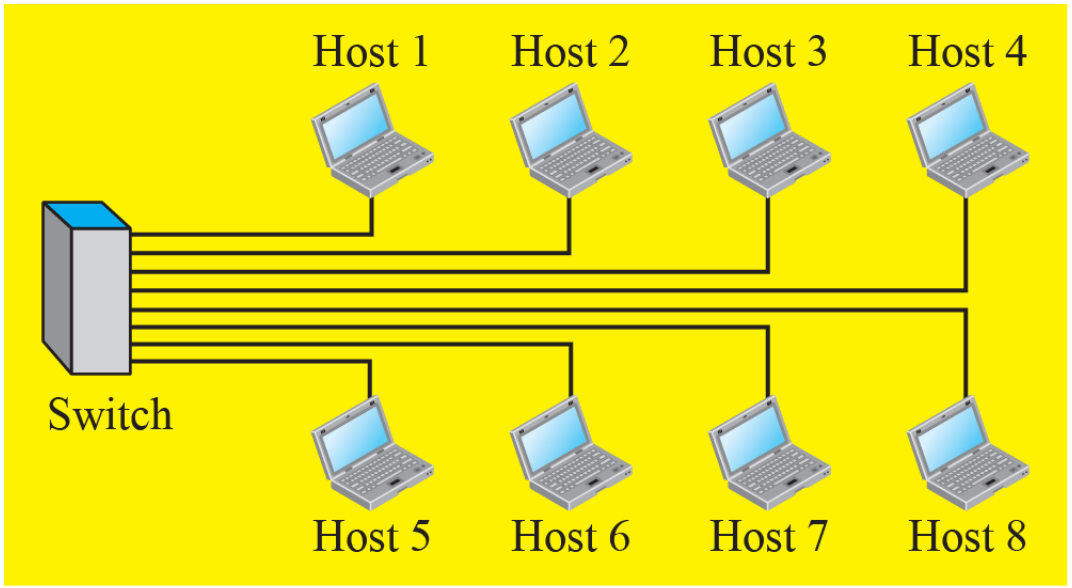
- A local area network (LAN)
  - usually privately owned and connects some hosts in a single office, building, or campus.
  - Depending on the needs of an organization, a LAN can be as simple as two PCs and a printer in someone's home office, or it can extend throughout a company and include audio and 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.

- The switch alleviates the traffic in the LAN
  - In the past, all hosts in a network were connected through a common cable

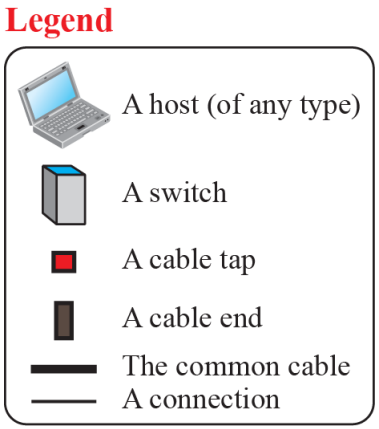
1.3.1 Local Area Network



a. LAN with a common cable (past)



b. LAN with a switch (today)

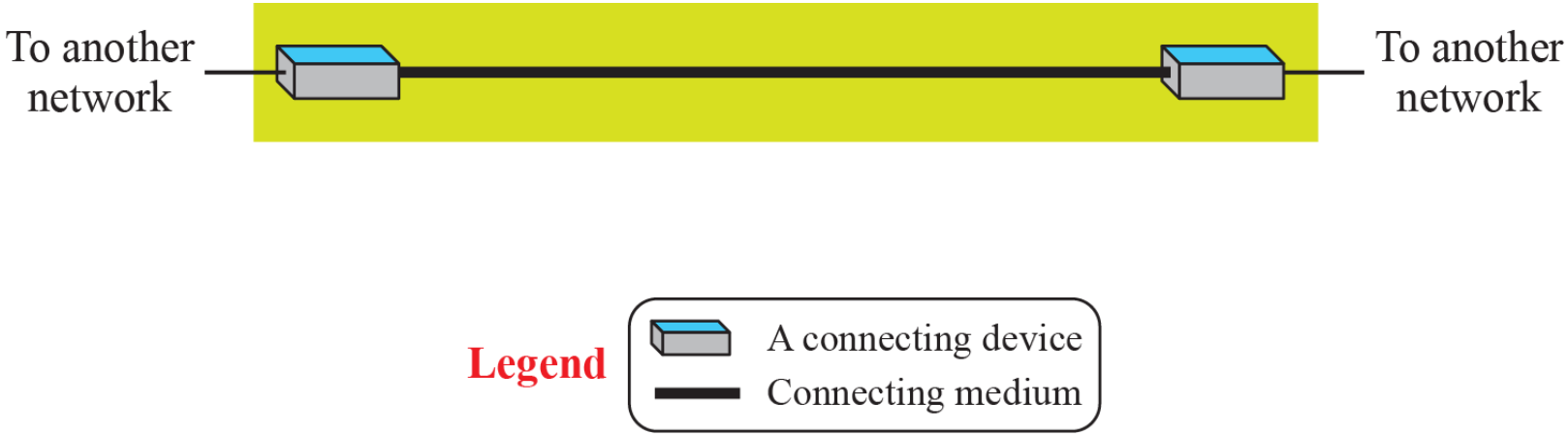


1.3.2 Wide Area Network

- A wide area network (WAN)
  - A connection of devices capable of communication
  - Some differences between a LAN and a WAN
    - A LAN is normally limited in size; a WAN has a wider geographical span, spanning a town, a state, a country, or even the world.
    - A LAN interconnects hosts; a WAN interconnects connecting devices such as switches, routers, or modems.
    - A LAN is normally privately owned by the organization that uses it; a WAN is normally created and run by communication companies and leased by an organization that uses it.

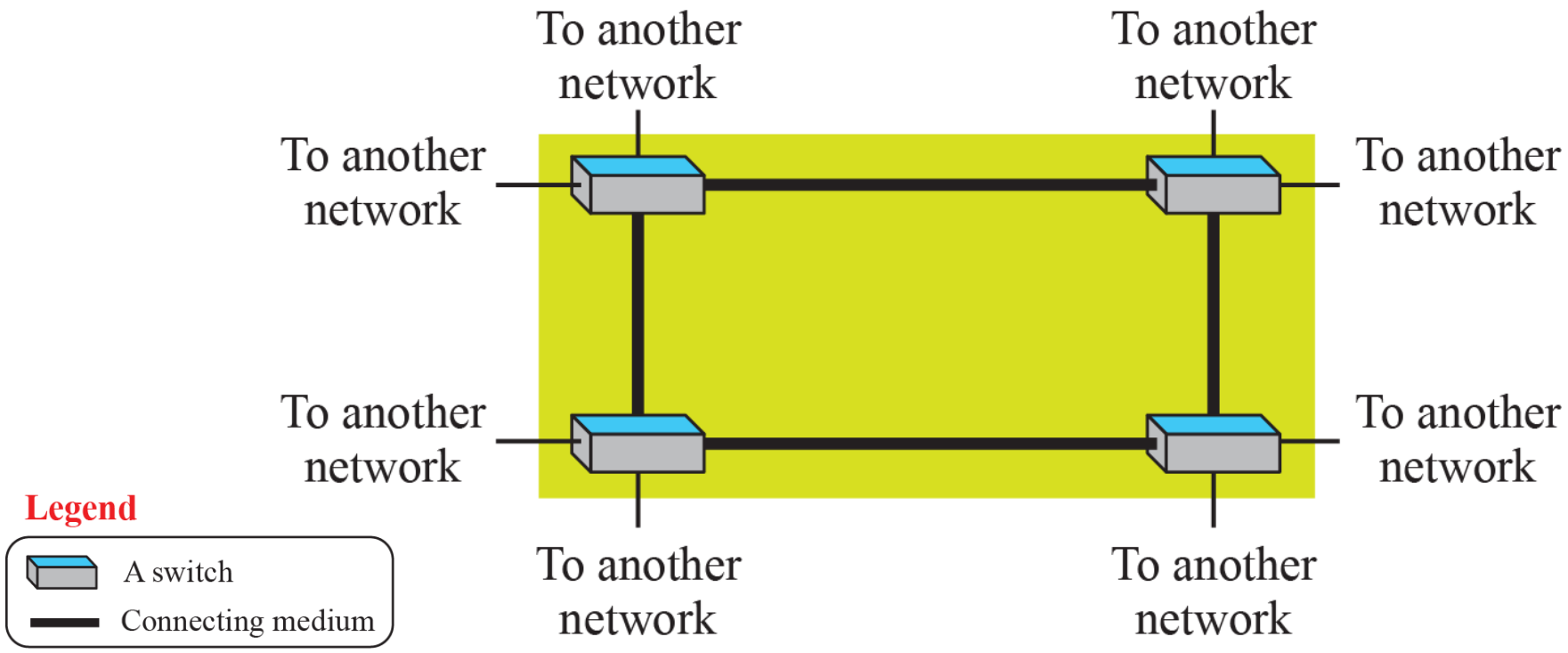
1.3.2 Wide Area Network

- Point-to-point WAN
  - A network that connects two communicating devices through a transmission media (cable or air)



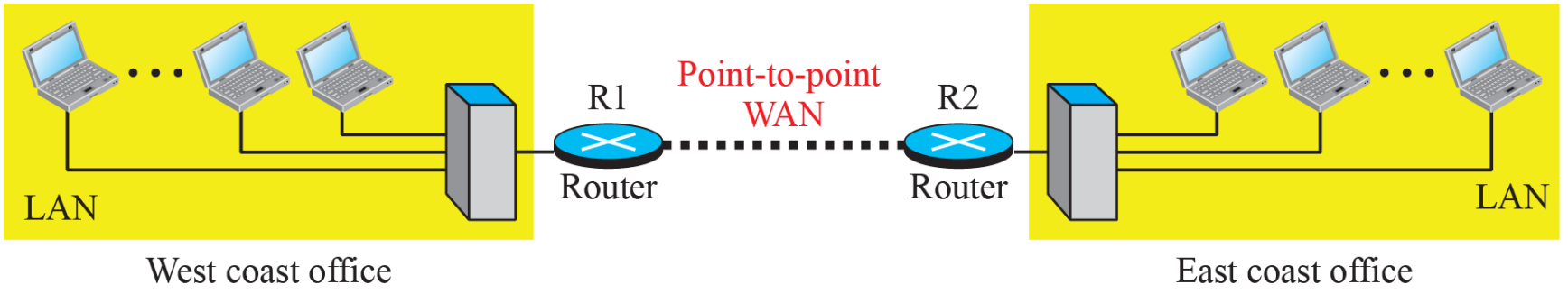
1.3.2 Wide Area Network

- Switched WAN
  - A network with more than two ends
  - Used in the backbone of global communication today



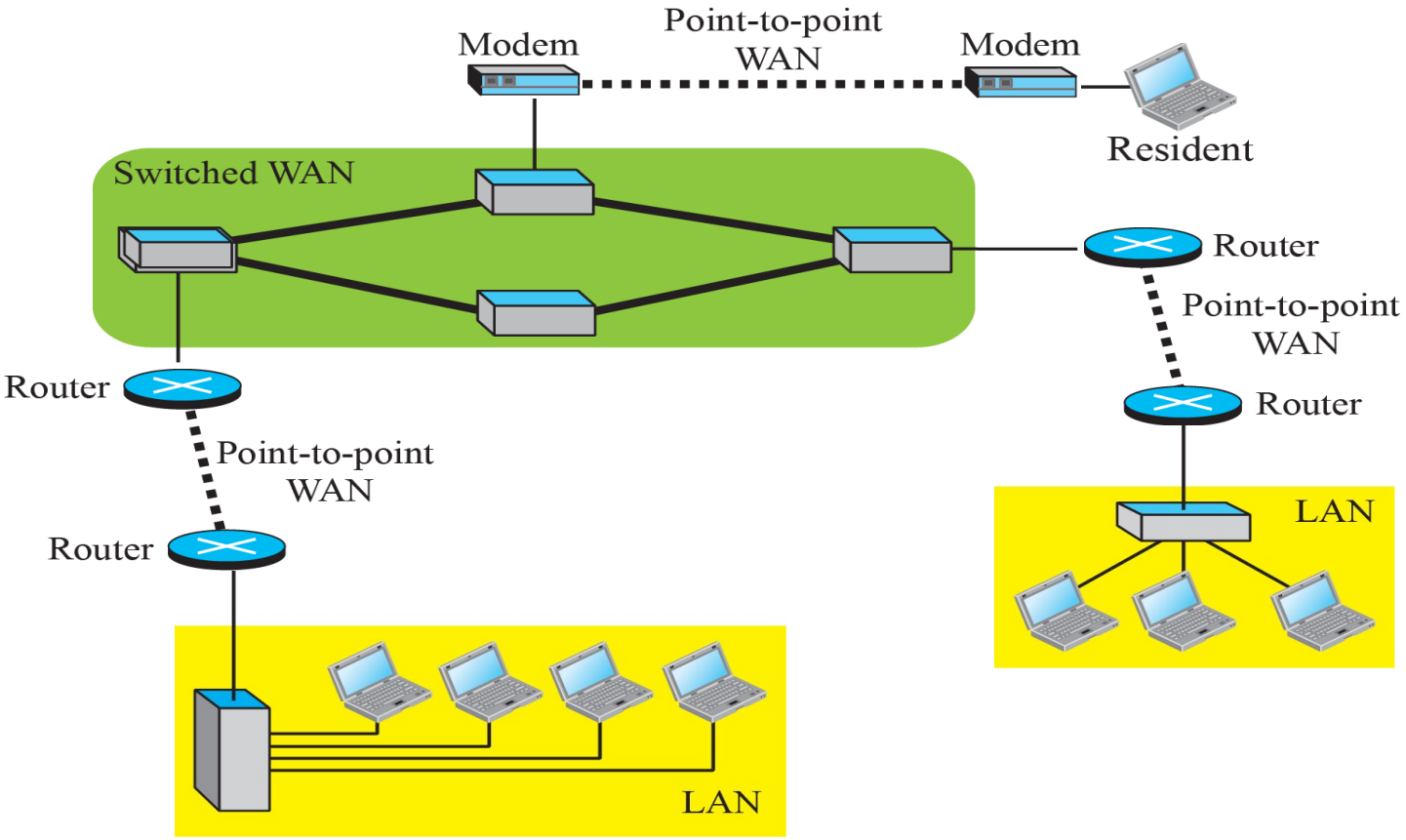
1.3.2 Wide Area Network

- Internetwork
  - Very rare to see a LAN and a WAN in isolation
  - When two or more networks are connected, they make an internetwork, or internet
  - E.g., to make the communication between employees at different offices possible, the management leases a point-to-point dedicated WAN
  - An internetwork make of two LANs and one point-to-point WAN



1.3.2 Wide Area Network

- Another internet with several LANs and WANs connected
  - One of the WANs is a switched WAN with four switched
  - A heterogeneous network consists of four WANs and three LANs

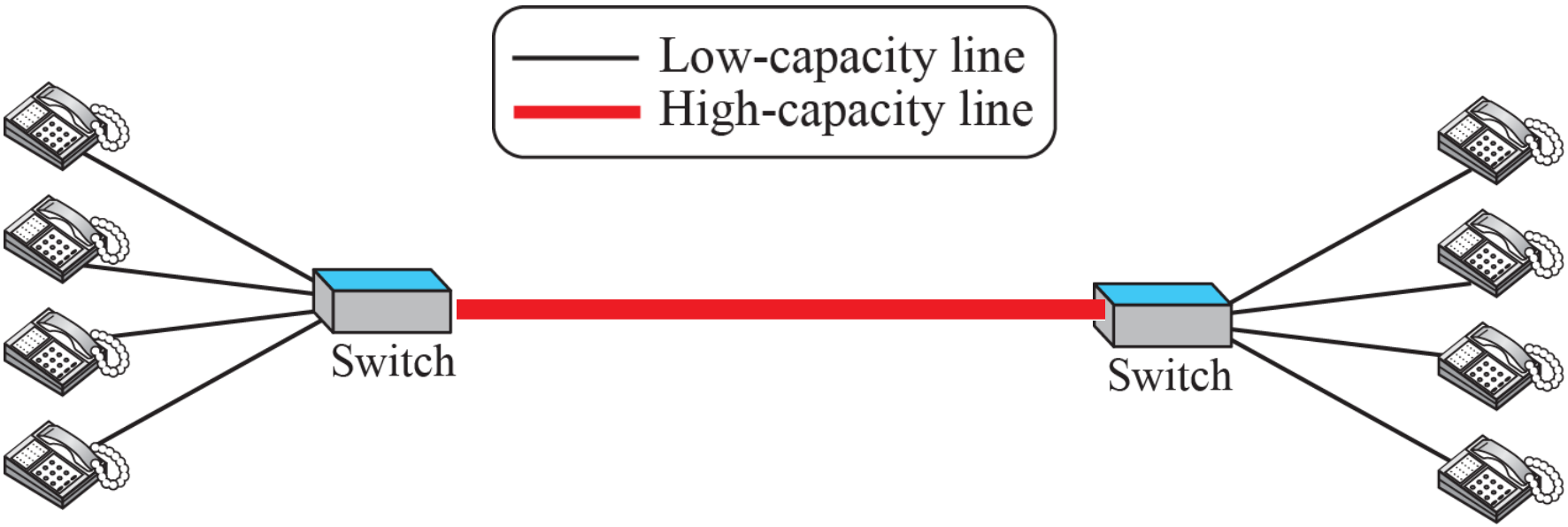


1.3.3 Switching

- 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
  - Packet-switched networks..

1.3.3 Switching

- Circuit-switched network
  - A dedicated connection, called a circuit, is always available between the two end systems
  - Efficient only when it is working at its full capacity
  - Most of the time, inefficient because it is working at partial capacity

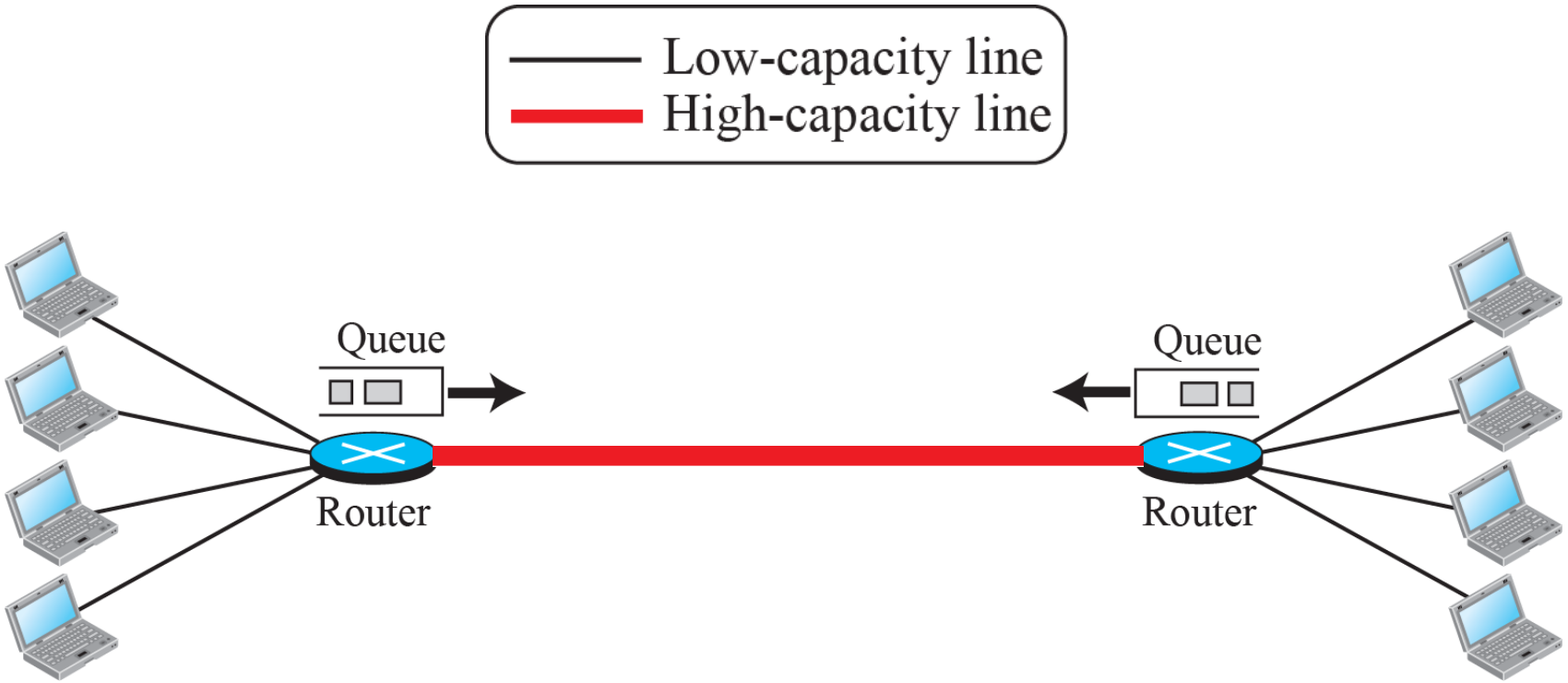


1.3.3 Switching

- Packet-switched network
  - The communication between the two ends is don in blocks of data called *packets*
  - Not continuous communication, but exchange of individual data packets when they are being used
  - Switch: both storing and forwarding
    - A packet is an independent entity that can be stored and sent later
  - A router in a packet-switched network
    - A queue that can store and forward the packet
  - More efficient than a circuit switched network, but some delays for packet transmission

1.3.3 Switching

- A packet-switched network



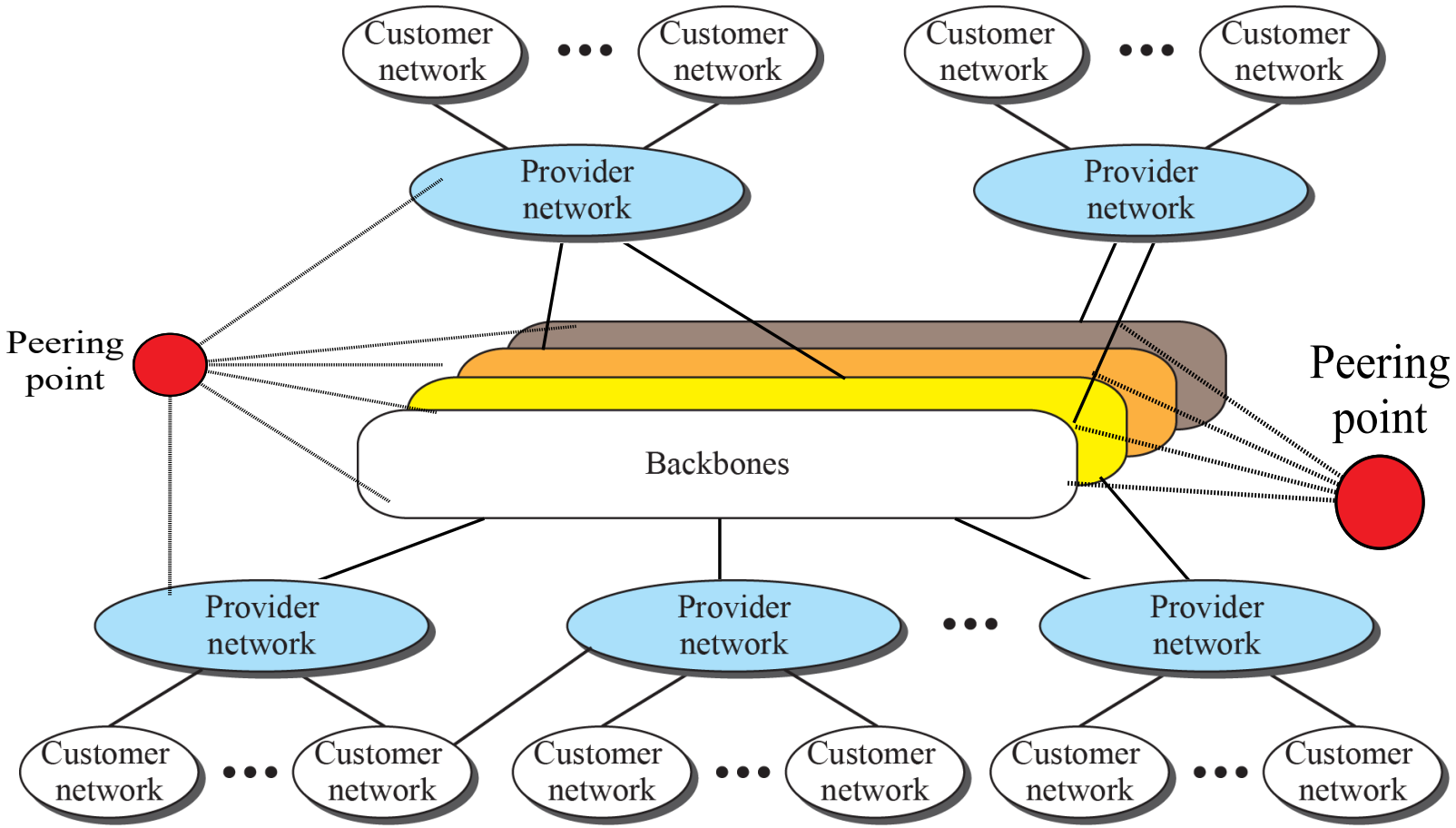
1.3.4 The Internet

- An internet (note the lowercase i)
  - two or more networks that can communicate with each other.

- The Internet (uppercase I)
  - The most notable internet
  - Composed of thousands of interconnected networks.

1.3.4 The Internet

- A conceptual (not geographical) view of the Internet.



1.3.4 The Internet

- Backbone
  - Large networks owned by some communication companies such as Sprint, Verizon, AT&T, and NTT
  - Connected via some complex switching systems, called peering points
- Provider networks
  - Using the services of the backbones for a fee
- Customer networks
  - Networks at the edge of the Internet
  - Paying fees to provider networks for receiving services
- Backbones and provider networks are also called Internet Service Providers (ISP)
  - International ISPs, national or regional ISPs

1.3.5 Accessing the Internet

- The Internet today is an internetwork that allows any user to become part of it.
  - The user, however, needs to be physically connected to an ISP.

- Using telephone networks
  - Dial-up service
  - DSL service
- Using cable networks
- Using wireless networks
- Direct connection to the Internet

1-4 Internet History

- Now that we have given an overview of the Internet and its protocol.

- A brief history makes it clear how the Internet has evolved from a private network to a global one in less than forty years.

1.4.1 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 (telephone) could be exchanged.

- A computer network, on the other hand, should be able to handle bursty data, which means data received at variable rates at different times.
  - The world needed to wait for the packet-switched network to be invented.
  - In the mid-1960, the Advanced Research Projects Agency in the Department of Defense (DoD) was interested
  - In 1967, at an Association for Computing Machinery (ACM) meeting, ideas for the ARPANET
  - By 1969, ARPANET was a reality

1.4.2 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.
- Cerf and Kahn devised the idea of a device called a gateway to serve as the intermediary hardware to transfer data from one network to another.
- Their landmark 1973 paper outlined the protocols to achieve end-to-end delivery of data
  - Transmission control protocol (TCP): concepts such as encapsulation, datagram, functions of a gateway
- Shortly thereafter, splitting TCP into TCP(segmentation, reassembly, error detection) and IP (Internet Protocol; routing) → new combination TCP/IP
- In 1981, UC Berkeley modified the UNIX to include TCP/IP
- In 1983, TCP/IP became the official protocol for ARPANET

1.4.3 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 (WWW)
  - Multimedia
    - Voice over IP (VoIP), video over IP (Skype), view sharing (YouTube), television over IP (PPLive)
  - Peer-to-peer applications

1.5 Standards and Administration

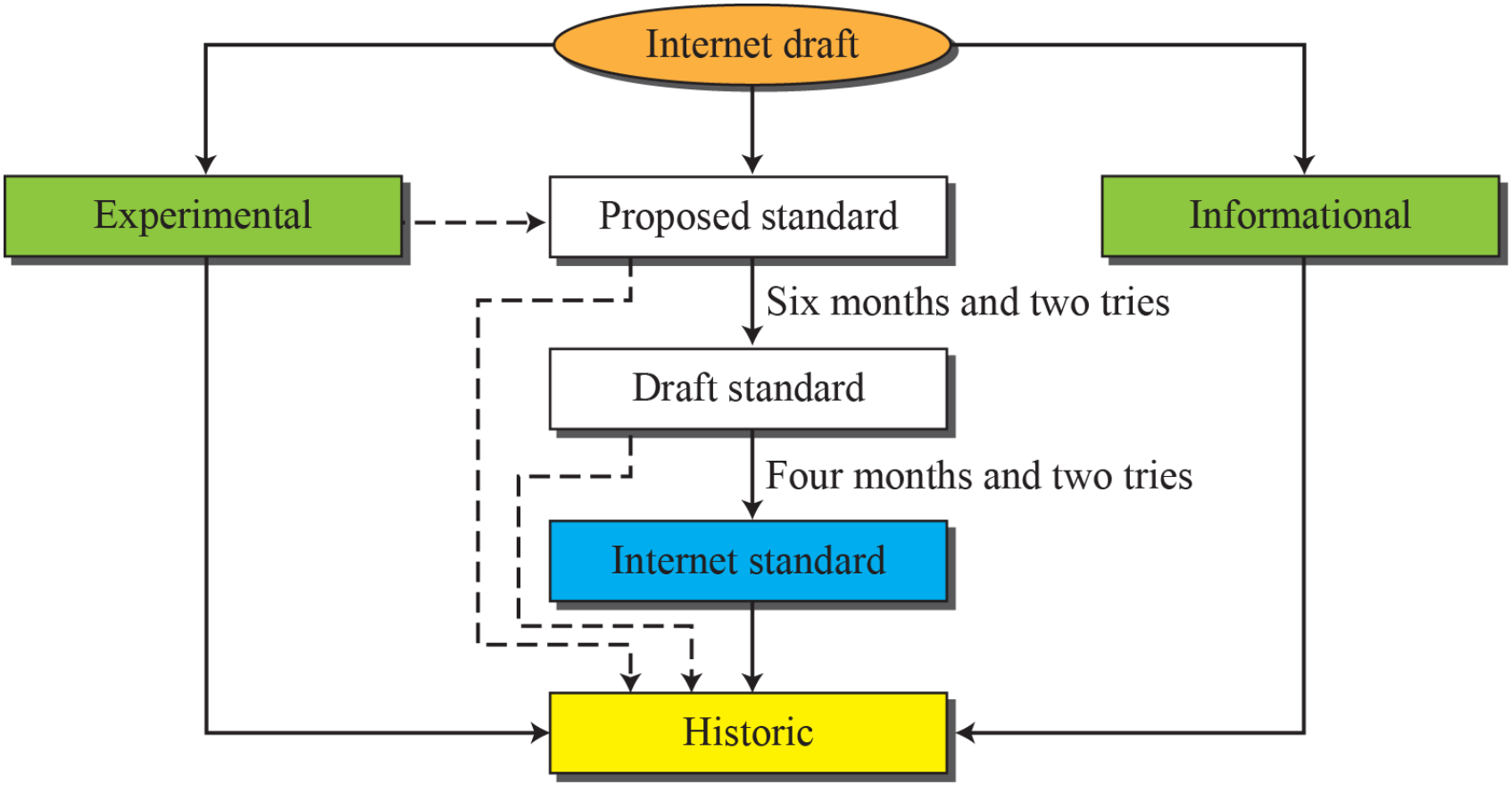
- In the discussion of the Internet and its protocol, we often see a reference to a standard or an administration entity.

1.5.1 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.
- An Internet draft is a working document (a work in progress) with no official status and a six-month lifetime.
- A draft may be published as a Request for Comment (RFC)
  - Each RFC is edited, assigned a number, and make available to all interested parties

1.5.1 Internet Standards

- Maturity levels



Important Standards

- RFC: Internet protocols (application, transport, network, (link) layers)
  - http://www.rfc-editor.org
  - RFC791 (IP), RFC817(TCP)
- IEEE 802 standards: physical & link layer protocols
  - http://www.ieee802.org/
  - 802.3(Ethernet), 802.11 (WiFi), 802.15 (Wireless PAN)
- 3GPP: focusing on wireless cellular networks (Big market)
  - http://www.3gpp.org
  - LTE (Release 8 @2008), LTE-Advanced (Release 10 @2011), 5G (Release 15 @2018, 16 @2019)
  - Now, Release 17

Ch 2. Network Models

: Protocol Layering, TCP/IP Protocol Suite, OSI Model

- Ch 1 Introduction
- Ch 2 Network models
- Summary & Next Class

Ch 2 Objective

- The first section: Protocol Layering
  - Concept of protocol layering using two scenarios.
  - Two principles upon which the protocol layering is based.
    - The first principle dictates that each layer needs to have two opposite tasks.
    - The second principle dictates that the corresponding layers should be identical.
  - A brief discussion of logical connection between two identical layers in protocol layering.
  - Throughout the book, need to distinguish between logical and physical connections.

Ch 2 Objective

- The second section: TCP/IP Protocol Suite
  - Five layers of the TCP/IP protocol suite.
  - How packets in each of the five layers (physical, data-link, network, transport, and application) are named.
  - Addressing mechanism used in each layer.
  - Each layer is discussed in several chapters; this section is just an introduction and preparation.

- The third section: The OSI Model
  - a brief discussion of the OSI model: Never implemented in practice
  - Comparison with the TCP/IP protocol suite: useful to better understand the TCP/IP protocol suite.
  - A brief reason for the OSI model's lack of success.

2.1 Protocol Layering

- A word we hear all the time when we talk about the Internet is protocol.
- A protocol defines the rules that both the sender and receiver and all intermediate devices need to follow to be able to communicate effectively.
- When communication is simple, we may need only one simple protocol; when the communication is complex, we need a protocol at each layer, or protocol layering.

2.1.1 Scenarios

- Two simple scenarios to better understand the need for protocol layering.
  - In the first scenario, communication is so simple that it can occur in only one layer.
  - In the second, the communication between Maria and Ann takes place in three layers.

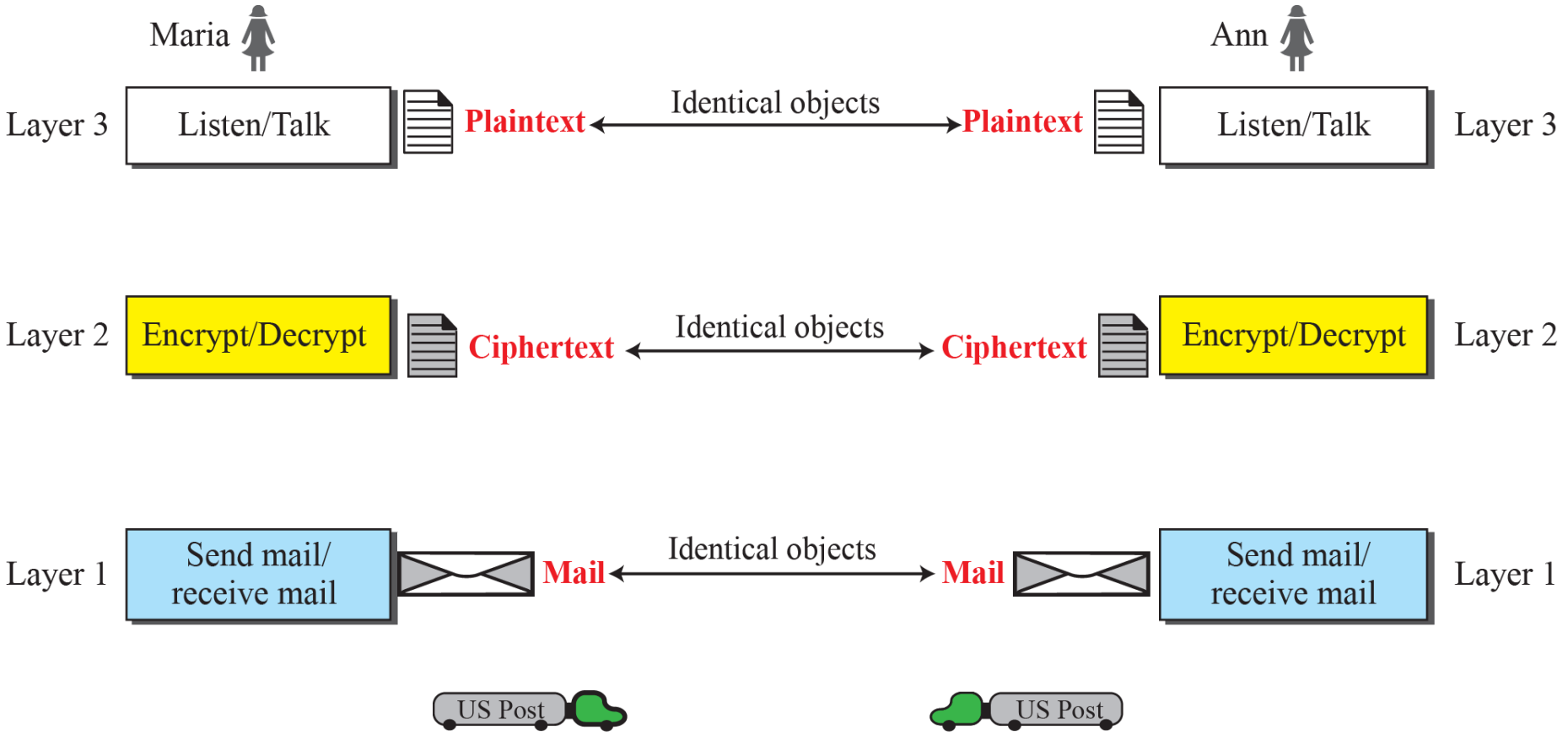
2.1.1 Scenarios

- A single-layer protocol
  - Greet each other when they meet
  - Confine their vocabulary to the level of their friendship
  - Refrain from speaking when the other party speaking
  - A dialog, not a monolog
  - Exchange some nice words when they leave

→ Different from the communication between a professor and the student in a lecture hall

2.1.1 Scenarios

- A three-layer protocol
  - Far communication between Maria and Ann



2.1.1 Scenarios

- Advantages of protocol layering
  - Division a complex task into several smaller and simpler task
  - Modularity
    - If two machines provide the same outputs when given the same inputs, they can replace each other
  - Separation of the services from the implementation
  - Intermediate systems, but not all layers
    - The whole system more expensive

- Disadvantage of protocol layering
  - A single layer makes the job easier
  - Cross-layer optimization

2.1.2 Principles of Protocol Layering

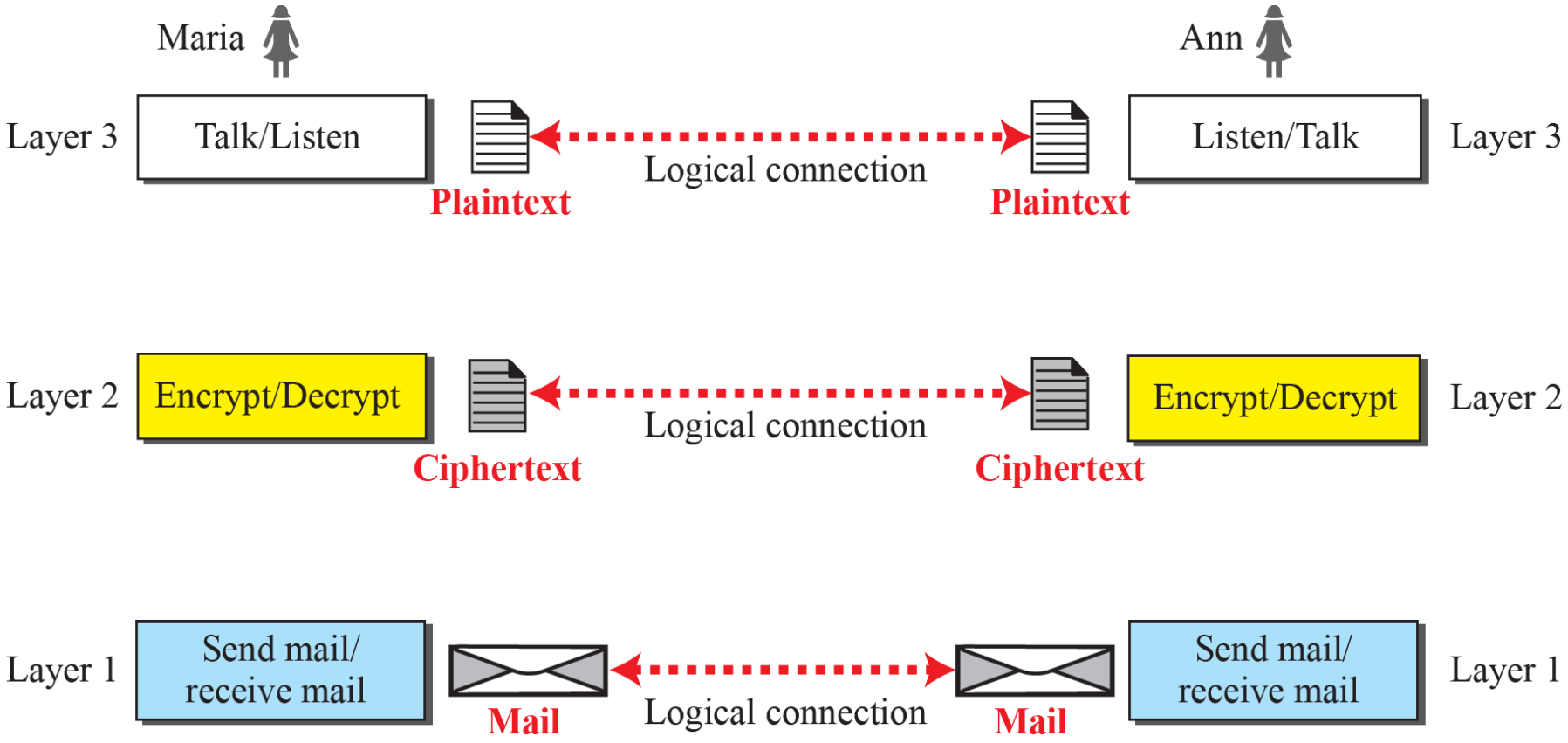
- Two principles of protocol layering.
  - The first principle dictates that if we want bidirectional communication, we need to make each layer so that it is able to perform two opposite tasks, one in each direction.
  - The second principle that we need to follow in protocol layering is that the two objects under each layer at both sites should be identical.

2.1.3 Logical Connections

- Logical connection between each layer
  - This means that we have 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.
  - We will see that the concept of logical connection will help us better understand the task of layering we encounter in data communication and networking.

2.1.3 Logical Connections

- Logical connection between peer layers



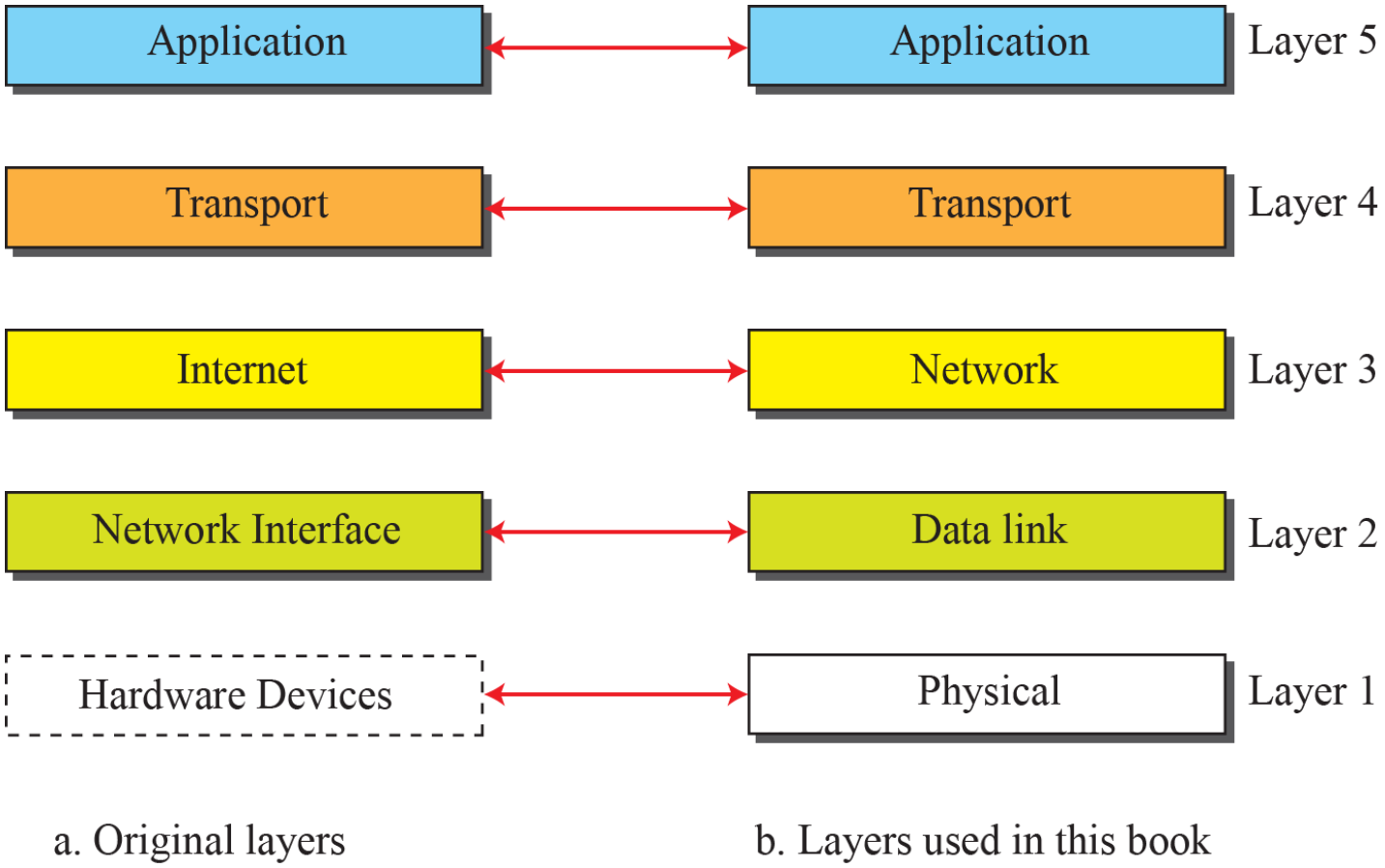
2.2 TCP/IP Protocol Suite

Protocol

- A protocol defines the rules that both the sender and receiver and all intermediate devices need to follow to be able to communicate effectively.
- When communication is simple, we may need only one simple protocol; when the communication is complex, we need a protocol at each layer, or protocol layering.

2.2 TCP/IP Protocol Suite

- Layers in the TCP/IP protocol suite

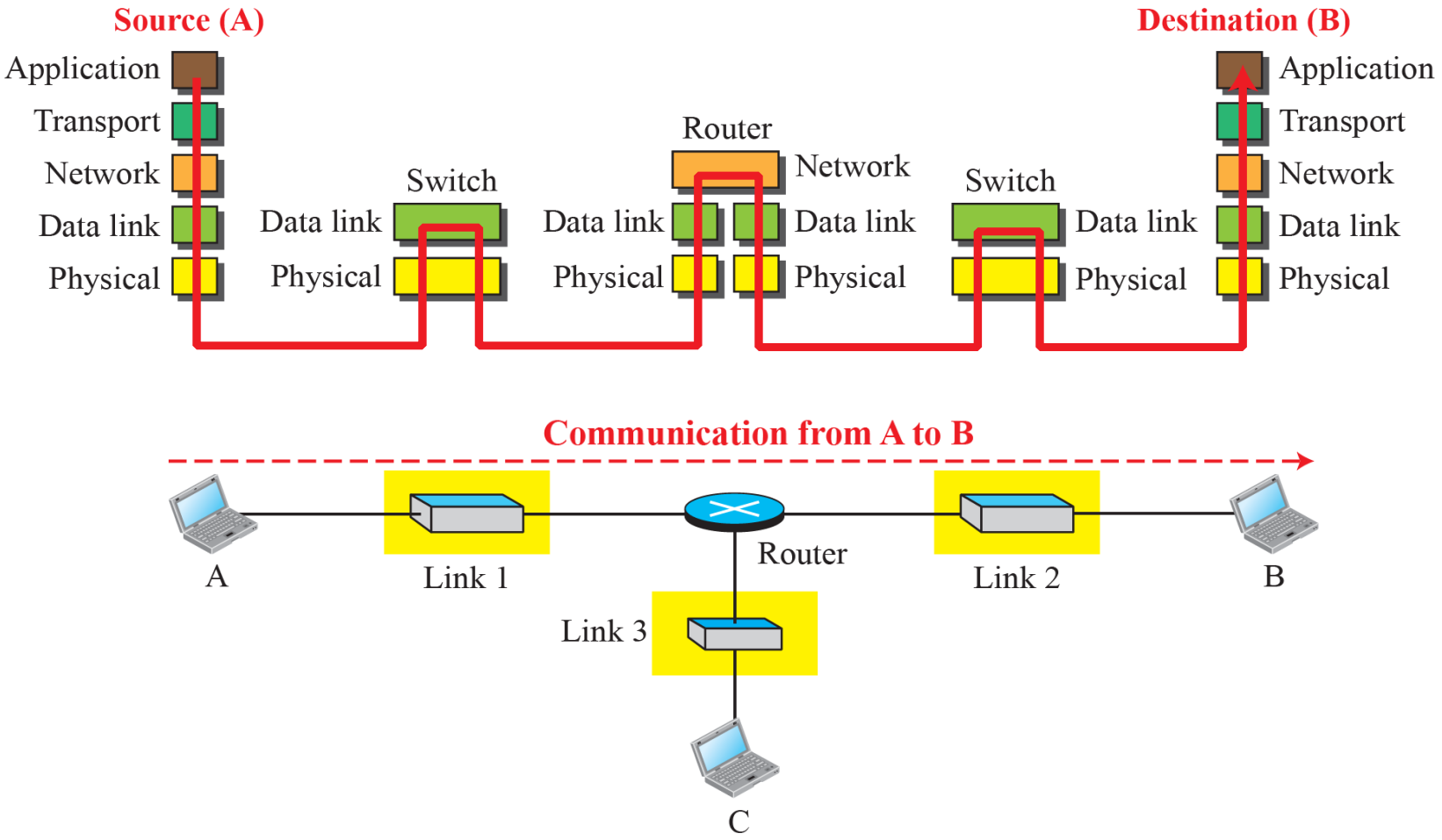


2.2.1 Layered Architecture

- Communication through an internet
  - The suite in a small internet made up of three LANs (links), each with a link-layer switch.
  - The links are connected by one router
  - Router
    - Only three layers
    - Always involved in one network layer
    - Involved in n combinations of link and physical layers in which n is the number of links the router is connected to
  - A link layer switch in a link
    - Only two layers
    - Using only one set of protocols

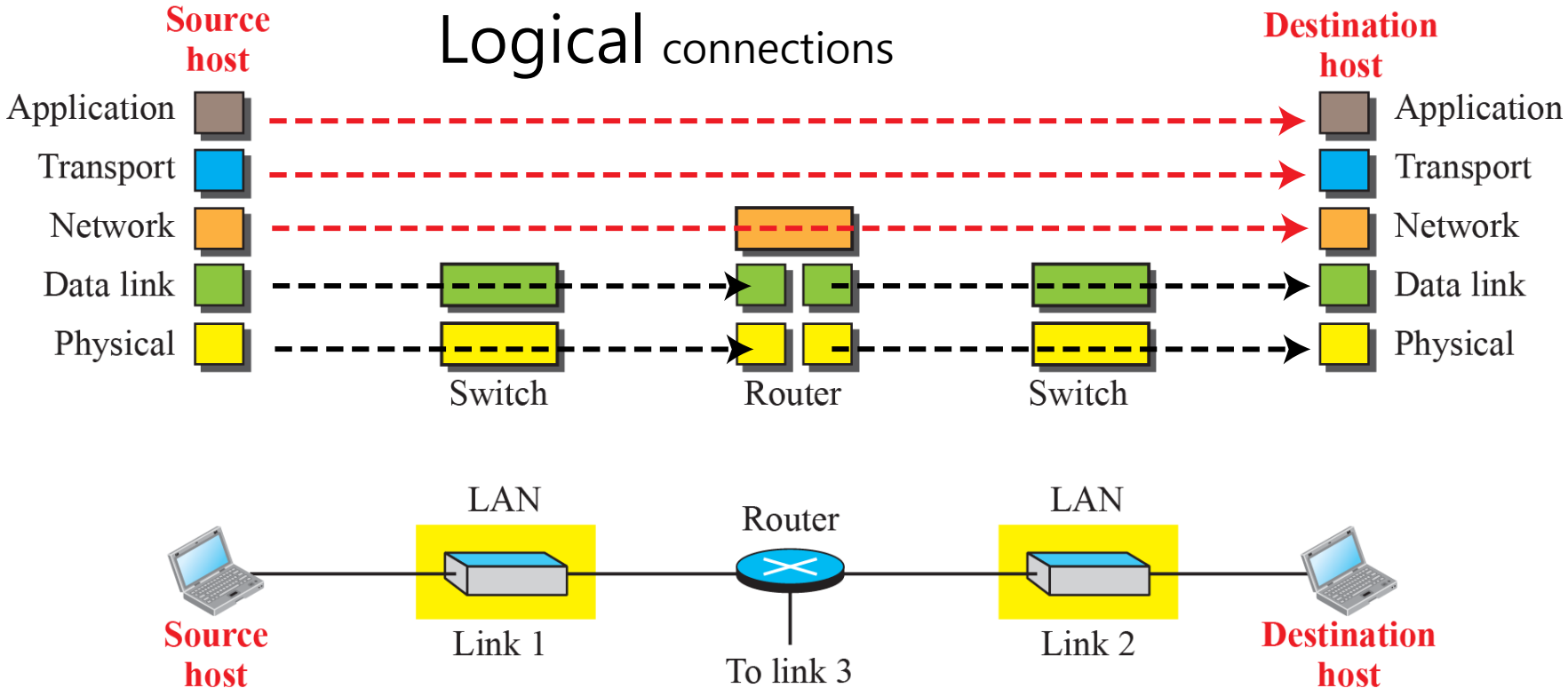
2.2.1 Layered Architecture

- Communication through an internet



2.2.2 Layers in the TCP/IP Protocol Suite

- Layers in the TCP/IP protocol suite
  - Each layer is discussed in detail in the next five parts of the book.
  - Logical connections between layers.

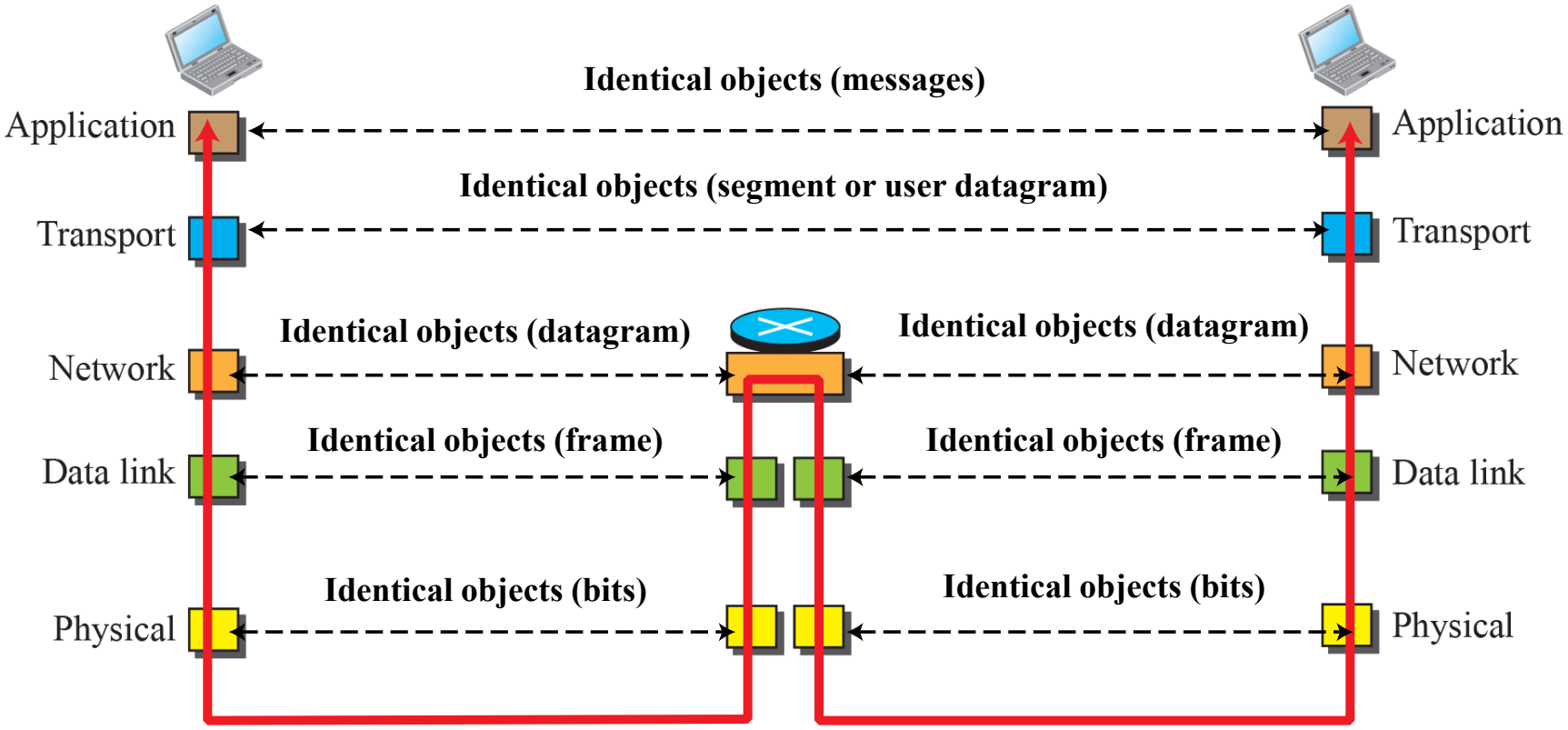


2.2.2 Layers in the TCP/IP Protocol Suite

- End-to-end logical connection (domain: internet)
  - The duty of the application, transport, and network layers
- Hop-to-hop logical connection (domain: link)
  - Data link and physical layers
  - Hop: host or router

2.2.2 Layers in the TCP/IP Protocol Suite

- Identical objects in the TCP/IP protocol suite



Notes: We have not shown switches because they don't change objects.

2.2.3 Description of Each Layer

- The discussion in this chapter will be very brief, but we come back to the duty of each layer in next five parts of the book.

- Physical layer or PHY layer
  - Carrying individual bits in a frame across the link
  - Still logical communication
    - Hidden layer: the transmission media under the physical layer
    - The transmission media carriers electrical or optical signals
  - The logical unit between two physical layers in two devices is a bit
  - Several protocols that transform a bit to a signal

2.2.3 Description of Each Layer

- Data link layer
  - Taking the datagram and moving it across the link
    - Routers: choosing the best links
    - An internet is make up of several links connected by routers
  - E.g., wired LAN (Ethernet), wireless LAN, wired WAN, wireless WAN (LTE)
  - This layer takes a datagram and encapsulates it in a packet called a frame
  - Some link layer protocols provide
    - Complete error detection and correction
    - Or only error correction

2.2.3 Description of Each Layer

- Network layer
  - Host-to-host communication and routing the packet through possible routes
    - Communication at the network is host-to-host
    - Choosing the best route for each packet
  - The network layer in the Internet: Internet Protocol (IP)
    - Connectionless protocol
      - No flow control, no error control, and no congestion control services
      - Unicast (one-to-one), multicast (one-to-many)
  - Auxiliary protocols that help IP in its delivery and routing tasks
    - Internet Control Message Protocol (ICMP)
    - Internet Group Management Protocol (IGMP)
    - Dynamic Host Configuration Protocol (DHCP)
    - Address Resolution Protocol (ARP)

2.2.3 Description of Each Layer

- Transport layer
  - Giving services to the application layer
    - Getting message from the application layer, encapsulating it in a transport layer packet (called a segment or a user data gram), and sending it
  - Transmission Control Protocol (TCP)
    - Connection-oriented protocol
    - Creating a logical pipe between two TCPs for transferring a stream of bytes
    - Flow control: matching the sending data rate of the source host with the receiving data rate of the destination host to prevent overwhelming the destination
    - Error control: guaranteeing that the segments arrive at the destination without error and resending the corrupted ones
    - Congestion control: reducing the loss of segments due to congestion in the network
  - User Datagram Protocol (UDP)
    - Connectionless protocol, small overhead (e.g., short messages)
  - Stream Control Transmission Protocol (STCP) for multimedia

2.2.3 Description of Each Layer

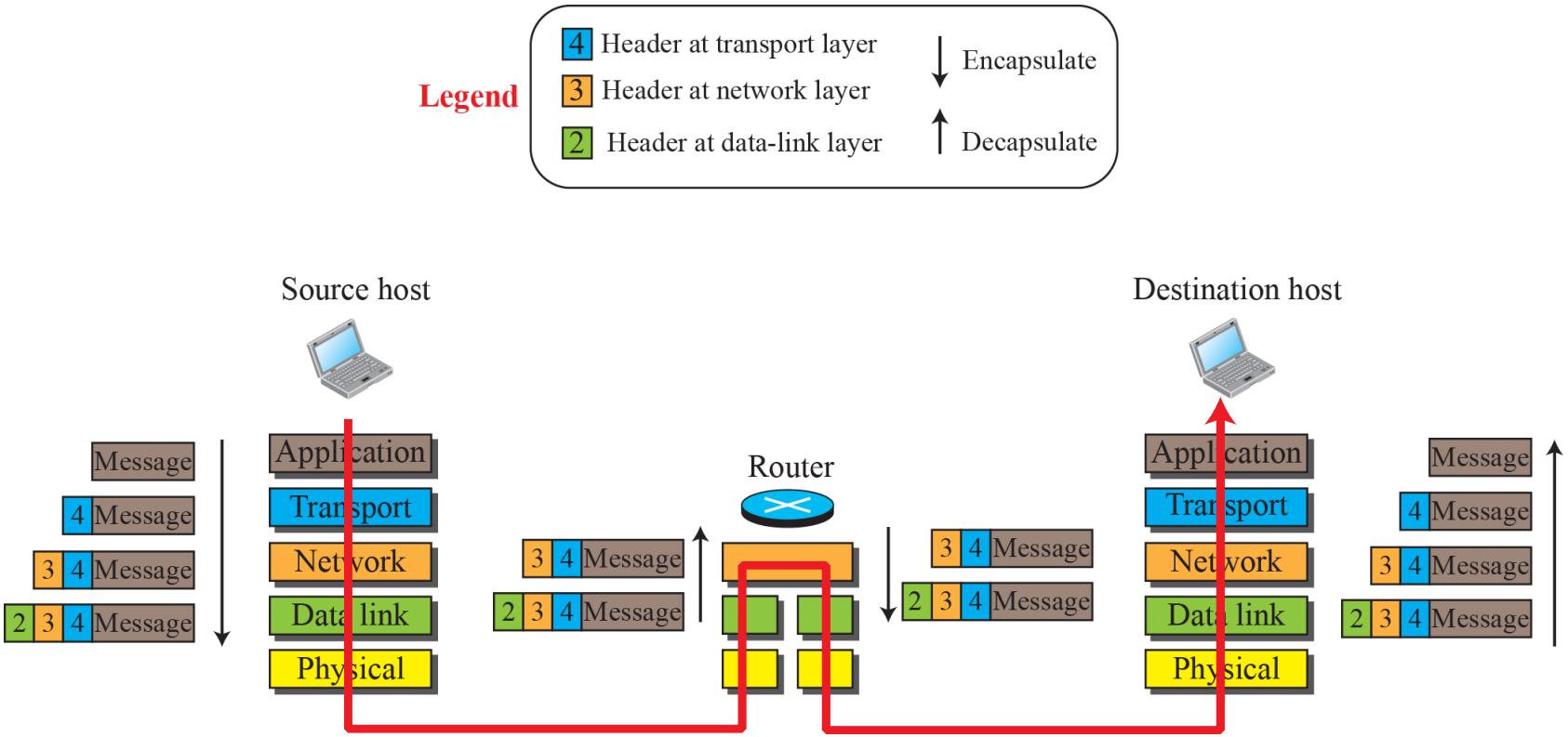
- Application layer
  - End-to-end logical connection
  - Process-to-process communication
  - Hypertext Transfer Protocol (HTTP): a vehicle for accessing the World Wide Web (WWW)
  - Simple Mail Transfer Protocol (SMTP): the main protocol used in e-mail
  - File Transfer Protocol (FTP): transferring files from one host to another
  - Terminal Network (TELNET), Secure Shell (SSH): for accessing a site remotely
  - Simple Network Management Protocol (SNMP): used by an administrator to manage the Internet at global and local levels
  - Domain Name System (DNS): used by other protocols to find the network-layer address of a computer

2.2.4 Encapsulation and Decapsulation

- Encapsulation & decapsulation
  - One of the important concepts in protocol layering in the Internet
  - Encapsulation in the source host
  - Decapsulation in the destination host
  - Encapsulation and decapsulation in the router

2.2.4 Encapsulation and Decapsulation

- Encapsulation/decapsulation



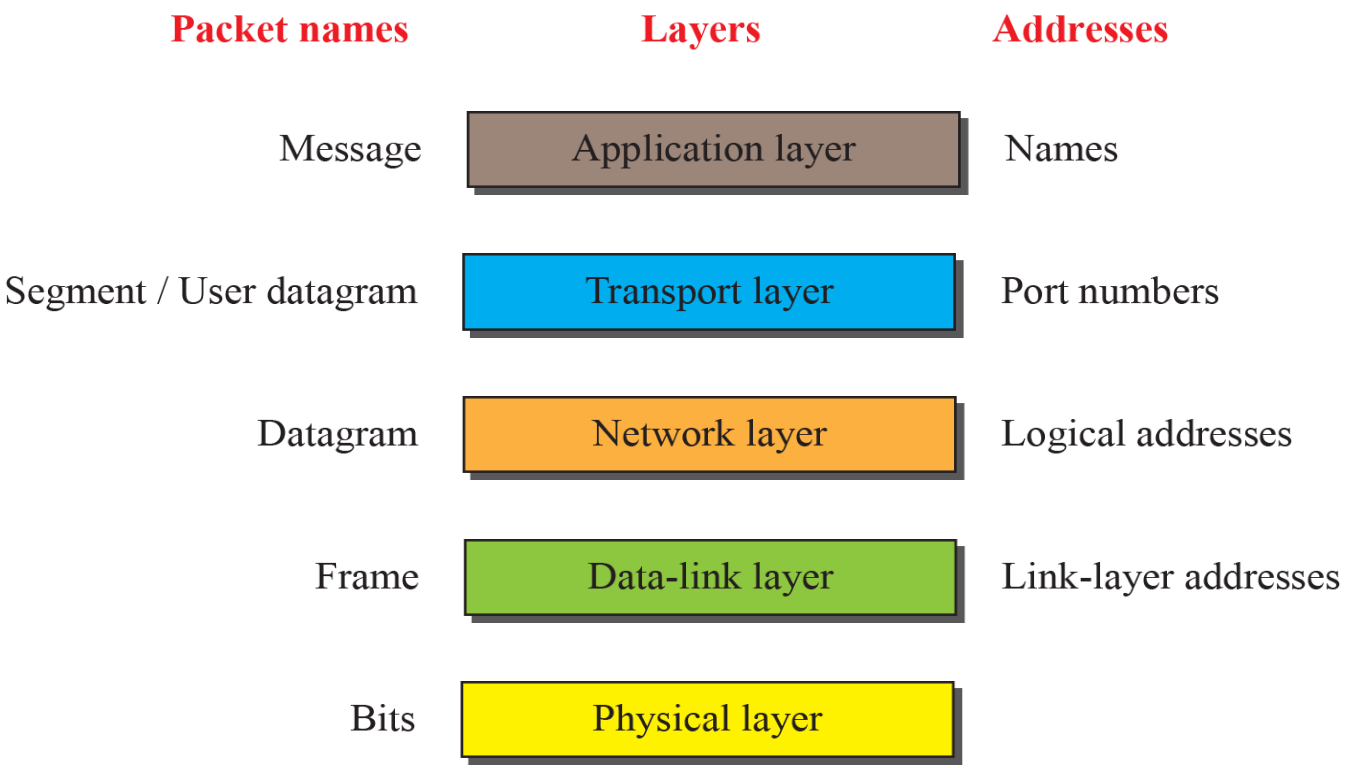
2.2.4 Encapsulation and Decapsulation

- Application layer: message
  - Normally not contain any header or trailer
- Transport layer: segment (in TCP), user datagram (in UDP)
  - Header: identifiers of source and destination programs for flow, error control, congestion control
- Network layer: datagram
  - Header: source and destination addresses, information for error checking and fragmentation
- Data link layer: frame
  - Link layer addresses of the host or next hop

2.2.5 Addressing

Addressing

- Any communication that involves two parties needs two addresses:
  - Source address and destination address.
  - Normally have only four because the physical layer does not need addresses; the unit of data exchange at the physical layer is a bit, which definitely cannot have an address.

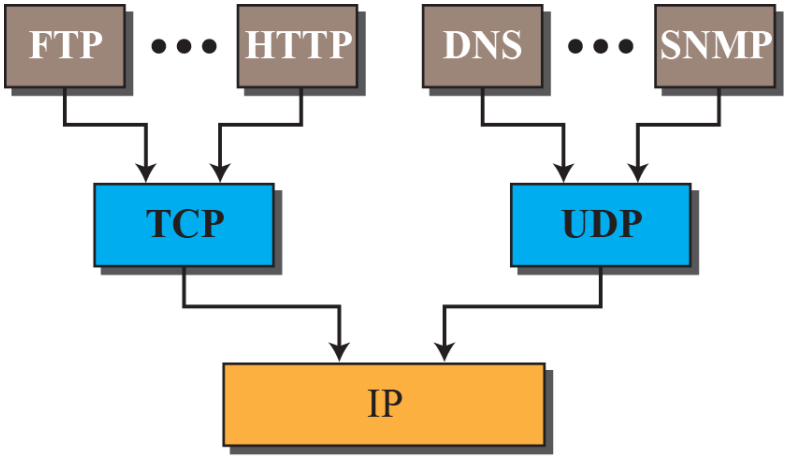


2.2.6 Multiplexing and Demultiplexing

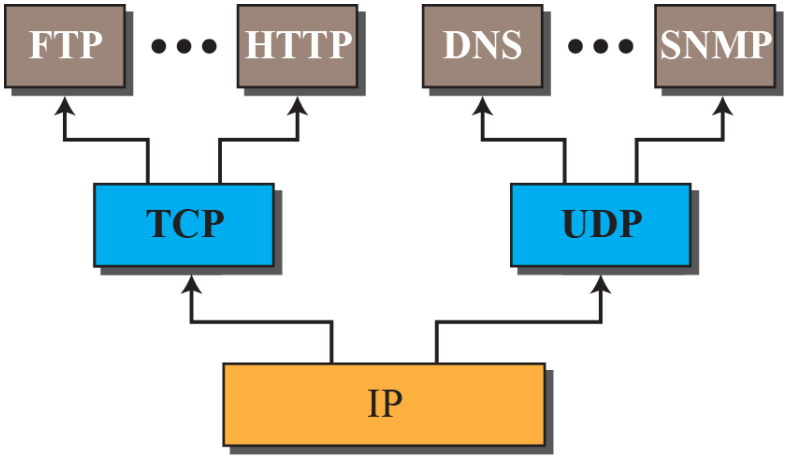
- Multiplexing at the source and demultiplexing at the destination
  - TCP/IP protocol suite uses several protocols at some layers
  - Multiplexing in this case means that a protocol at a layer can encapsulate a packet from several next-higher layer protocols (one at a time)
  - Demultiplexing means that a protocol can decapsulate and deliver a packet to several next-higher layer protocols (one at a time).
  - Figure 2.10 shows the concept of multiplexing and demultiplexing at the three upper layers.

2.2.6 Multiplexing and Demultiplexing

- Multiplexing and demultiplexing



a. Multiplexing at source



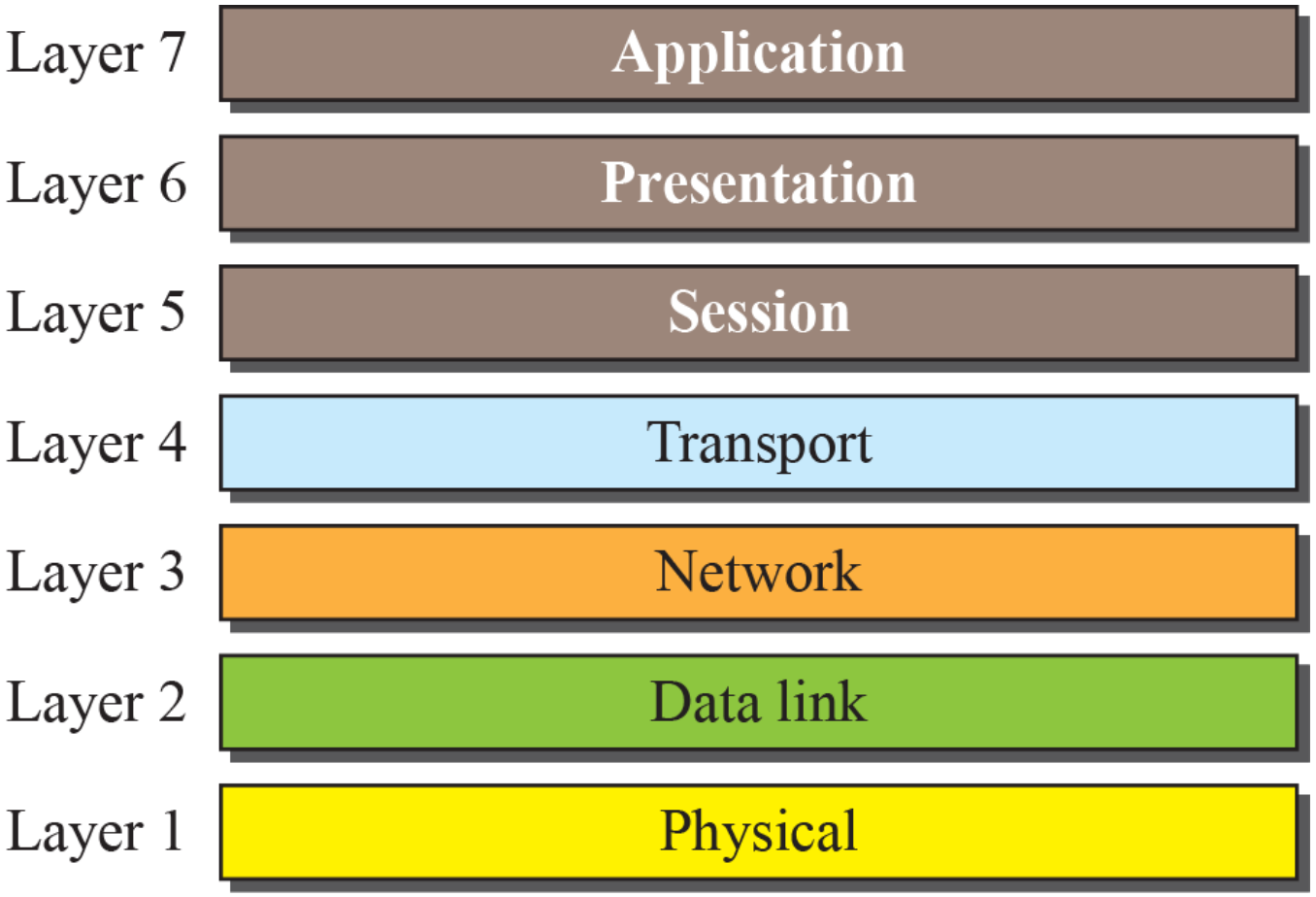
b. Demultiplexing at destination

2-3 OSI Model

- A protocol defines the rules that both the sender and receiver and all intermediate devices need to follow to be able to communicate effectively.
- When communication is simple, we may need only one simple protocol; when the communication is complex, we need a protocol at each layer, or protocol layering.
- International organization for standardization (ISO)
  - A multinational body dedicated to worldwide agreement on international standards
- Open systems interconnection (OSI) model
  - An ISO standard that covers all aspects of network communcations
- Open system
  - A set of protocols that allows any two different systems to communicate regardless of their underlying architecture

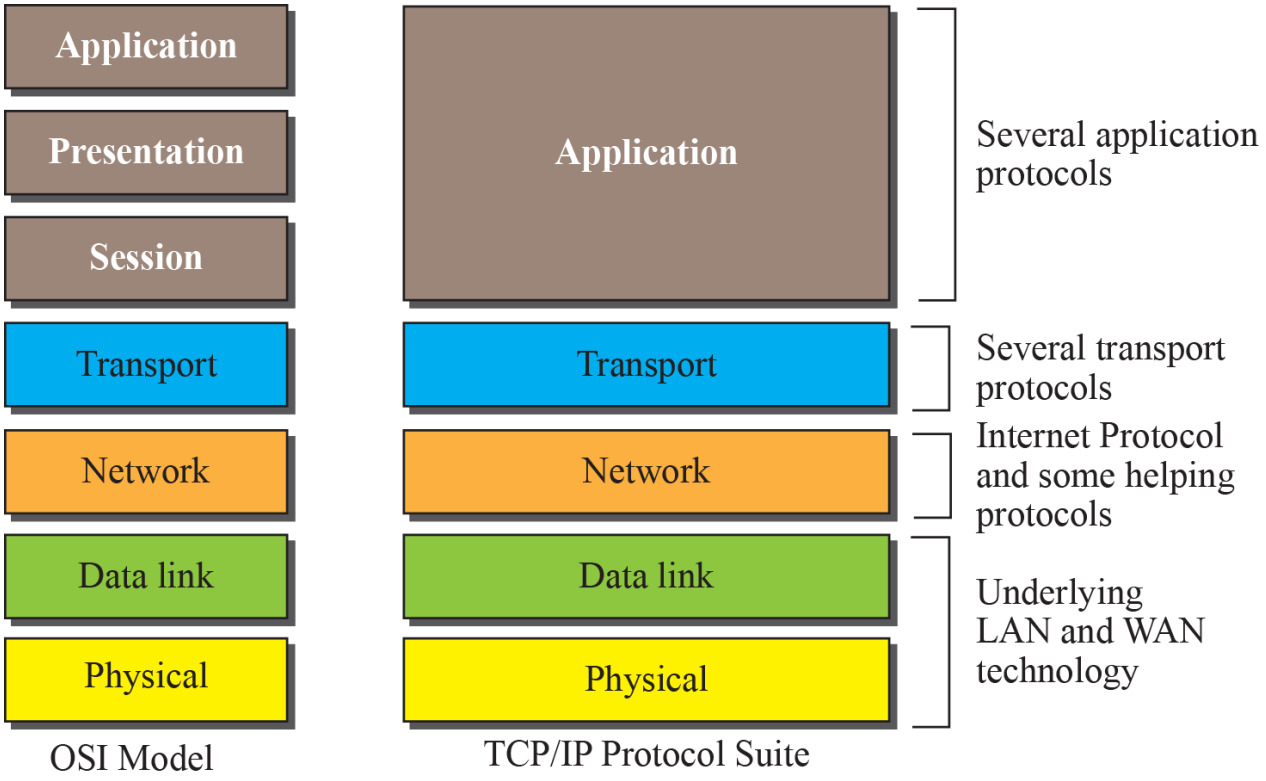
2-3 OSI Model

- The OSI Model



2.3.1 OSI versus TCP/IP

- Two layers: session and presentation
  - The application layer in the suite is usually considered to be the combination of three layers in the OSI model2.



2.3.2 Lack of OSI Model's Success

- The OSI model appeared after the TCP/IP protocol suite.
- Most experts were at first excited and thought that the TCP/IP protocol would be fully replaced by the OSI model.
- This did not happen for several reasons, but we describe only three, which are agreed upon by all experts in the field.
  - OSI was completed when TCP/IP was fully in place
  - Some layers in the OSI model were never fully defined
  - Not a high enough level of performance

Summary & Next Class

- Ch 1 Introduction
- Ch 2 Network models
- Summary & Next Class

Summary: Ch 1

- Data communications: transfer of data from one device to another via some form of transmission medium
- Network: a set of communication deices connected by media links
- Network is categorized as
  - LAN and WAN
- The Internet history
  - Started with the theory of packet switching for bursty traffic
  - ARPA, ARPANET
  - The idea of a device called a gateway to serve as the intermediary hardware to transfer data from one network to another
- Internet standard
  - RFC, IEEE 802, 3GPP

Summary: Ch 2

- A protocol is a set of rules that governs communication
  - Two principles for bidirectional communication: opposite and identical
  - Logical connection vs. physical connection
- TCP/IP
  - Physical, data link, network, transport, and application lsyers
- Four levels of addressed used in an internet
  - Physical (link) address: MAC (medium access control) address
  - Logical (IP) address
  - Port address
  - Specific address

Assignment

- **Solve Assignment 01 problems posted on eClass website exercise**
  - eClass → Data Communication → Assignment
  - Textbook problems: **P1-1,2,6,7, P2-4,11,13**
  - List at least **2 RFC standards** including brief introduction (at most 3 lines), and at least **2 IEEE 802 standards** including brief introduction (at most 3 lines).
    - http://www.rfc-editor.org
    - http://www.ieee802.org/
- **Upload your answer sheet** on eClass **until the dealine**
  - **Firm deadline!!**: **late** submission is **not accepted**
  - Only **docx, hwp, pdf** format allowed (**NOT any figure format including jpg, bmp, png** etc.)
  - eClass → Data Communciaton → Assignment
  - Don't forget to write your **name**, **student ID number**.
  - It is not important whether or not your answers are correct. That is, if you **just try to write an answer**, you can **get the perfect scores**.
  - Exams will rigorously check your efforts on solving the assignment and practice problems by yourself.
- In order to inquire about the assignment (problem or scoring), please contact to the teaching assistant

Important Standards

- RFC: Internet protocols (application, transport, network, (link) layers)
  - http://www.rfc-editor.org
  - RFC791 (IP), RFC817(TCP)
- IEEE 802 standards: physical & link layer protocols
  - http://www.ieee802.org/
  - 802.3(Ethernet), 802.11 (WiFi), 802.15 (Wireless PAN)
- 3GPP: focusing on wireless cellular networks (Big market)
  - http://www.3gpp.org
  - LTE (Release 8 @2008), LTE-Advanced (Release 10 @2011), 5G (Release 15 @2018, 16 @2019)
  - Now, Release 14/15

Course Schedule (Tentative)

- FL: Flipped learning
- **Rec: Recorded video for makeup class**

No	Topics	Date-M		Date-Th	
1	Introduction to course and data communications (Ch1)	09/05	FL (**Zoom**)	09/08	FL
2	Intro. to data communications (Ch1) & Network models (Ch2)	09/12	**Rec**	09/15	FL
3	Intro. to physical layer (Ch3)	09/19	FL	09/22	FL
4	Digital transmission (Ch4)	09/26	FL	09/29	FL
5	Analog transmission (Ch5) & Bandwidth utilization: multiplexing (Ch6.1)	10/03	**Rec**	10/06	**Rec**
6	Bandwidth utilization: spread spectrum (Ch6.2) Transmission Media (Ch7)	10/10	**Rec**	10/13	FL
7	Switching (Ch8) Introduction to Data-Link Layer (Ch9)	10/17	FL	10/20	FL
8	**Midterm exam**	**10/24**	**Evening**	**10/24**	**Evening**
9	Error detection and correction (Ch10)	10/31	FL	11/03	FL
10	Data link control (Ch11)	11/07	FL	11/10	FL
11	Media Access Control (Ch12)	11/14	FL	11/17	**Rec**
12	Wired LAN (Ethernet) (Ch13) & Other wired network (Ch14)	11/21	**Rec**	11/24	FL
13	Wireless LAN (Ch15)	11/28	FL	12/01	FL
14	Other wireless networks (Ch16) Connecting devices and virtual LANs (Ch17)	12/05	FL	12/08	FL
15	**Final exam**	**12/12**	**Evening**	**12/12**	**Evening**