Objectives

In this chapter, you will learn about:

- Basic networking concepts
- Communication protocols
- Network services and benefits
- A brief history of the Internet and the World Wide Web
Introduction

- Computer network
  - Computers connected together
  - **Purpose**: exchanging resources and information
  - Just about any kind of information can be sent
    - **Examples**: television and radio signals, voice, graphics, handwriting, photographs, movies
Basic Networking Concepts

- Computer network
  - Set of independent computer systems connected by telecommunication links
  - **Purpose**: sharing information and resources

- Nodes, hosts, or end systems
  - Individual computers on a network
Communication Links

- Switched, dial-up telephone line
  - A circuit is temporarily established between the caller and callee
  - Analog medium
  - Requires modem at both ends to transmit information produced by a computer
- Computer produces digital information
Figure 7.1 Two Forms of Information Representation
Figure 7.2
Modulation of a Carrier to Encode Binary Information
Communication Links (continued)

- **Dial-up phone links**
  - Transmission rate: 56,000 bps (56 Kbps)

- **Broadband**
  - Transmission rate: exceeding 128,000 bps (128 Kbps)
Communication Links (continued)

- Options for broadband communications
  - Home use
    - Digital subscriber line (DSL)
    - Cable modem
  - Commercial and office environment
    - Ethernet
    - Fast Ethernet
    - Gigabit Ethernet
### Figure 7.3
Transmission Time of an Image at Different Transmission Speeds

<table>
<thead>
<tr>
<th>Line Type</th>
<th>Speed</th>
<th>Time to Transmit 8 Million Bits (one compressed image)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dial-up phone line</td>
<td>56 Kbps</td>
<td>2.4 minutes</td>
</tr>
<tr>
<td>DSL line, cable modem</td>
<td>2 Mbps</td>
<td>4 seconds</td>
</tr>
<tr>
<td>Ethernet</td>
<td>10 Mbps</td>
<td>0.8 second</td>
</tr>
<tr>
<td>Fast Ethernet</td>
<td>100 Mbps</td>
<td>0.08 second</td>
</tr>
<tr>
<td>Gigabit Ethernet</td>
<td>1 Gbps</td>
<td>0.008 second</td>
</tr>
</tbody>
</table>
Communication Links (continued)

- Wireless data communication
  - Uses radio, microwave, and infrared signals
  - Enables “mobile computing”

- Types of wireless data communication
  - Wireless local access network
  - Wireless wide-area access network
Local Area Networks

- Local area network (LAN)
  - Connects hardware devices that are in close proximity
  - The owner of the devices is also the owner of the means of communications
  - Common wired LAN topologies
    - Bus
    - Ring
    - Star
Figure 7.4
Some Common LAN Topologies

(a) Bus

(b) Ring

(c) Star
Local Area Networks (continued)

- Ethernet
  - Most widely used LAN technology
  - Uses the bus topology
  - Two ways to construct an Ethernet LAN
    - Shared cable
    - Hubs: the most widely used technology
Figure 7.5: An Ethernet LAN Implemented Using Shared Cables
Figure 7.6
An Ethernet LAN Implemented Using a Hub
Wide Area Networks

- Wide area networks (WANs)
  - Connect devices that are across town, across the country, or across the ocean
  - Users must purchase telecommunications services from an external provider
  - Dedicated point-to-point lines
  - Most use a store-and-forward, packet-switched technology to deliver messages
Figure 7.7
Typical Structure of a Wide Area Network
Overall Structure of the Internet

- All real-world networks, including the Internet, are a mix of LANs and WANs
  - Example: a company or a college
    - One or more LANs connecting its local computers
    - Individual LANs interconnected into a wide-area “company network”
Figure 7.8(a)
Structure of a Typical Company Network
Overall Structure of the Internet (continued)

- Internet Service Provider (ISP)
  - A wide-area network
  - Provides a pathway from a specific network to other networks, or from an individual to other networks

- ISPs are hierarchical
  - Interconnect to each other in multiple layers to provide greater geographical coverage
Figure 7.8(b)
Structure of a Network Using an ISP
Figure 7.8(c)
Hierarchy of Internet Service Providers
Overall Structure of the Internet (continued)

- **Internet**
  - A huge interconnected “network of networks”
  - Includes nodes, LANs, WANs, bridges, routers, and multiple levels of ISPs
  - Early 2003
    - 170 million nodes (hosts)
    - Hundreds of thousands of separate networks located in over 225 countries
Communication Protocols

- A protocol
  - A mutually agreed upon set of rules, conventions, and agreements for the efficient and orderly exchange of information

- TCP/IP
  - The Internet protocol hierarchy
  - Governs the operation of the Internet
  - Five layers
<table>
<thead>
<tr>
<th>Layer</th>
<th>Name</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Application</td>
<td>HTTP, SMTP, FTP</td>
</tr>
<tr>
<td>4</td>
<td>Transport</td>
<td>TCP, UDP</td>
</tr>
<tr>
<td>3</td>
<td>Network</td>
<td>IP</td>
</tr>
<tr>
<td>2b</td>
<td>Logical Link Control</td>
<td>PPP, Ethernet</td>
</tr>
<tr>
<td>2a</td>
<td>Medium Access Control</td>
<td>Ethernet</td>
</tr>
<tr>
<td>1</td>
<td>Physical</td>
<td>Modem, DSL, Cable Modem</td>
</tr>
</tbody>
</table>

Figure 7.10
The Five-Layer TCP/IP Internet Protocol Hierarchy
Physical Layer

- Protocols govern the exchange of binary digits across a physical communication channel

- **Goal**: create a “bit pipe” between two computers
Data Link Layer

- Protocols carry out
  - Error handling
  - Framing
- Creates an error-free “message pipe”
- Composed of two services
  - Layer 2a: medium access control
  - Layer 2b: logical link control
Data Link Layer (continued)

- Medium access control protocols
  - Determine how to arbitrate ownership of a shared line when multiple nodes want to send at the same time

- Logical link control protocols
  - Ensure that a message traveling across a channel from source to destination arrives correctly
Network Layer

- Delivers a message from the site where it was created to its ultimate destination

- Critical responsibilities
  - Creating a universal addressing scheme for all network nodes
  - Delivering messages between any two nodes in the network
Network Layer (continued)

- Provides a true “network delivery service”
  - Messages are delivered between any two nodes in the network, regardless of where they are located

- IP (Internet Protocol) layer
  - Network layer in the Internet
Transport Layer

- Provides a high-quality, error-free, order preserving end-to-end delivery service

- TCP (Transport Control Protocol)
  - Primary transport protocol on the Internet
  - Requires the source and destination programs to initially establish a connection
Figure 7.15
Logical View of a TCP Connection
Application Layer

- Implements the end-user services provided by a network
- There are many application protocols, including:
  - HTTP
  - SMTP
  - POP3
  - IMAP
  - FTP
### Figure 7.16

**Some Popular Application Protocols on the Internet**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name</th>
<th>Application</th>
<th>Well-known</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTTP</td>
<td>Hypertext Transfer Protocol</td>
<td>Accessing web pages</td>
<td>80</td>
</tr>
<tr>
<td>SMTP</td>
<td>Simple Mail Transfer Protocol</td>
<td>Sending electronic mail</td>
<td>25</td>
</tr>
<tr>
<td>POP3</td>
<td>Post Office Protocol</td>
<td>Receiving electronic mail</td>
<td>110</td>
</tr>
<tr>
<td>IMAP</td>
<td>Internet Mail Access Protocol</td>
<td>Receiving electronic mail</td>
<td>143</td>
</tr>
<tr>
<td>FTP</td>
<td>File Transfer Protocol</td>
<td>Accessing remote files</td>
<td>21</td>
</tr>
<tr>
<td>TELNET</td>
<td>Terminal Emulation Protocol</td>
<td>Remote terminal access</td>
<td>23</td>
</tr>
<tr>
<td>DNS</td>
<td>Domain Name Service</td>
<td>Translating symbolic host names to 32-bit IP addresses</td>
<td>42</td>
</tr>
</tbody>
</table>
Application Layer (continued)

- Uniform Resource Locator (URL)
  - A symbolic string that identifies a Web page
  - Form
    - protocol://host address/page
  - The most common Web page format is hypertext information
    - Accessed using the HTTP protocol
Network Services and Benefits

- Services offered by computer networks
  - Electronic mail (email)
  - Bulletin boards
  - News groups
  - Chat rooms
  - Resource sharing
    - Physical resources
    - Logical resources
Network Services and Benefits (continued)

- Services offered by computer networks
  - Client-server computing
  - Information sharing
  - Information utility
  - Electronic commerce (e-commerce)
A Brief History of the Internet and the World Wide Web:
The Internet

- **August 1962**: first proposal for building a computer network
  - Made by J. C. R. Licklider of MIT

- **ARPANET**
  - Built by the Advanced Research Projects Agency (ARPA) in the 1960s
  - Grew quickly during the early 1970s
The Internet (continued)

- **NSFNet**: A national network built by the National Science Foundation (NSF)

- October 24, 1995: Formal acceptance of the term “Internet”

- Internet service providers start offering Internet access once provided by the ARPANET and NSFNet
Figure 7.20
State of Networking in the Late 1980s
The World Wide Web

- Development completed in May 1991
- Designed and built by Tim Berners-Lee
- Components
  - Hypertext
    - A collection of documents interconnected by pointers called links
  - URL (Uniform Resource Locator)
    - The worldwide identification of a Web page located on a specific host computer
Figure 7.21
Hypertext Documents
Summary of Level 3

- Virtual environment
  - Created by system software
  - Easy to use and easy to understand
  - Provides services such as:
    - Resource management
    - Security
    - Access control
    - Efficient resource use

- Operating systems continue to evolve
Summary

- **Computer network**: a set of independent computer systems connected by telecommunication links

- Options for transmitting data on a network: dial-up telephone lines, DSL, cable modem, Ethernet, Fast Ethernet

- **Types of networks**: local area network (LAN) and wide area network (WAN)
Summary

- The Internet is a huge interconnected "network of networks"

- TCP/IP is the Internet protocol hierarchy, composed of five layers: physical, data link, network, transport, and application

- The World Wide Web is an information system based on the concept of hypertext