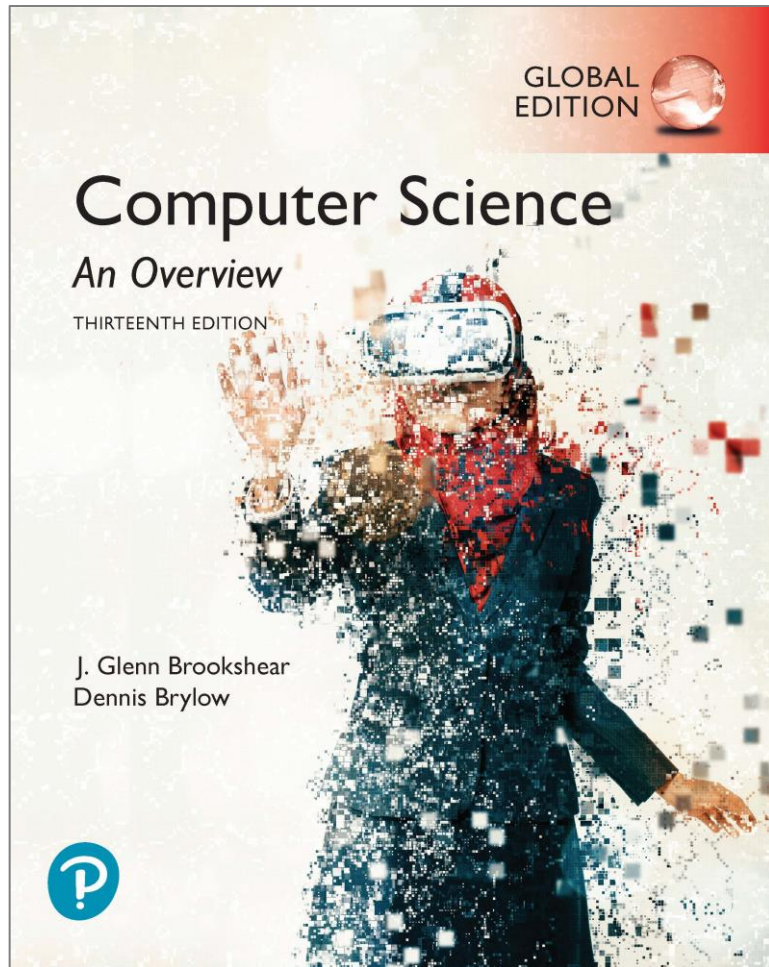# Computer Science An Overview

13th Edition, Global Edition

Chapter 4

Networking and
the Internet

Chapter 4: Networking and the Internet

- 4.1 Network Fundamentals

- 4.2 The Internet

- 4.3 The World Wide Web

- 4.4 Internet Protocols

- 4.5 Simple Client Server

- 4.6 Security

4.1 Network Fundamentals

- Network Software allows users to exchange information and share resources
  - Content
  - Software
  - Data storage facilities

- Network software has evolved into a network-wide operating system

Network Classifications

- Scope
  - Personal Area Network (short-range)
  - Local Area Network (building/campus)
  - Metropolitan Area Network (community)
  - Wide Area Network (greater distances)

- Ownership
  - Closed versus open

- Topology (configuration)
  - Bus (Ethernet)
  - Star (Wireless networks with central Access Point)

Figure 4.1 Two popular network topologies (1 of 2)
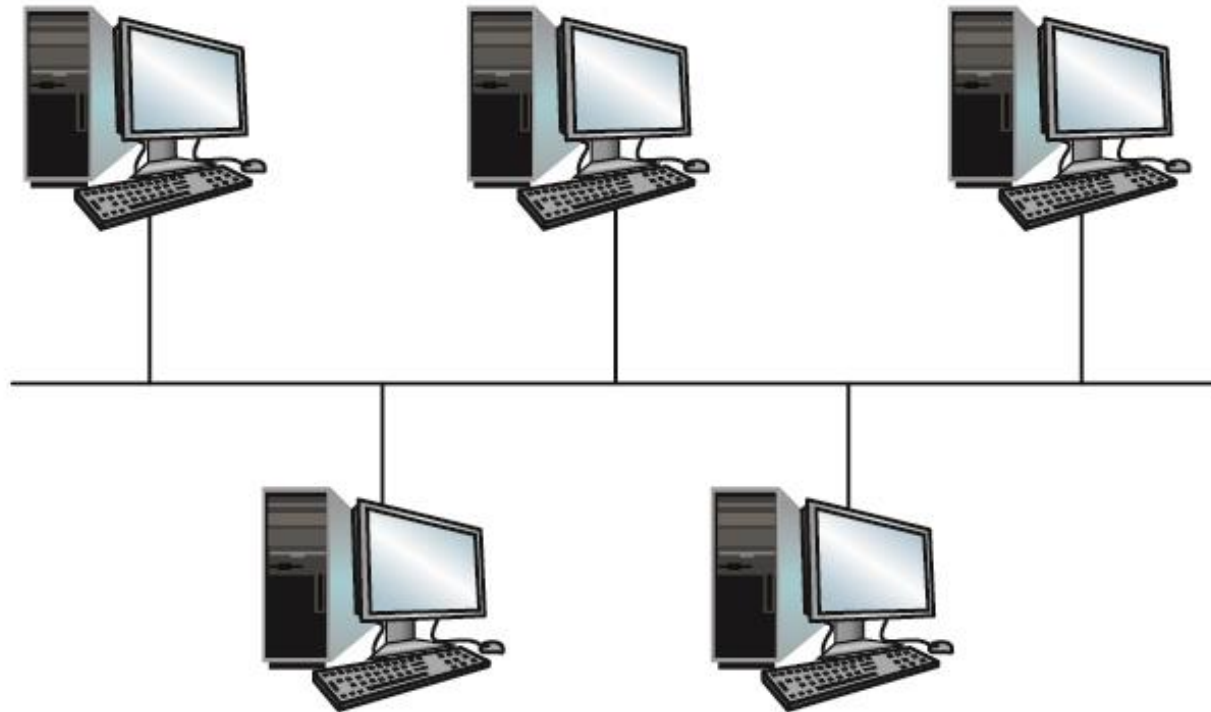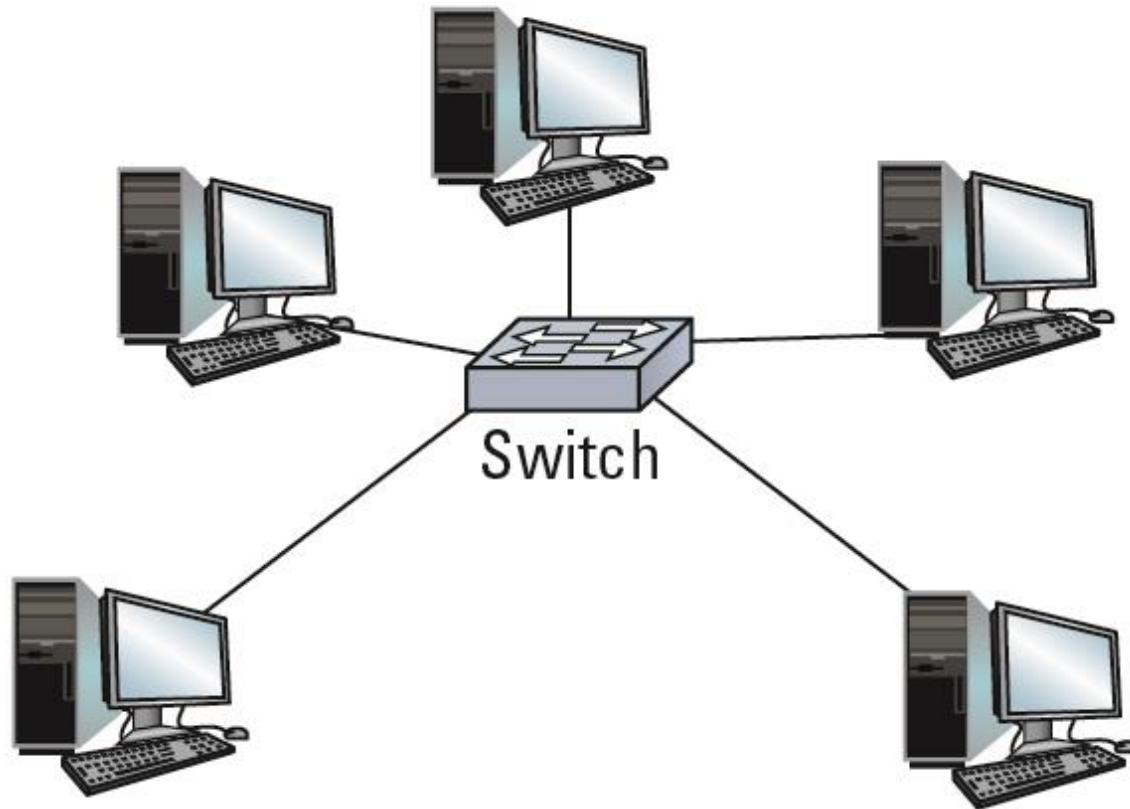
a. Bus

Figure 4.1 Two popular network topologies (2 of 2)

b. Star

Switch

Protocols

- Rules by which activities are conducted on a network
  - Example: Coordinating the transmission of messages between computers
    - Need to avoid all machines transmitting at the same time

- Allows vendors to build products that are compatible with products from other vendors

Protocols for Transmitting Messages

- CSMA/Collision Detection
    - used in Ethernet
    - both machines stop and wait for a independent, random time

- CSMA/Collision Avoidance
    - used in WiFi, where not all machines can hear each other (hidden terminal problem)
    - give advantage to the machine that has already been waiting

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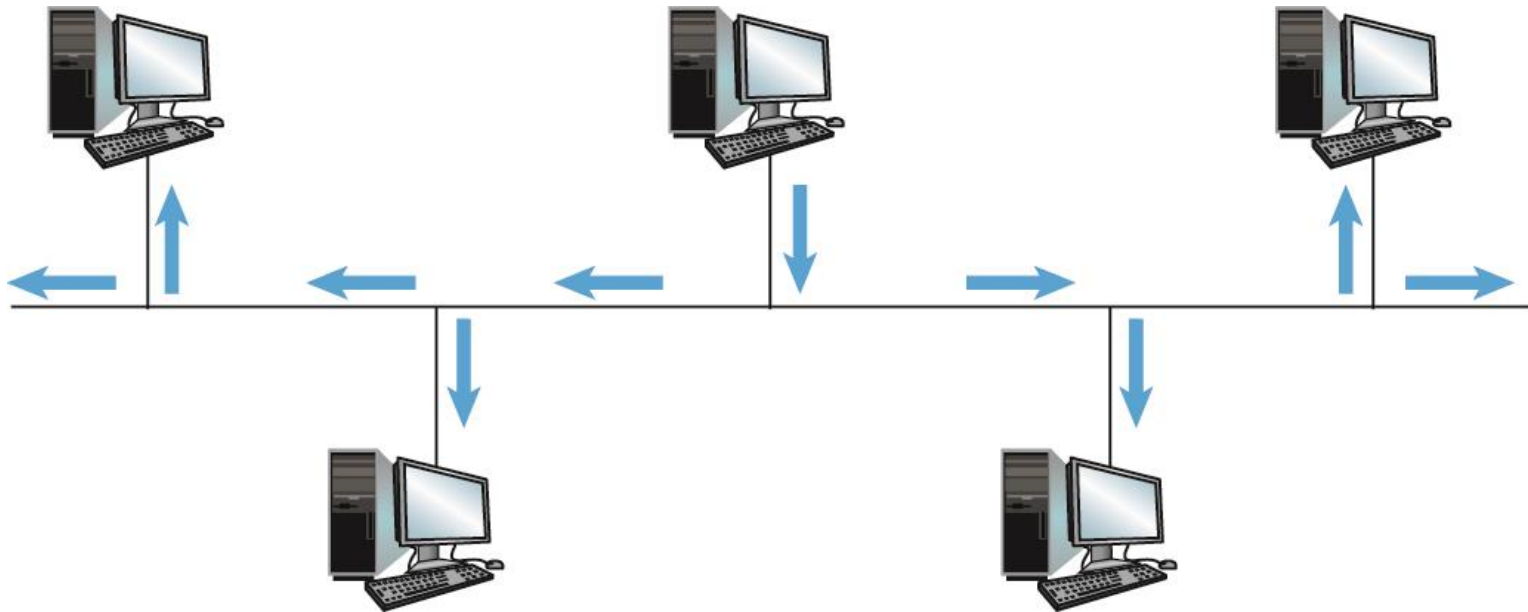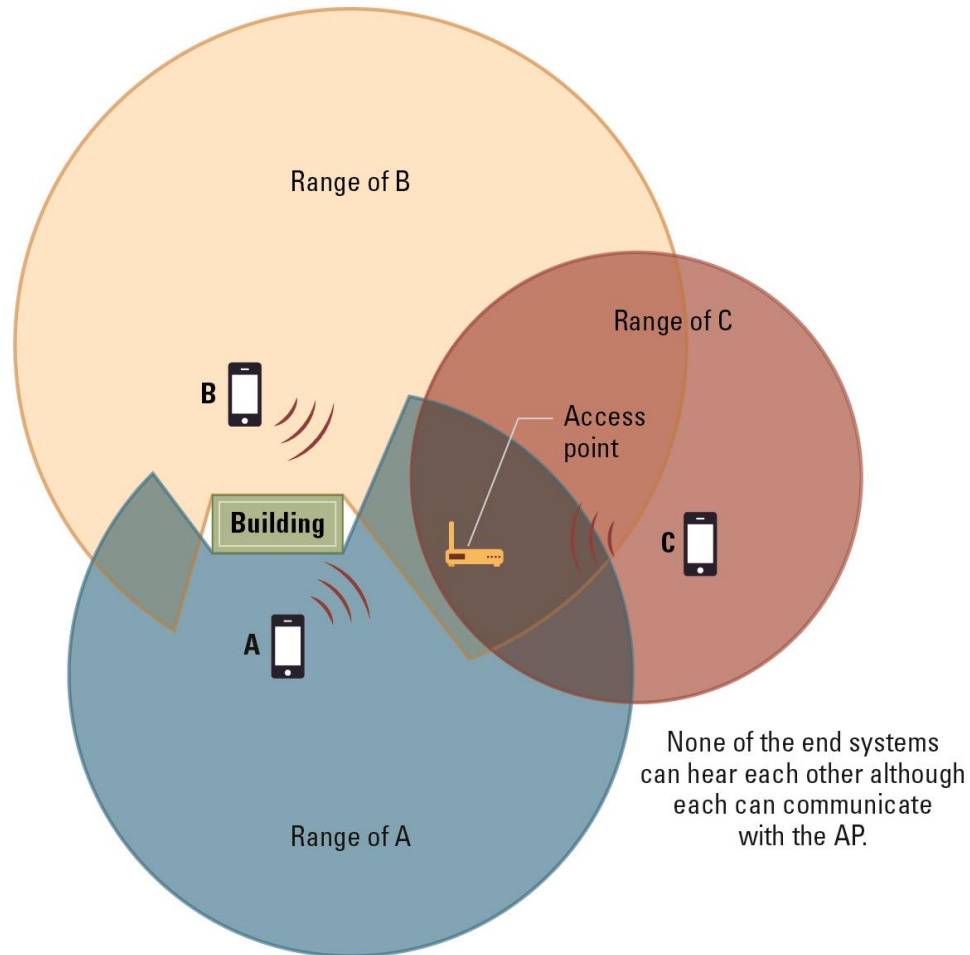# Figure 4.2 Communication over a bus network

Figure 4.3 The hidden terminal problem

Range of B

Range of C

B

Access
point

Building

C

A

None of the end systems
can hear each other although
each can communicate
with the AP.

Range of A

Pearson

Combining Networks

- **Repeater:** passes all messages across two busses

- **Bridge:** passes only messages that are destined for computers on the other bus

- **Switch:** acts like a bridge, but with connections to multiple busses

- **Router:** Connects two incompatible networks resulting in a network of networks called an **internet**

Figure 4.4 Building a large bus network from smaller ones
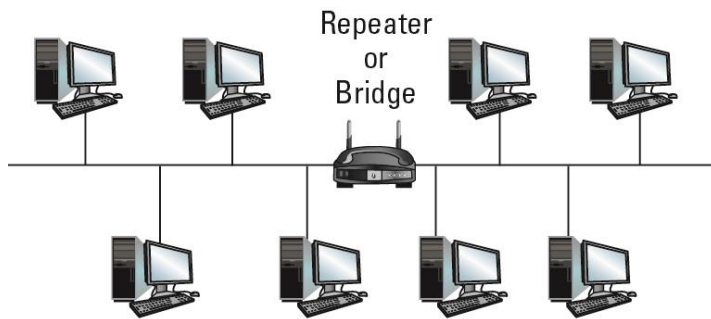
a. A repeater or bridge connecting two buses
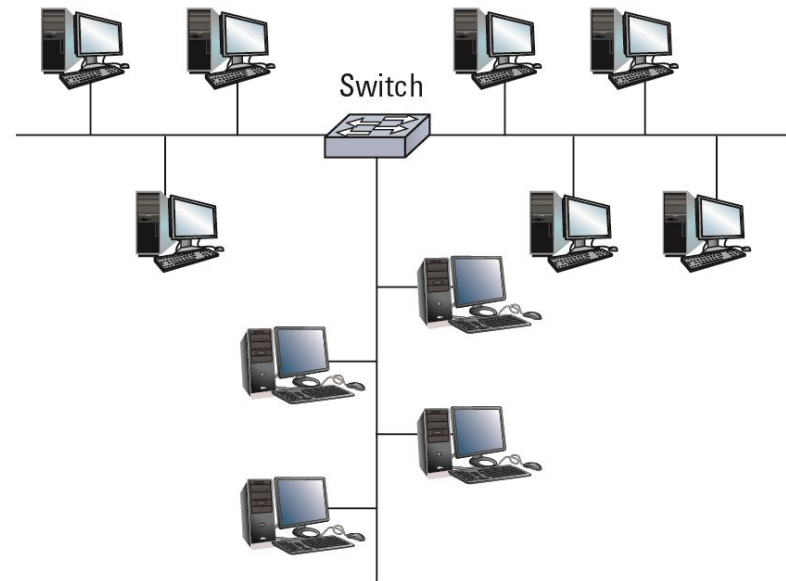
b. A switch connecting multiple buses

Figure 4.5 Routers connecting two WiFi networks and an Ethernet network to form an internet
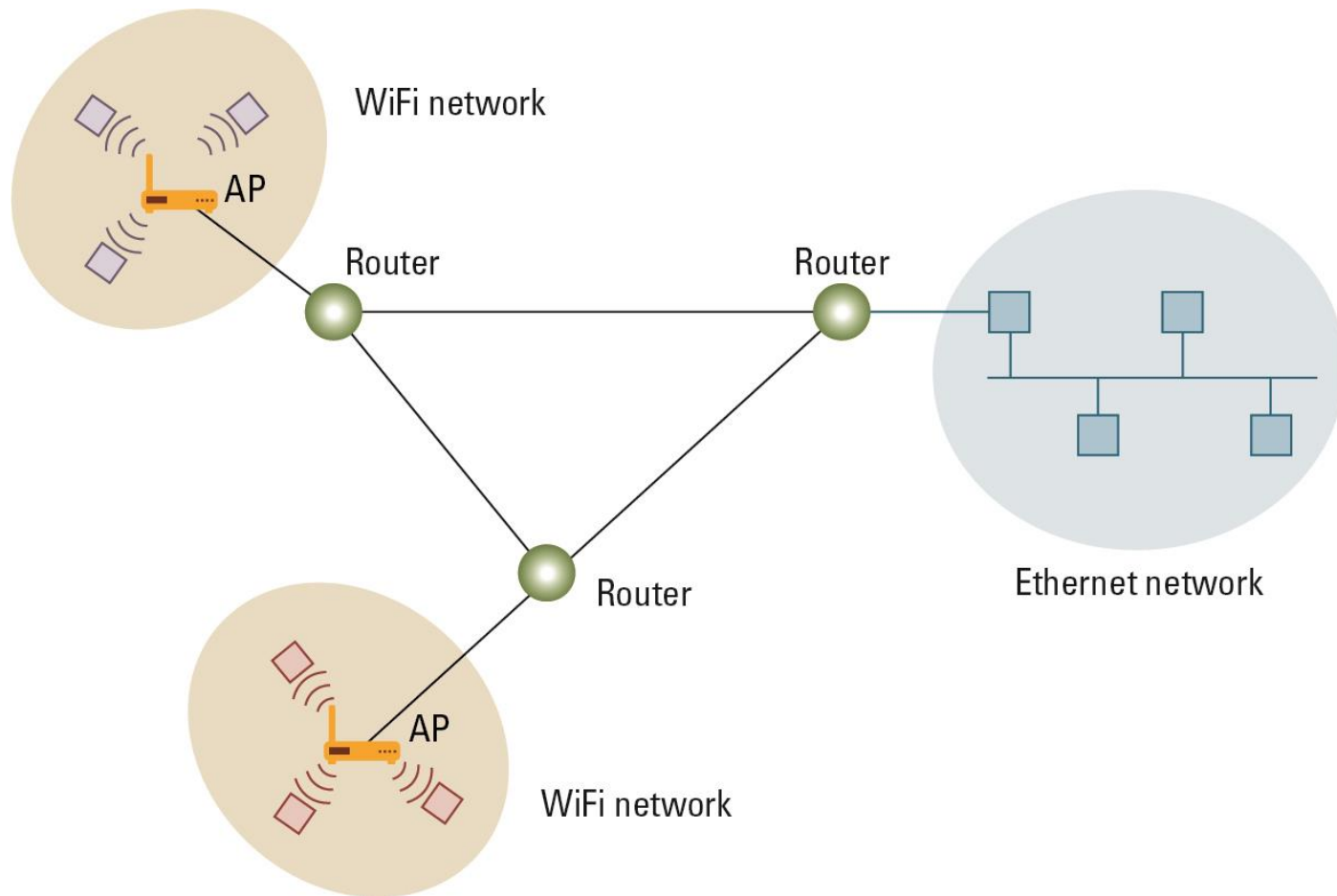
Methods of Process Communication

- Client-server
  - Many clients, one server (executing continuously)
  - Clients make requests of other processes
  - Server satisfies requests made by clients

- Peer-to-peer (P2P)
  - Two processes communicating as equals
  - Processes execute on a temporary basis

Figure 4.6 The client/server model compared to the peer-to-peer model
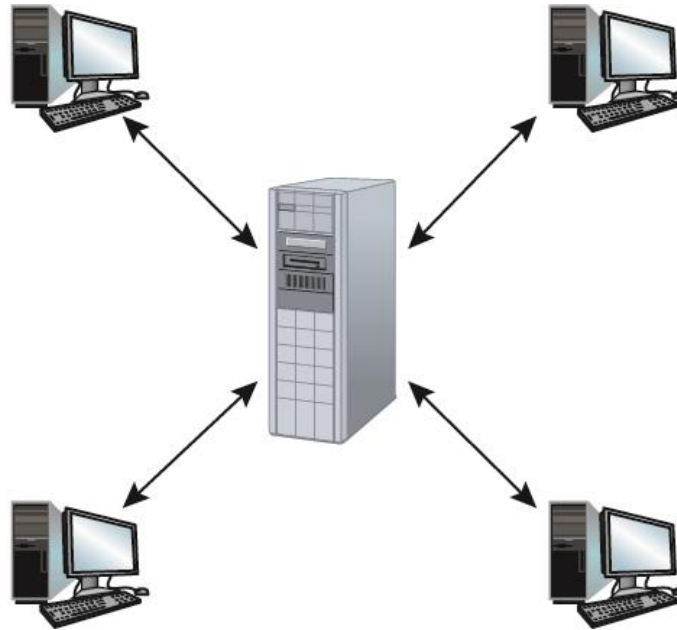
a. Server must be prepared to serve multiple clients at any time.

b. Peers communicate as equals on a one-to-one basis.

Distributed Systems

- Systems units that execute as processes on different computers
  - Cluster computing
    - Independent computers work closely together instead of a single, much larger machine
  - Grid computing
    - Millions of home PCs (not connected to each other) work on a complex problem
  - Cloud computing
    - Provide services, hide the details

4.2 The Internet

- The Internet is an internet that spans the world
  - Original goal was to link a variety of networks into a connected system unaffected by local disasters
  - Today, it is a commercial undertaking that links a worldwide combination of PANs, LANs, MANs, and WANs involving millions of computers

Internet Architecture

- Internet Service Provider (ISP)
  - Tier-1 (Internet backbone)
  - Tier-2

- Access or Tier-3 ISP: Provides connectivity to the Internet
  - Hot spot (wireless)
  - Telephone lines
  - Cellular
  - Cable/Satellite systems

Figure 4.7 Internet Composition

Tier-1 ISPs

Tier-2 ISPs

Access ISPs

End systems

Pearson
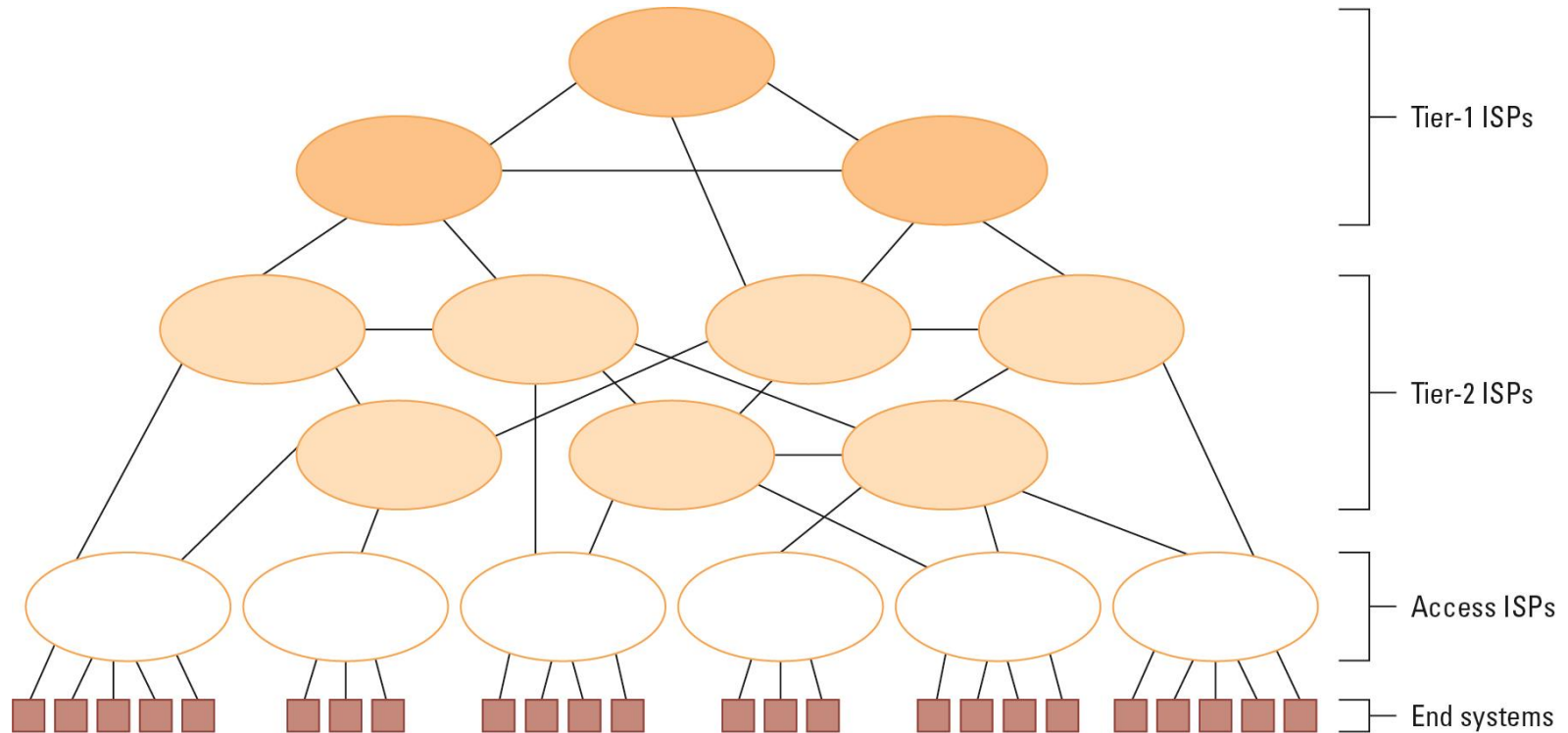
Internet Addressing

- IP address: pattern of 32 or 128 bits often represented in dotted decimal notation

- Mnemonic address:
  - Domain names   (mu.edu)
  - Top-Level Domains
    - .org, .gov, .com, .mil, .net, .au, .ca, .biz, ….

- Domain name system (DNS)
  - Name servers
  - DNS lookup

Internet Corporation for Assigned Names & Numbers (ICANN)

- Allocates blocks of IP addresses to ISPs who then assign those addresses within their regions.

- Oversees the registration of domains and domain names.

Early Internet Applications

- Network News Transfer Protocol (NNTP)

- File Transfer Protocol (FTP)

- Telnet and Secure Shell (SSH)

- Hypertext Transfer Protocol (HTTP)

- Electronic Mail (email)
  - Domain mail server collects incoming mail and transmits outing mail
  - Mail server delivers collected incoming mail to clients via POP3 or IMAP

SMTP Simple Mail Transfer Protocol

```
220 mail.tardis.edu SMTP Sendmail Gallifrey-1.0; Fri, 23 Aug 2413
14:34:10
HELO mail.skaro.gov
250 mail.tardis.edu Hello mail.skaro.gov, pleased to meet you
MAIL From: dalek@skaro.gov
250 2.1.0 dalek@skaro.gov... Sender ok
RCPT To: doctor@tardis.edu
250 2.1.5 doctor@tardis.edu... Recipient ok
DATA
354 Enter mail, end with "." on a line by itself
Subject: Extermination.

EXTERMINATE!
Regards, Dalek
.
250 2.0.0 r7NJYAEl028071 Message accepted for delivery
QUIT
221 2.0.0 mail.tardis.edu closing connection
```

More Recent Applications

- Voice Over IP (VoIP)

- Internet Multimedia Streaming
  - N-unicast
  - Multicast
  - On-demand streaming
  - Content delivery networks (CDNs)

4.3 World Wide Web

- **Hypertext** combines internet technology with concept of linked-documents
  - Embeds **hyperlinks** to other documents
- **Browsers** present materials to the user
- **Webservers** provide access to documents
- Documents are identified by **URL**s and transferred using **HTTP**

Figure 4.8 A typical URL

`http://eagle.mu.edu/authors/Shakespeare/Julius_Caesar.html`

Protocol required to access the document. In this case it is hypertext transfer protocol (http).

Mnemonic name of host holding the document

Directory path indicating the location of the document within the host's file system

Document name
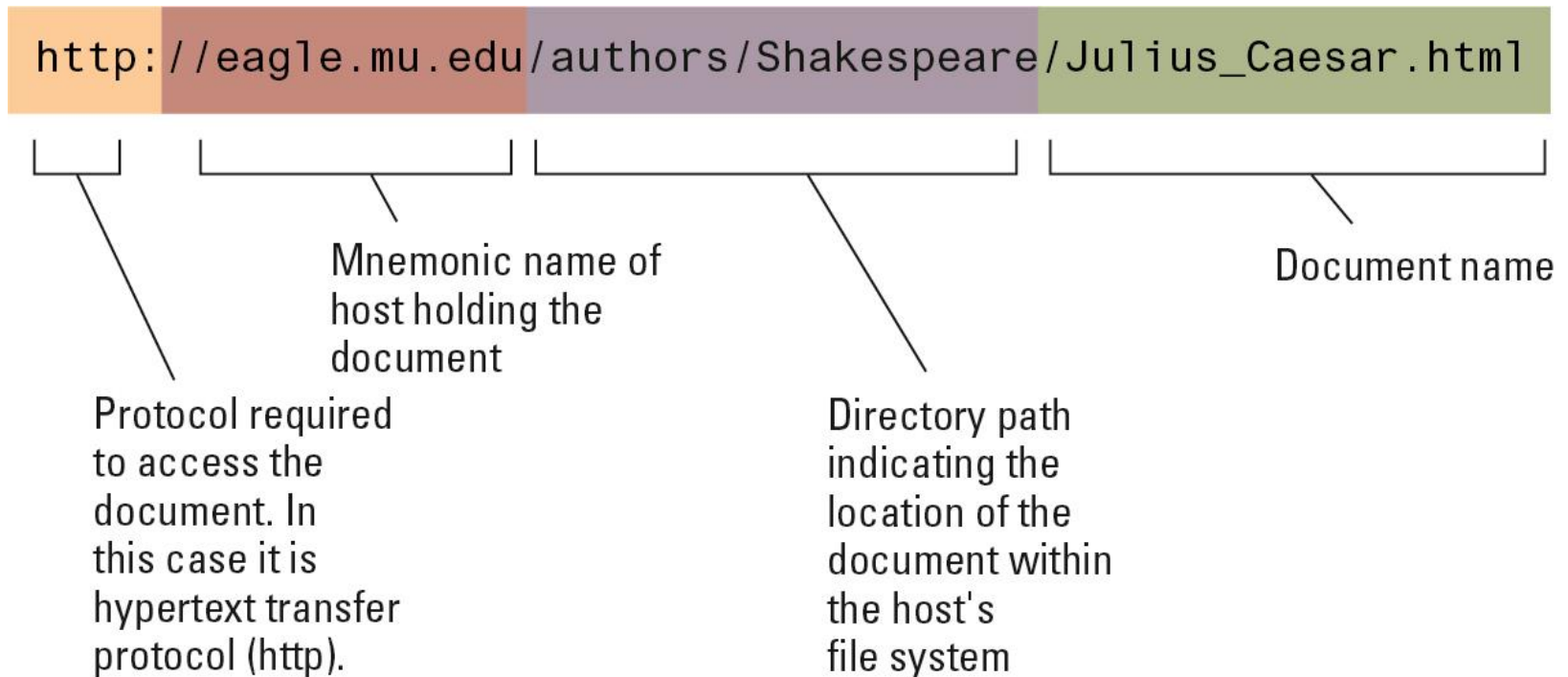
Hypertext Markup Language (HTML)

- Encoded as text file

- Contains tags to communicate with browser
  - Appearance
    - <h1> to start a level one heading
    - <p> to start a new paragraph
  - Links to other documents and content
    - <a href = . . . >
  - Insert images
    - <img src = . . . >

Figure 4.9 A simple webpage

a. The page encoded using HTML.
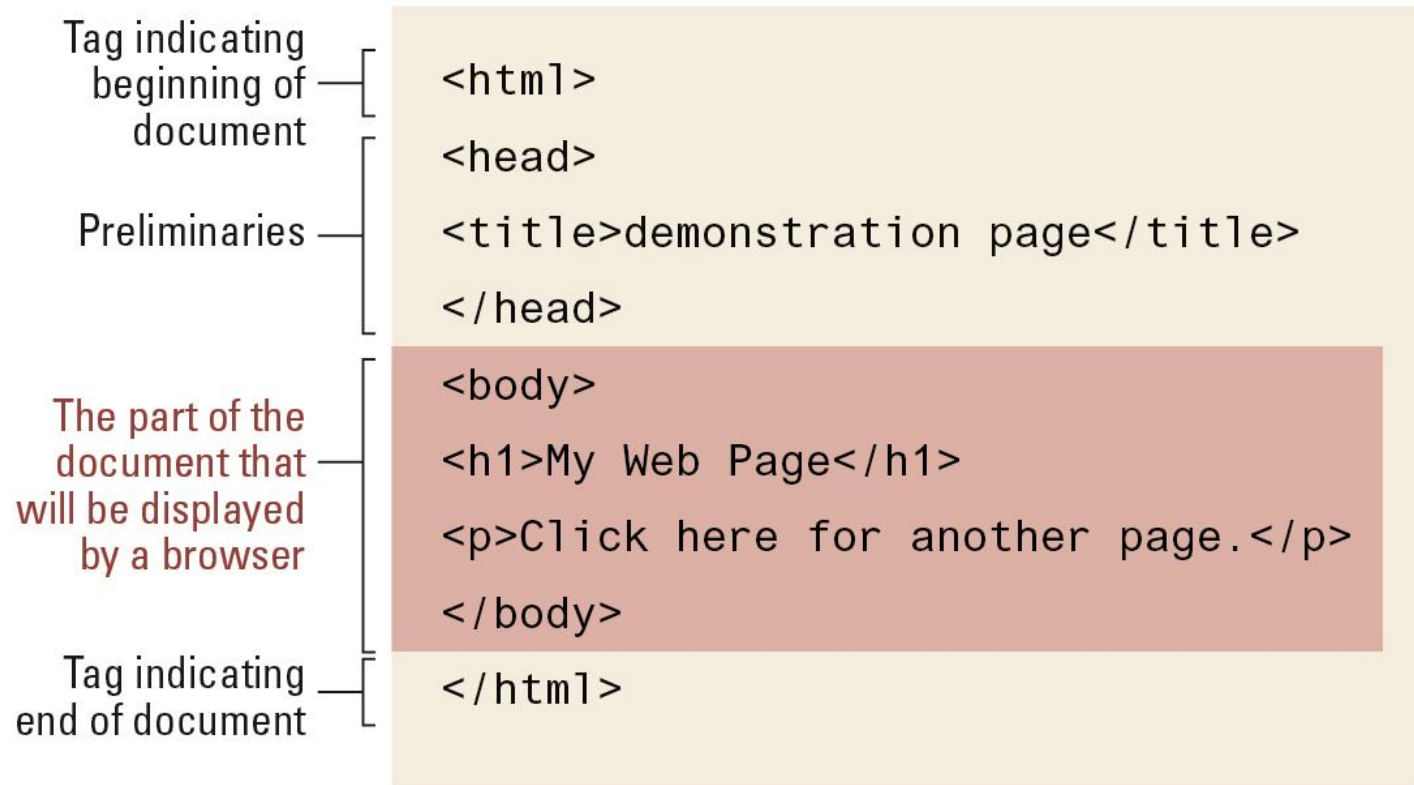
Tag indicating beginning of document
`<html>`

Preliminaries
`<head>`
`<title>demonstration page</title>`
`</head>`

The part of the document that will be displayed by a browser
`<body>`
`<h1>My Web Page</h1>`
`<p>Click here for another page.</p>`
`</body>`

Tag indicating end of document
`</html>`

Figure 4.9 A simple webpage (continued)

b. The page as it would appear on a computer screen.

My Web Page

Click here for another page.

Pearson

Figure 4.10 An enhanced simple webpage

a. The page encoded using HTML.

```
<html>
<head>
<title>demonstration page</title>
</head>
<body>
<h1>My Web Page</h1>
<p>Click
    <a href="http://crafty.com/demo.html">
    here
    </a>
    for another page.</p>
</body>
</html>
```

Anchor tag containing parameter — `<a href="http://crafty.com/demo.html">`

Closing anchor tag — `</a>`

Figure 4.10 An enhanced simple Web page (continued)

b. The page as it would appear on a computer screen.

My Web Page
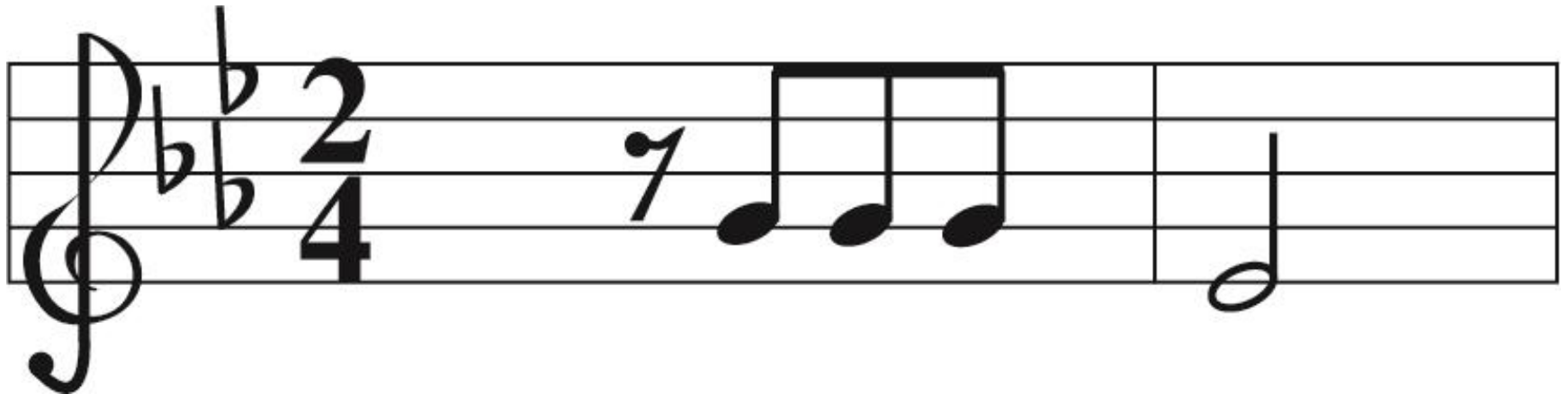
Click here for another page.

Extensible Markup Language (XML)

- XML: A language for constructing markup languages similar to HTML
  - A descendant of the Standard Generalized Markup Language
  - Opens door to a World Wide *Semantic* Web

Using XML to encode music

```
<staff clef = "treble"> <key>C minor</key>

<time> 2/4 </time>

<measure> < rest> egth </rest> <notes> egth G,
   egth G, egth G  </notes></measure>

<measure> <notes> hlf E </notes></measure>

</staff>
```

Figure 4.11 The first two bars of Beethoven's Fifth Symphony

Client Side Versus Server Side

- Client-side activities (browser)
  - Javascript
  - Java applets
  - Macromedia Flash

- Server-side activities (webserver)
  - Common Gateway Interface (CGI)
  - Servlets
  - JavaServer Pages (JSP) / Active Server Pages (ASP)
  - PHP

4.4 Internet Protocols

- Control how messages are transferred over the Internet

- This software must reside on every computer in the Internet

- Accomplished by a multi-level hierarchy

Figure 4.12 Package-shipping example
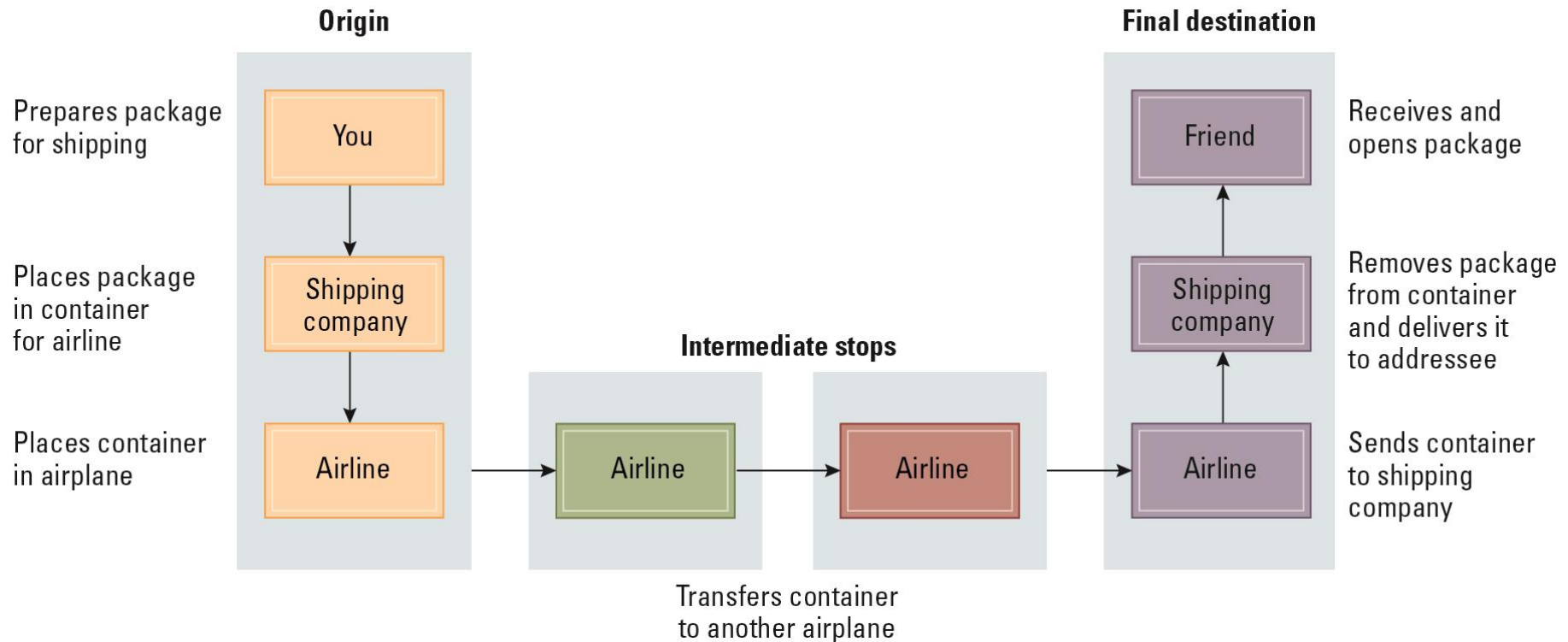
Internet Software Layers

- **Application:** Constructs message with address

- **Transport:** Chops message into packets

- **Network:** Handles routing through the Internet

- **Link:** Handles actual transmission of packets

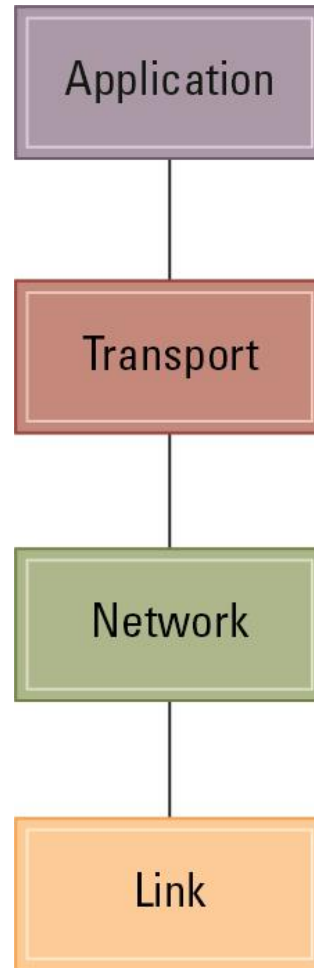# Figure 4.13 The Internet software layers

Figure 4.14 Following a message through the Internet

At each intermediate stop the network layer determines the direction in which the packet should be forwarded.

Origin

Prepares message and provides destination address — Application

Chops message into packets — Transport

Assigns intermediate address to each packet — Network

Transfers packet — Link

Intermediate stops

Network

Link

Network

Link

Final destination

Application — Receives message

Transport — Collects packets and reassembles message

Network — Detects that packet has reached its final destination

Link — Receives packet

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TCP/IP Protocol Suite

- Transport Layer
  - Transmission Control Protocol (TCP)
  - User Datagram Protocol (UDP)

- Network Layer
  - Internet Protocol (IP)
    - IPv4
    - IPv6

Figure 4.15 Choosing between TCP and UDP
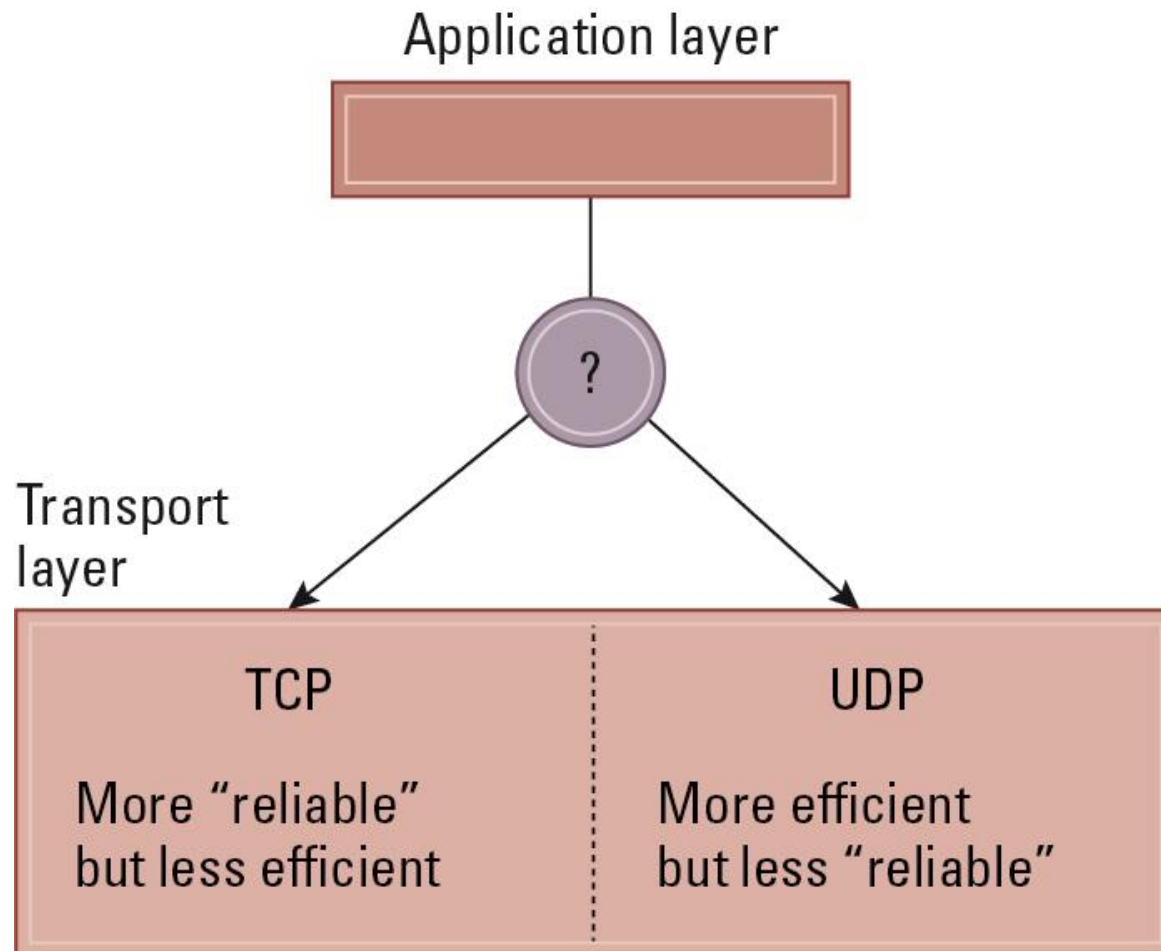
4.5 Simple Client Server Program

- Socket: an abstraction for processes at the application layer to connect to the network via the transport layer
  - Needs to know
    - Source Address name (localhost)
    - Source Port number(1023…65535)
    - Destination Address
    - Destination Port number

4.6 Cybersecurity

- Forms of Attack
  - Malware (viruses, worms, Trojan horses, spyware, phishing software)
  - Denial of service (DoS)
  - Spam (common medium for delivering malware)

- Protection and Cures
  - Firewalls
  - Spam filters
  - Proxy Servers
  - Antivirus software

Cryptography

- HTTPS for secure Internet access

- Public-key Encryption (asymmetric)
  - Public key: Used to encrypt messages
  - Private key: Used to decrypt messages

- Certificate Authorities
  - Trusted to maintain lists of public keys
  - Provide Certificates to clients containing a party's name and its public key

Figure 4.16 Public key encryption

Alice holds public key

Encrypted messages →

Carol holds public key

Encrypted messages →

Bob holds private key

Both Alice and Carol can send encrypted messages to Bob.

Alice holds public key

Encrypted message →

?

Carol holds public key

Bob holds private key

Carol cannot decrypt Alice's message even though she knows how Alice encrypted it.

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