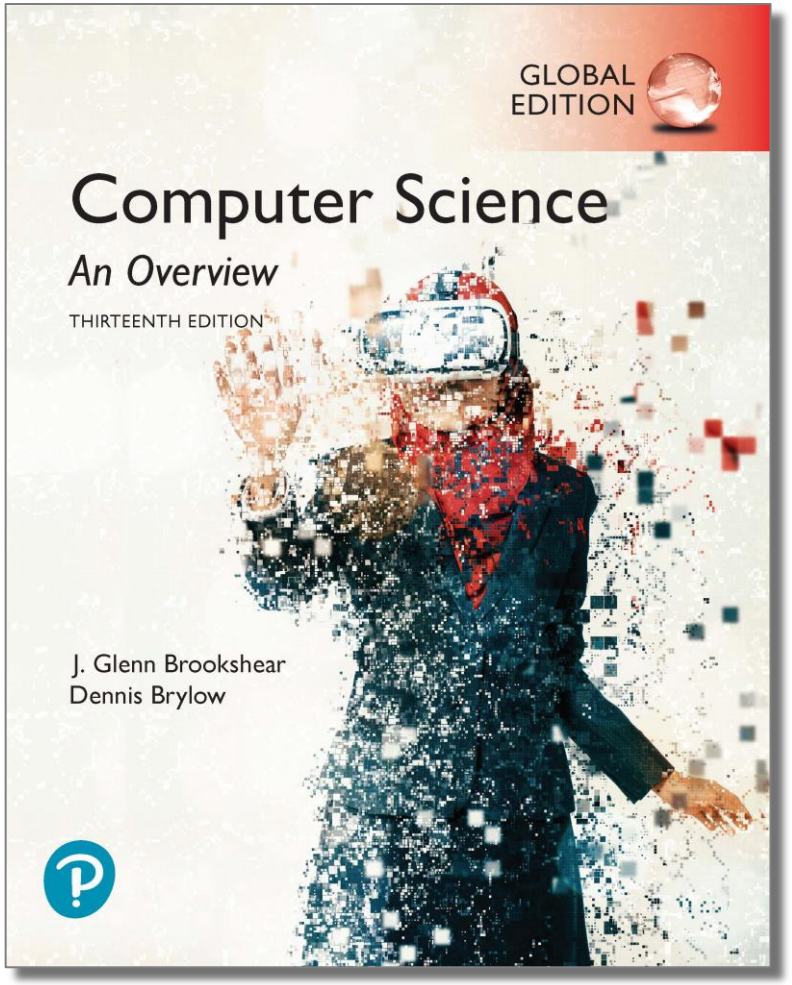
Computer Science An Overview

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)

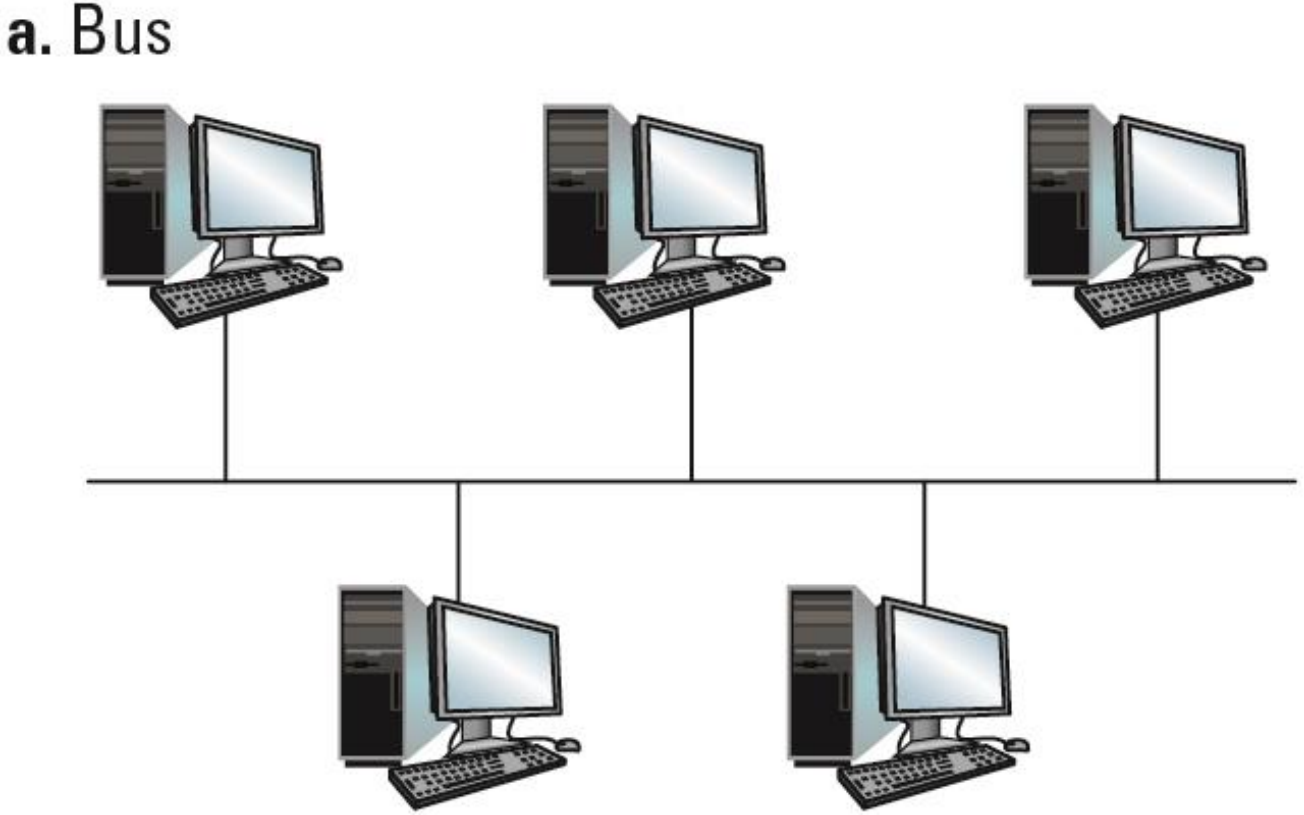
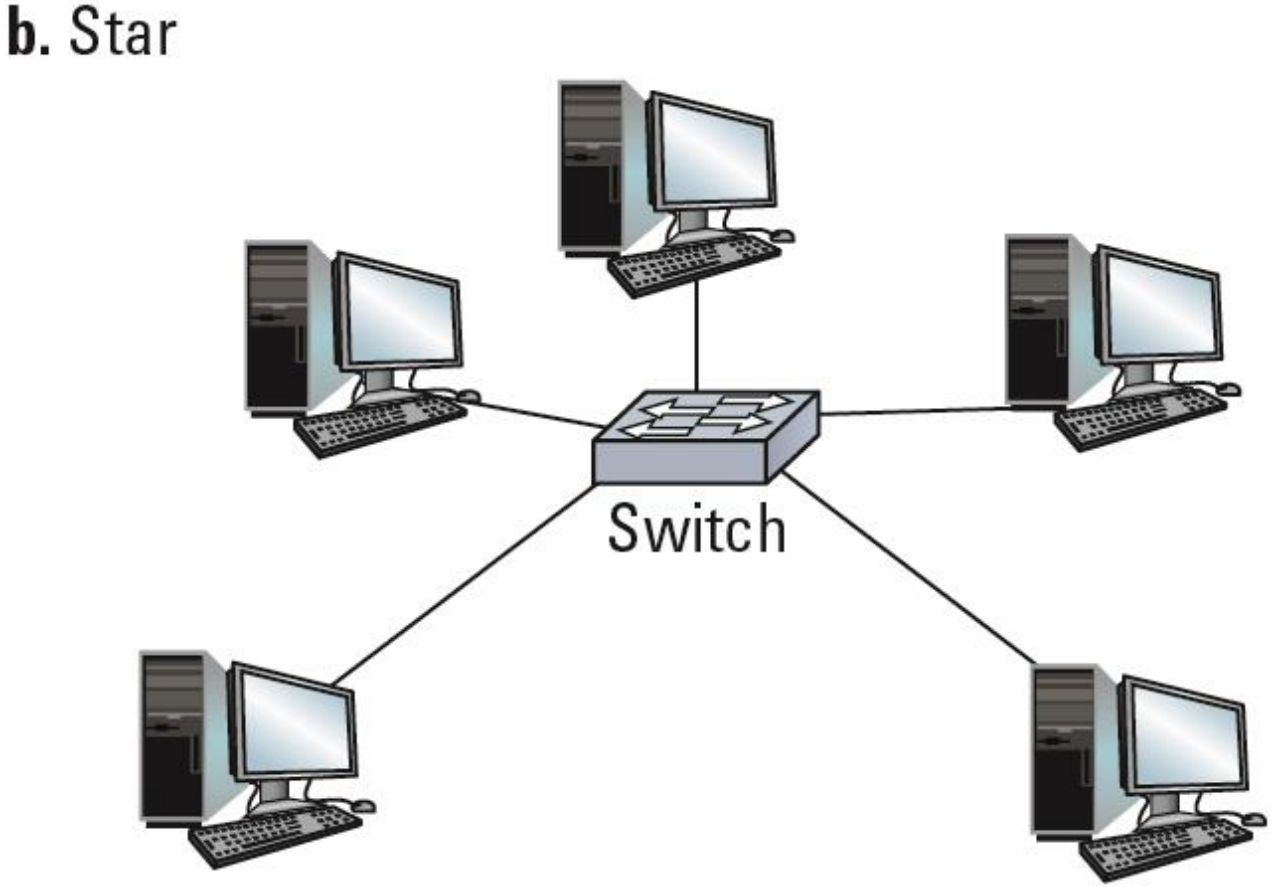


Figure 4.1 Two popular network topologies (2 of 2)



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

Figure 4.2 Communication over a bus network

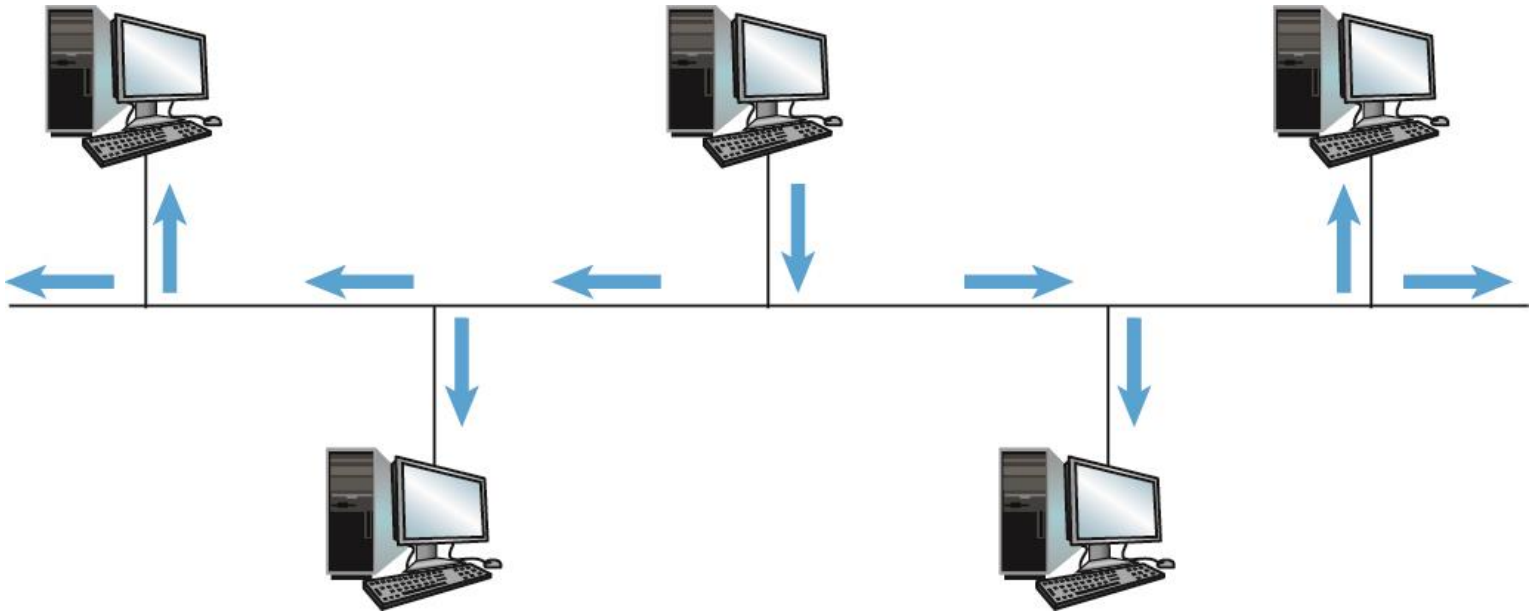
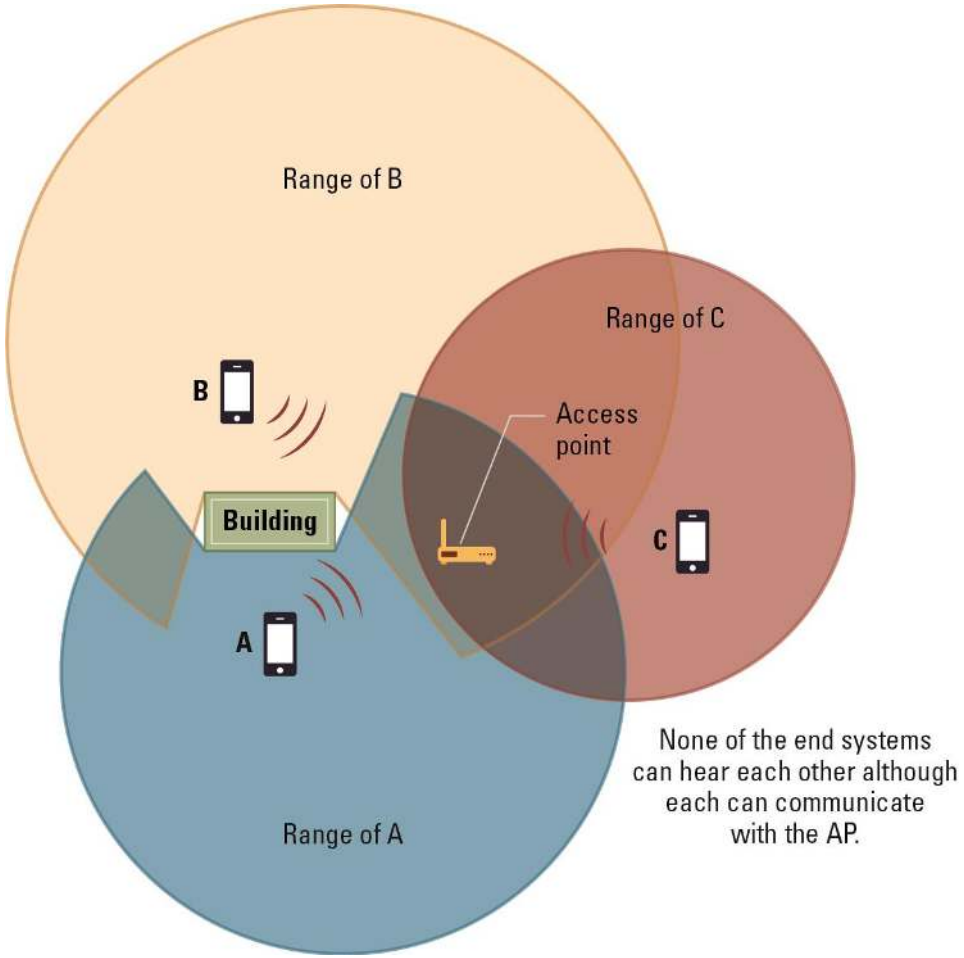


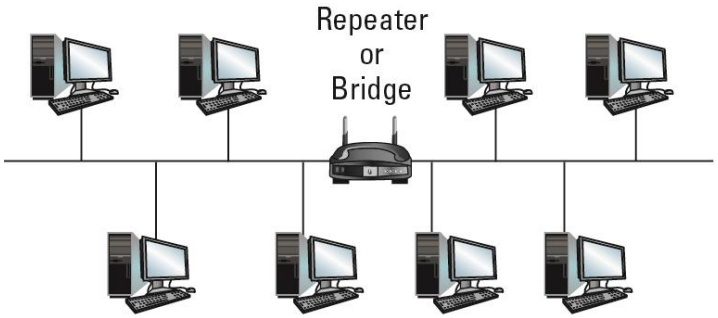
Figure 4.3 The hidden terminal problem



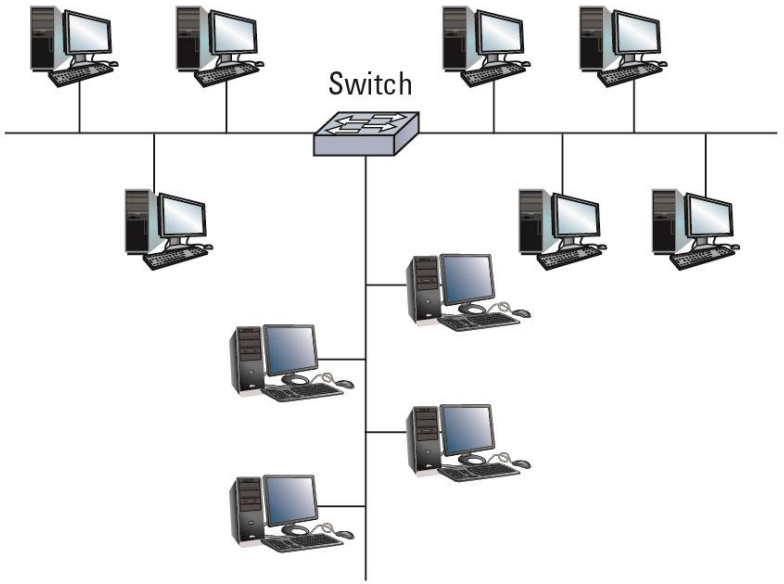
Combining Networks

- **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

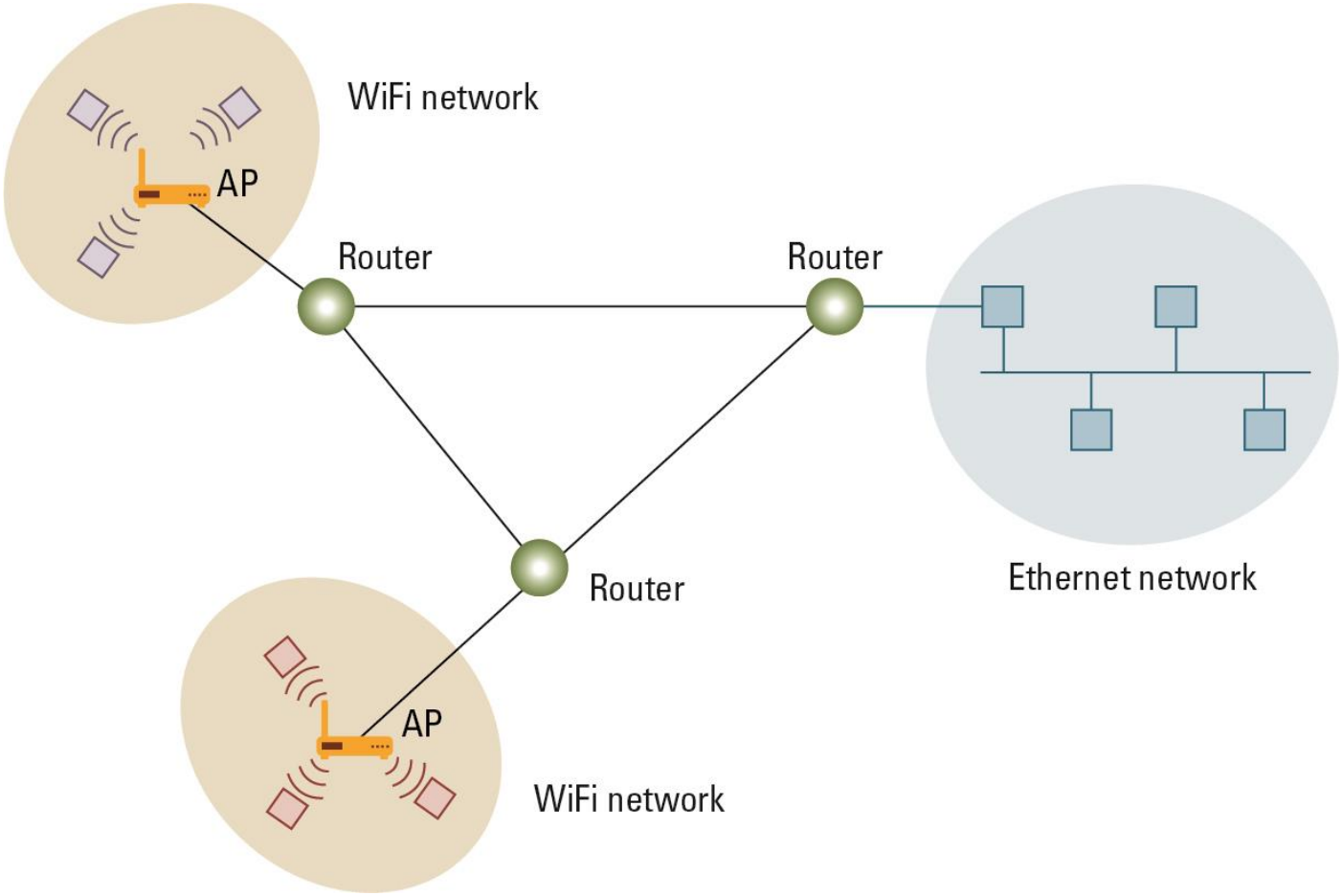


a. A repeater or bridge connecting two buses



b. A switch connecting multiple buses

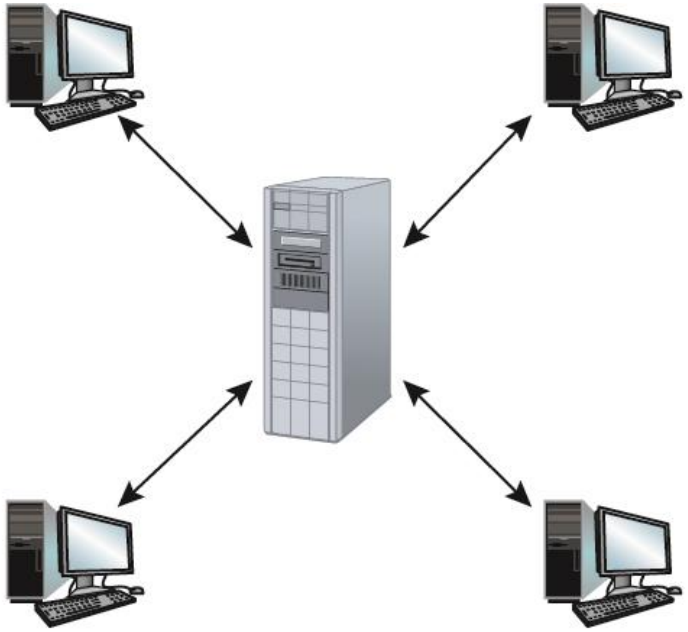
Figure 4.5 Routers connecting two WiFi networks and an Ethernet network to form an internet



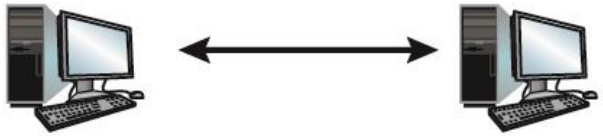
Methods of Process Communication

- 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

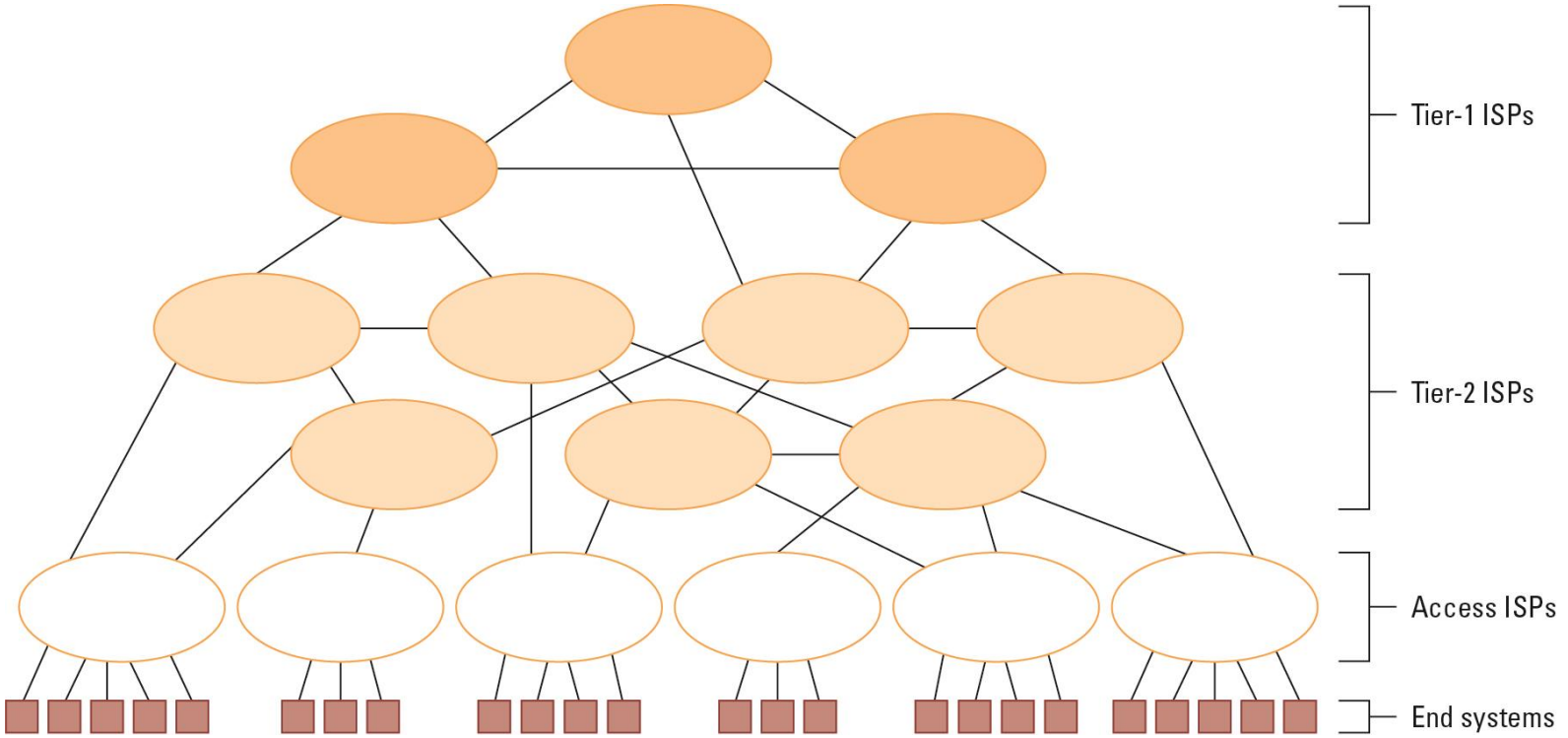
4.2 The Internet

- 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



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
```

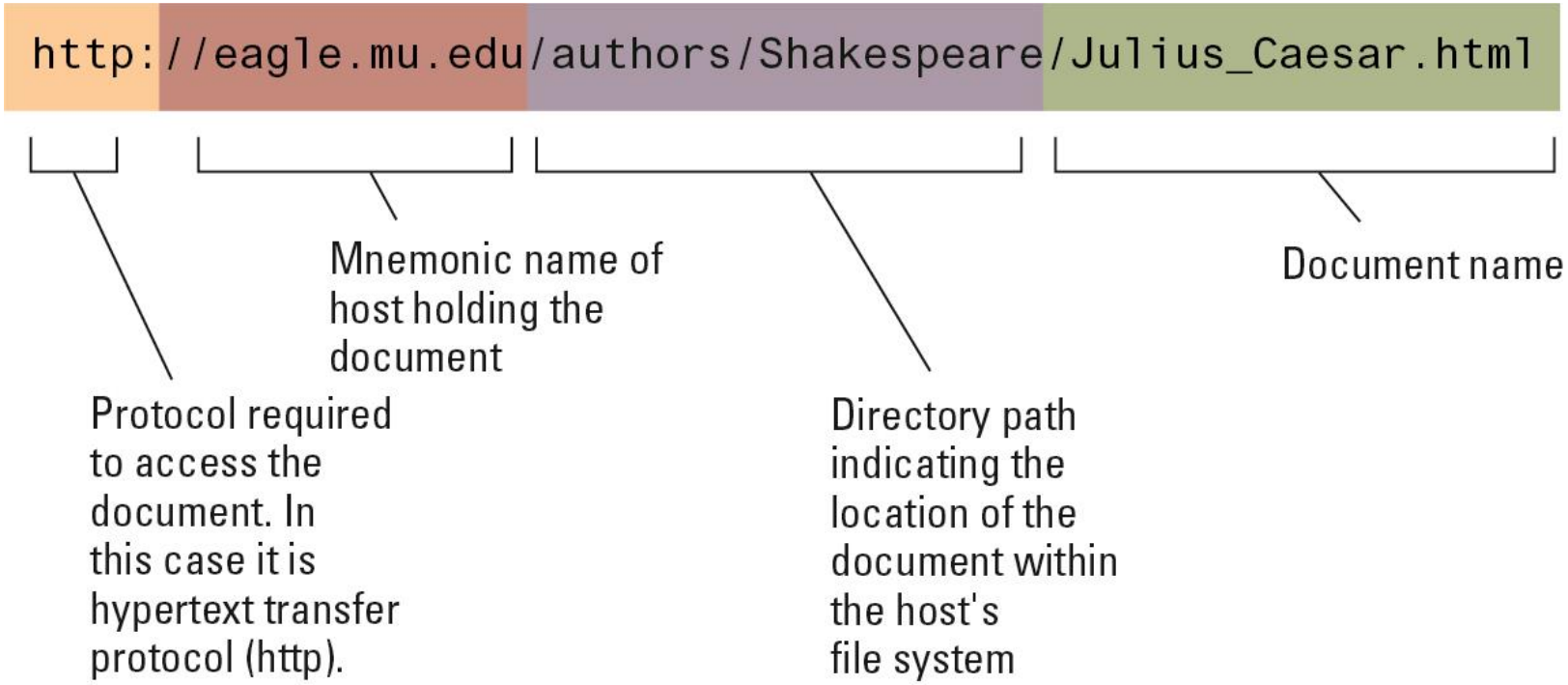
More Recent Applications

- 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



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.

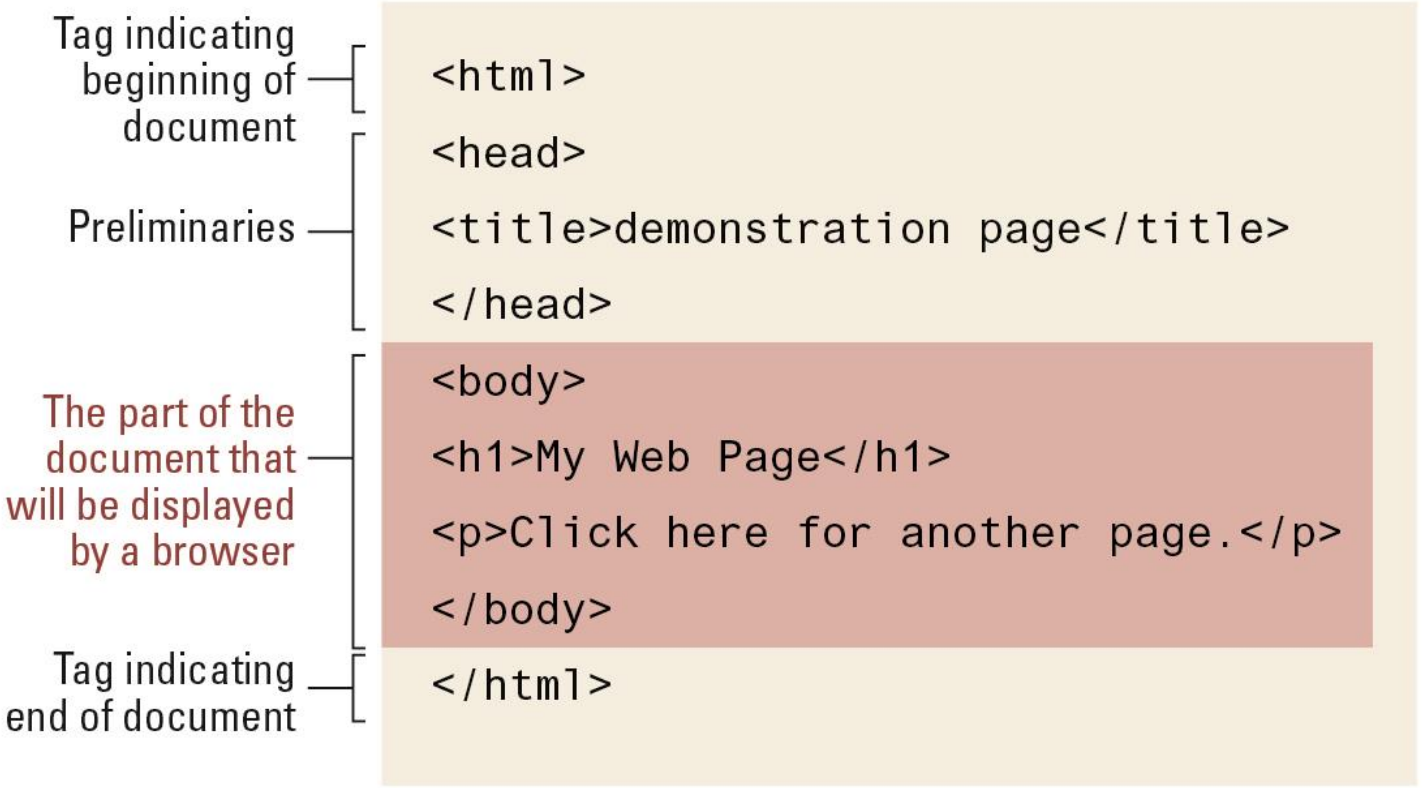


Figure 4.9 A simple webpage (continued)

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

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>
```

Figure 4.10 An enhanced simple Web page (continued)

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

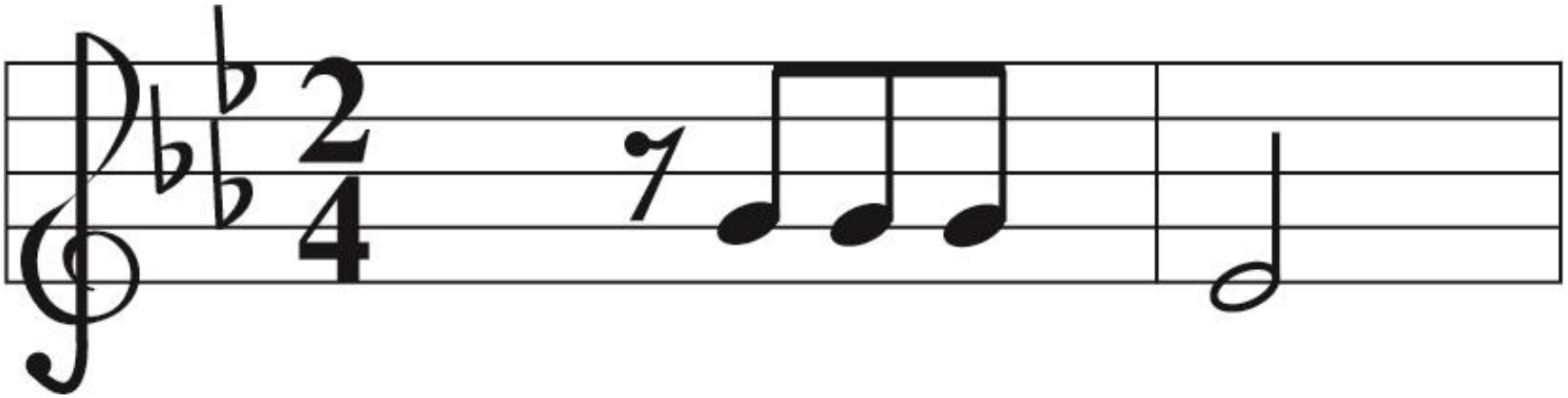
Extensible Markup Language (XML)

- 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



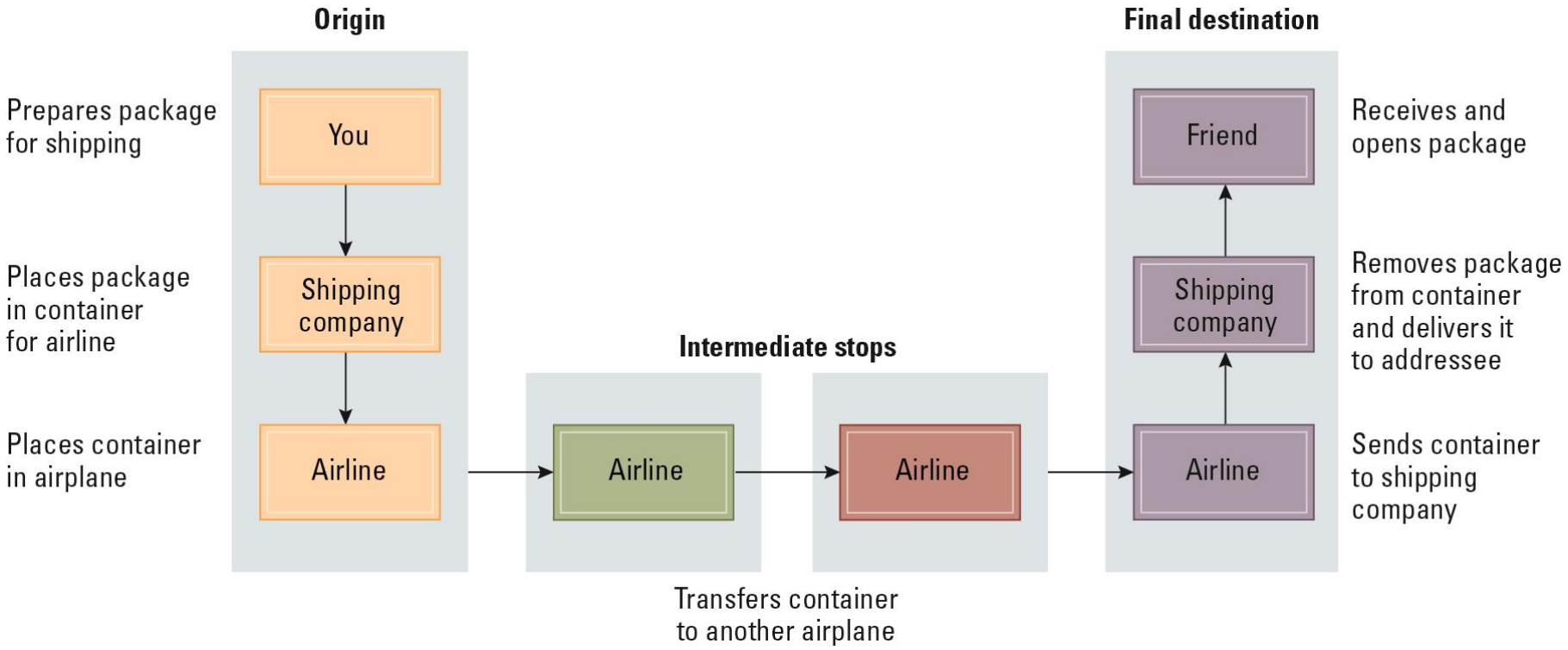
Client Side Versus Server Side

- 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

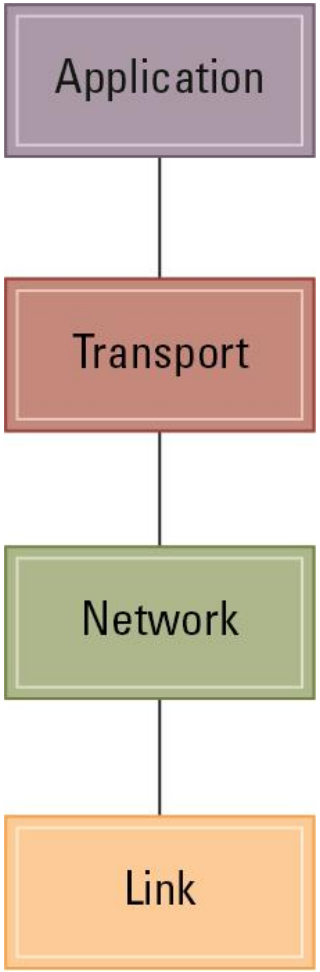
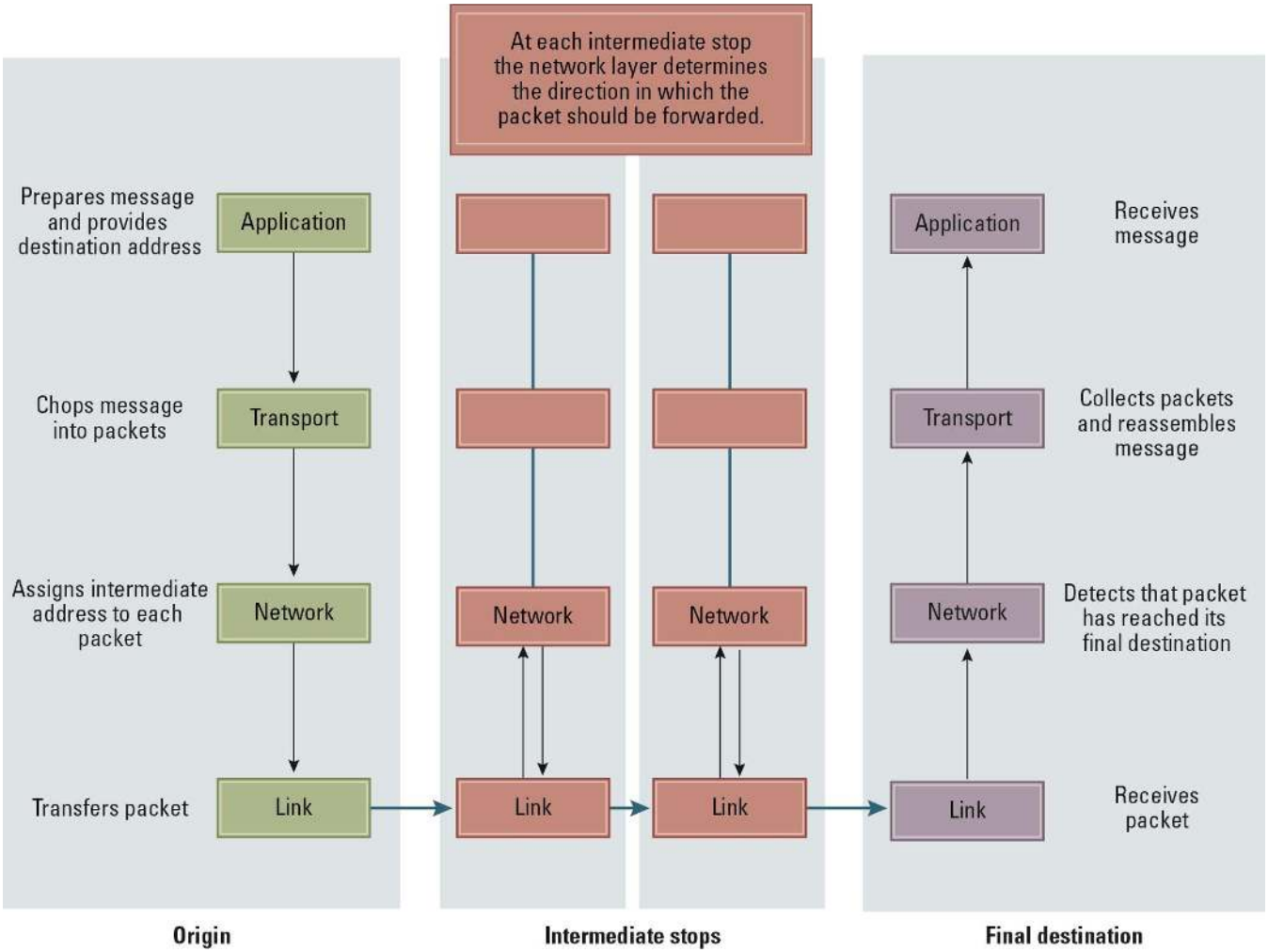


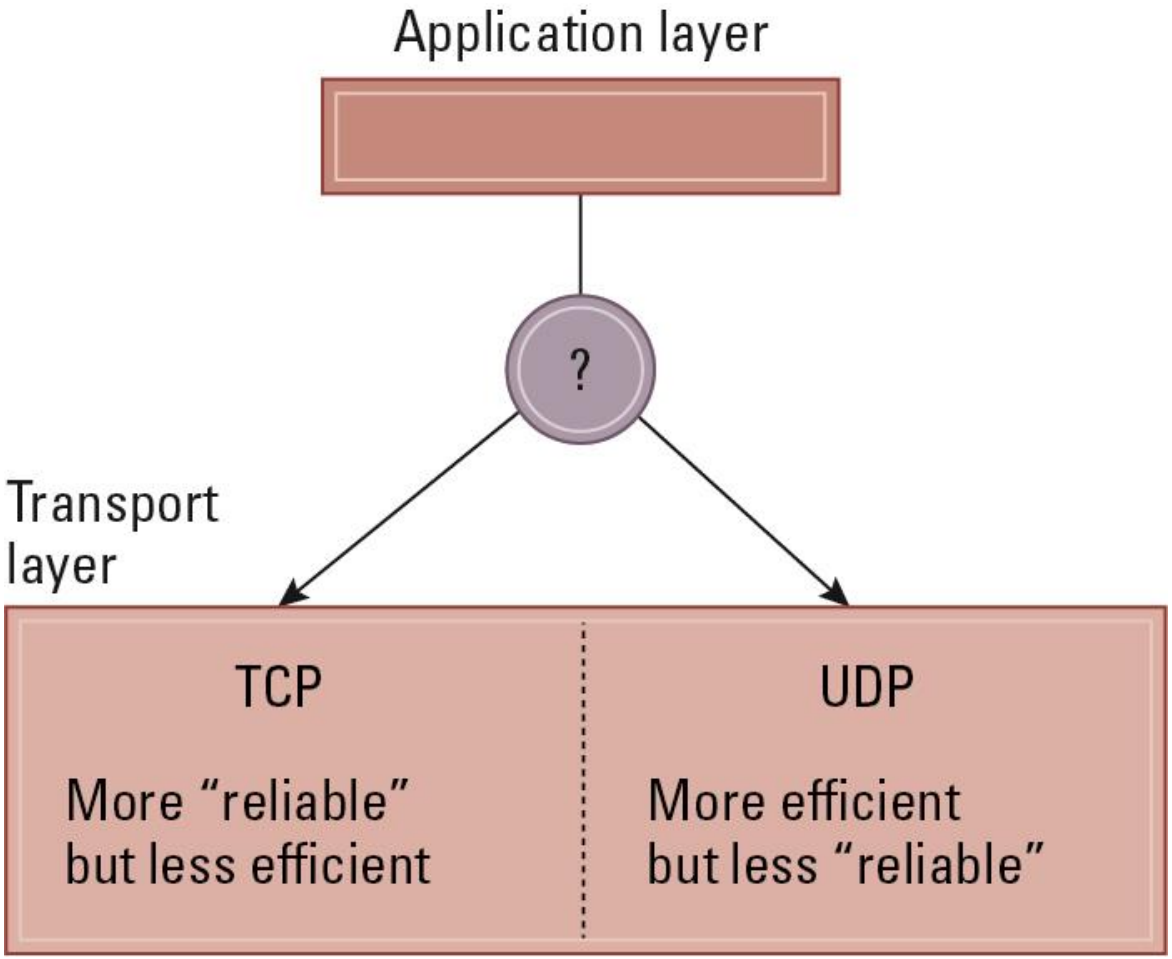
Figure 4.14 Following a message through the Internet



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