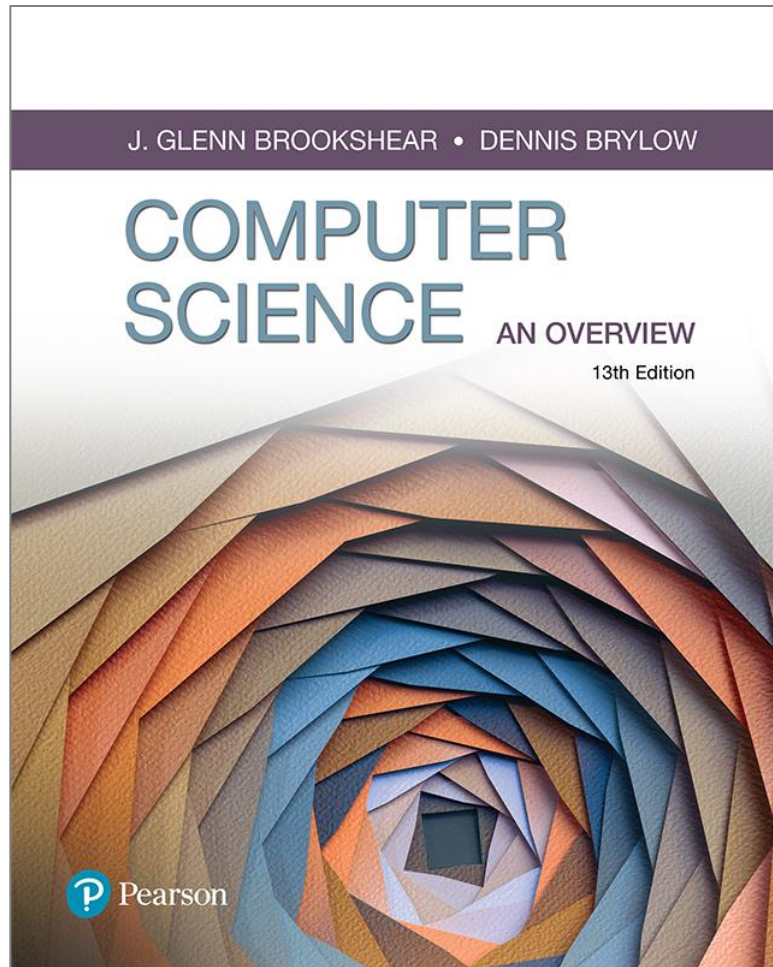


Computer Science An Overview

13th 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

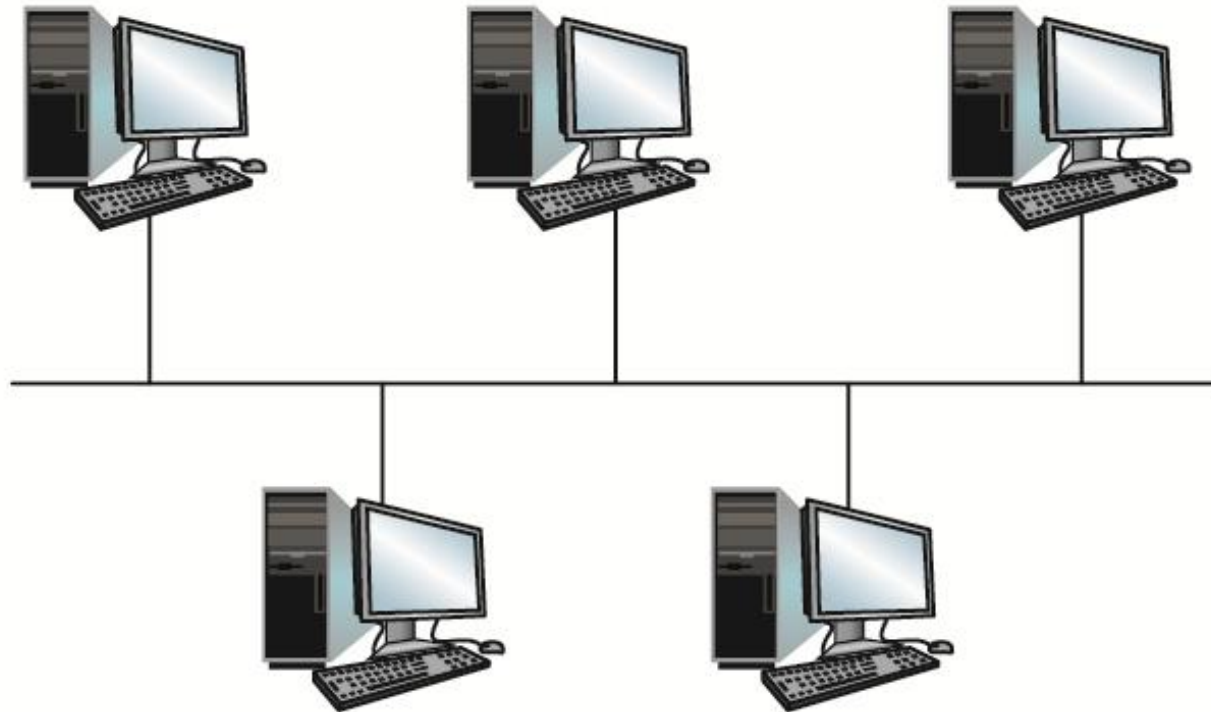
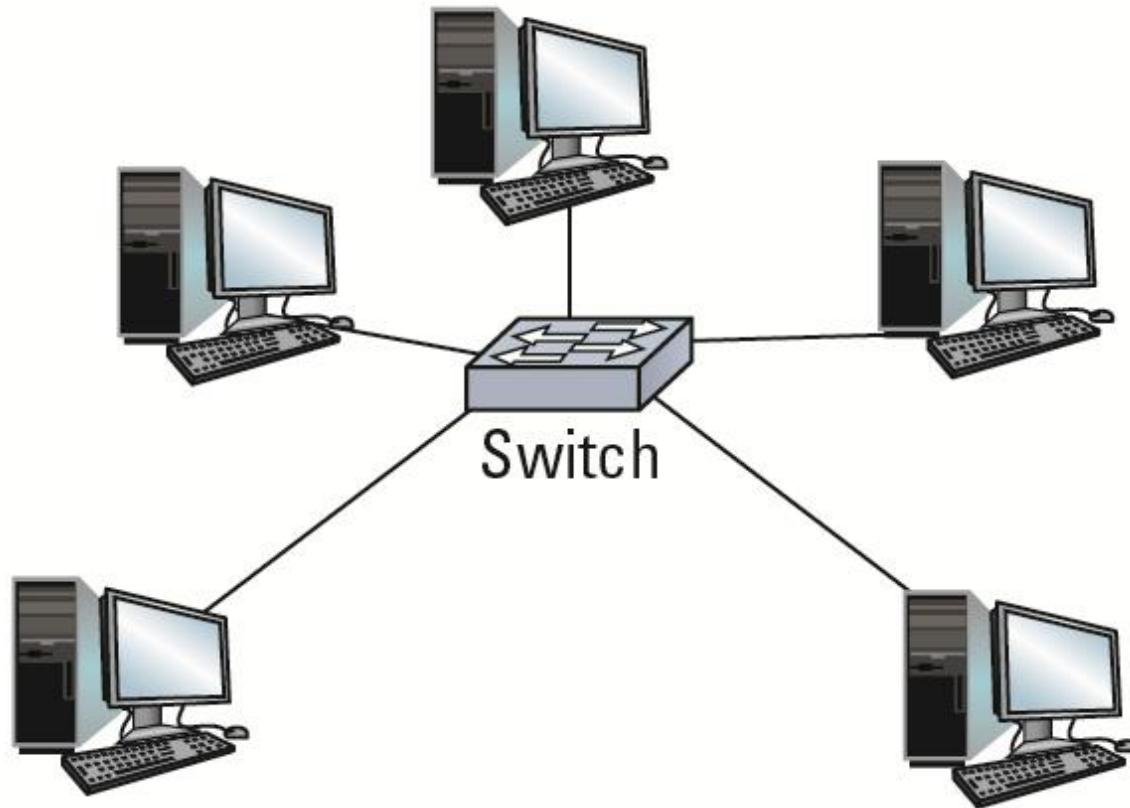


Figure 4.1 Two popular network topologies (2 of 2)

b. Star



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

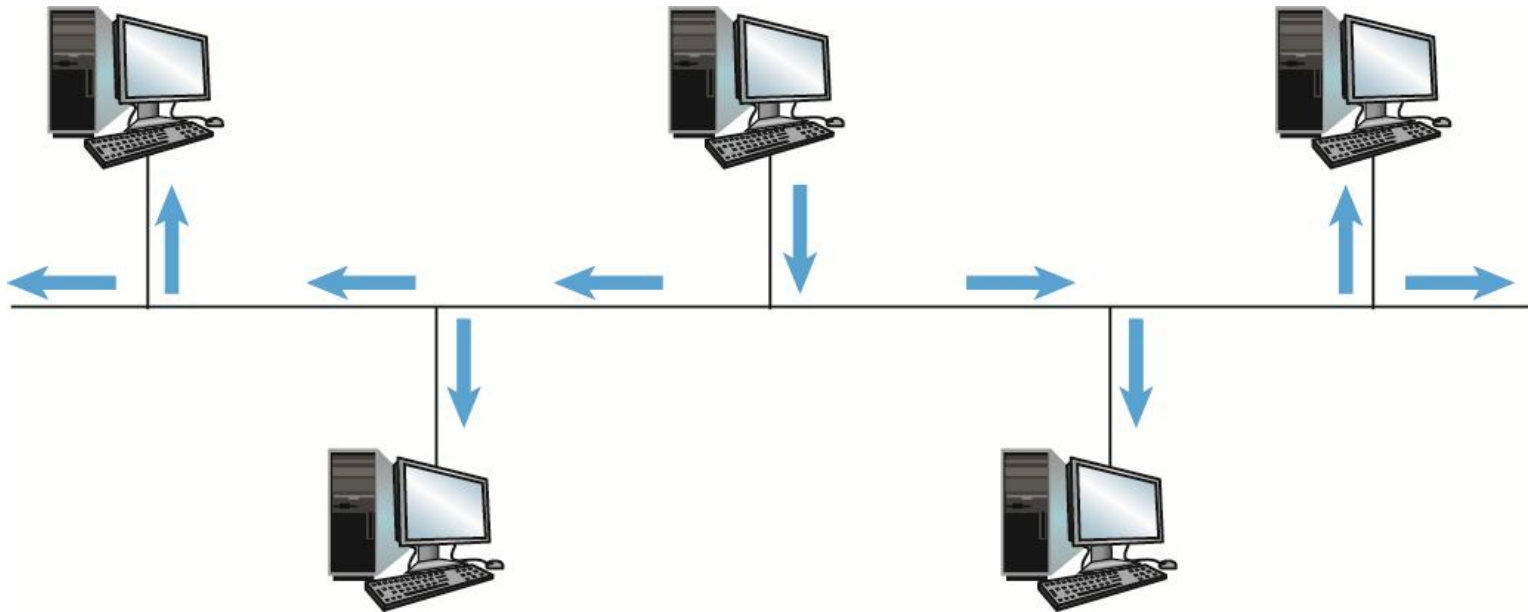
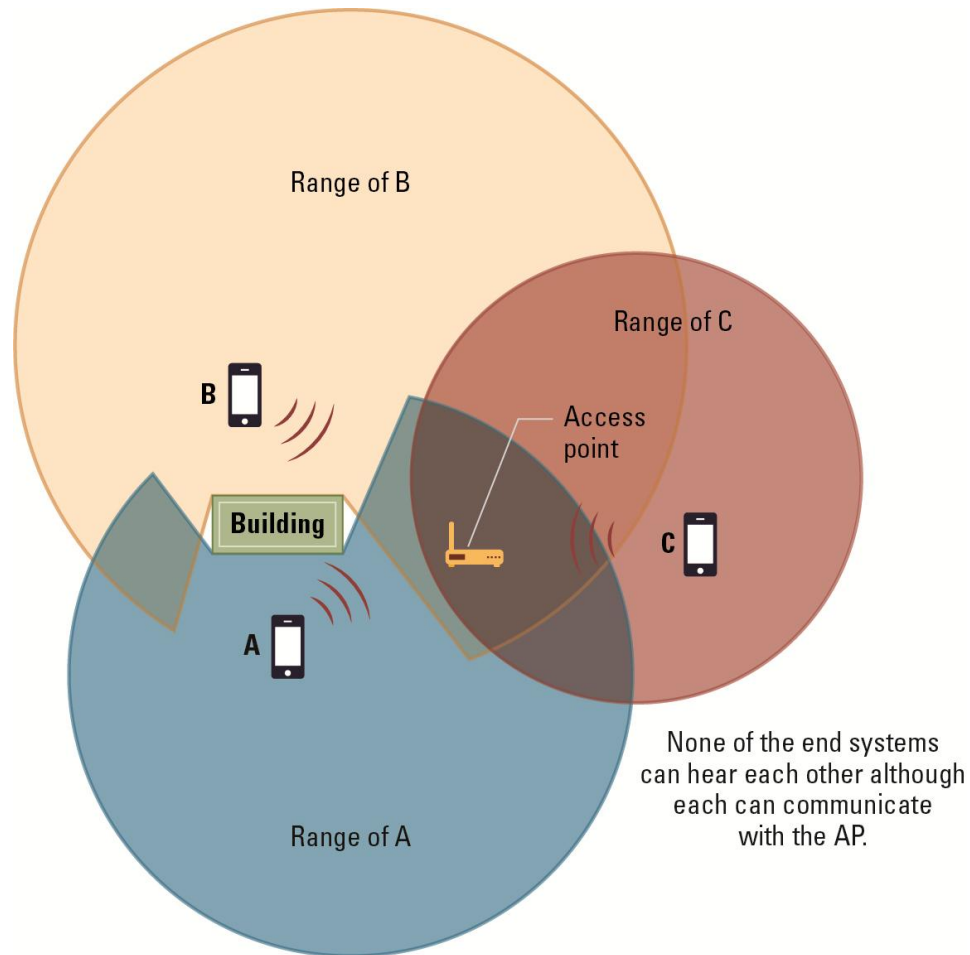


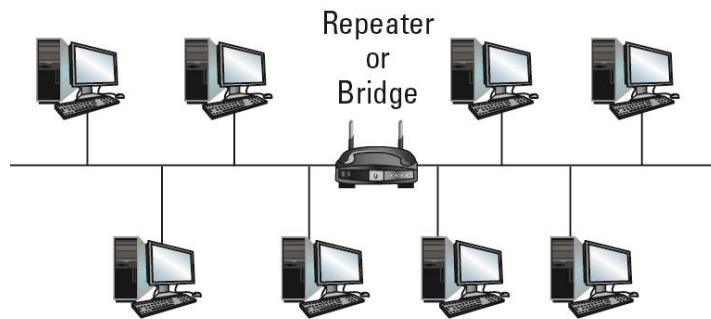
Figure 4.3 The hidden terminal problem



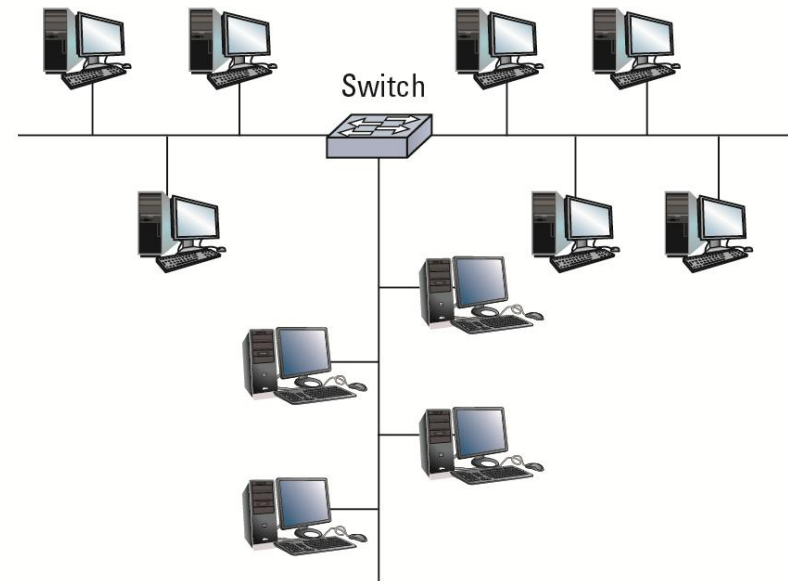
Combining Networks

- **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

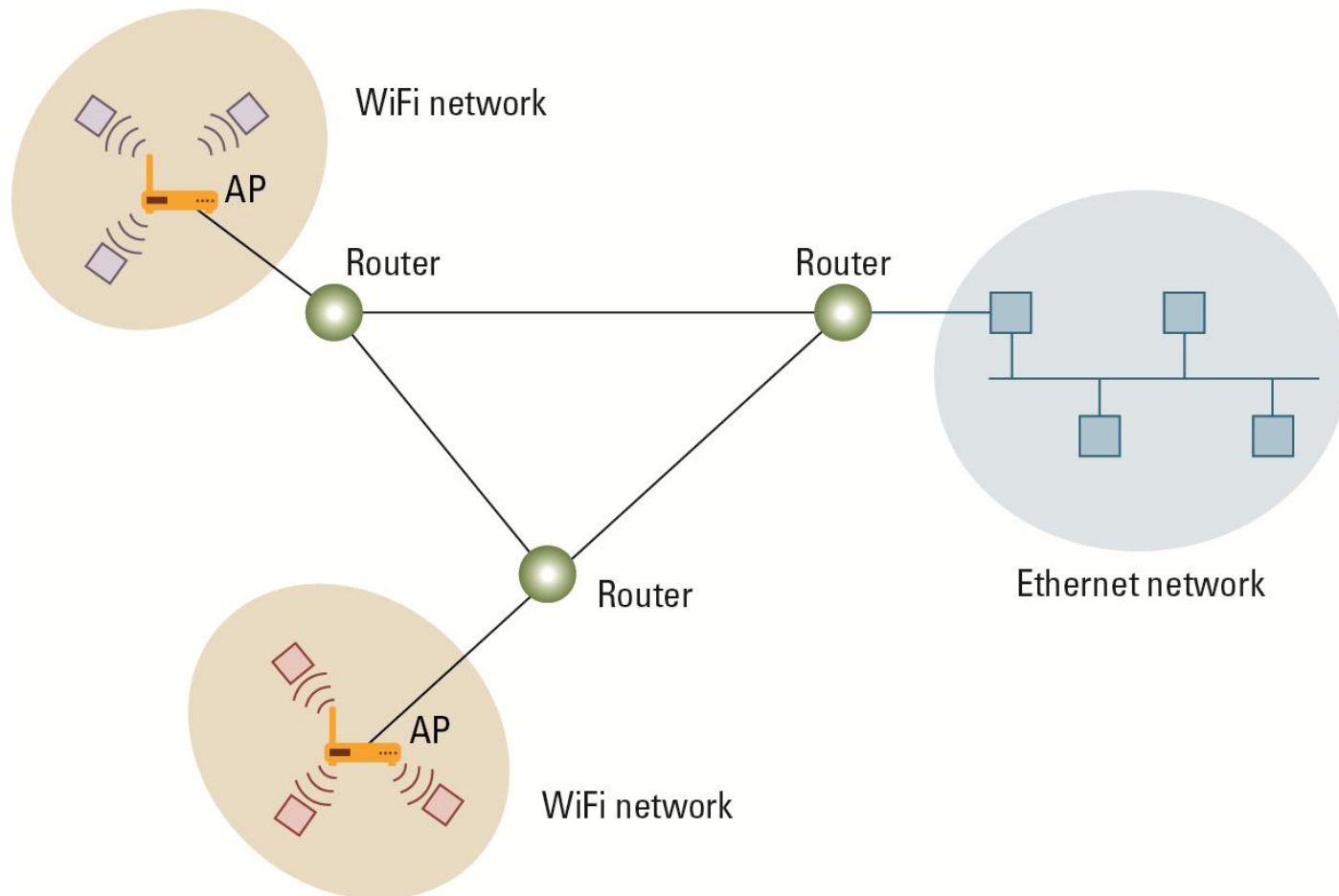


a. A repeater or bridge connecting two buses



b. A switch connecting multiple buses

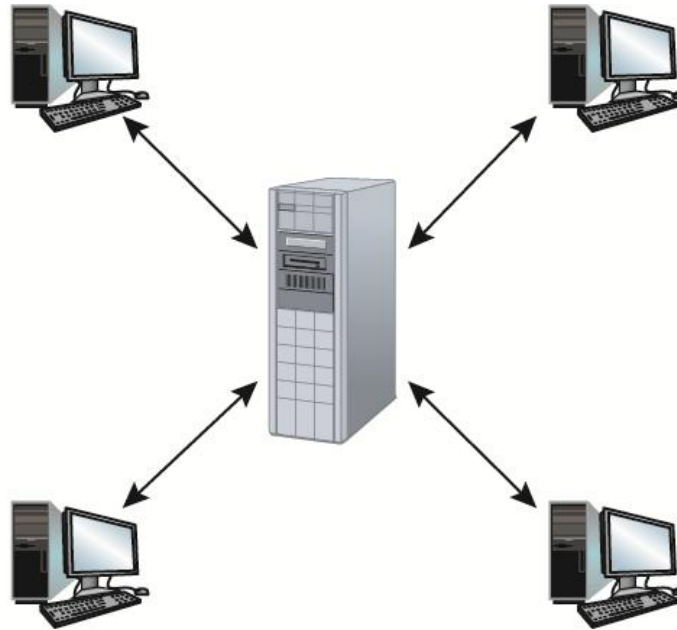
Figure 4.5 Routers connecting two WiFi networks and an Ethernet network to form an internet



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

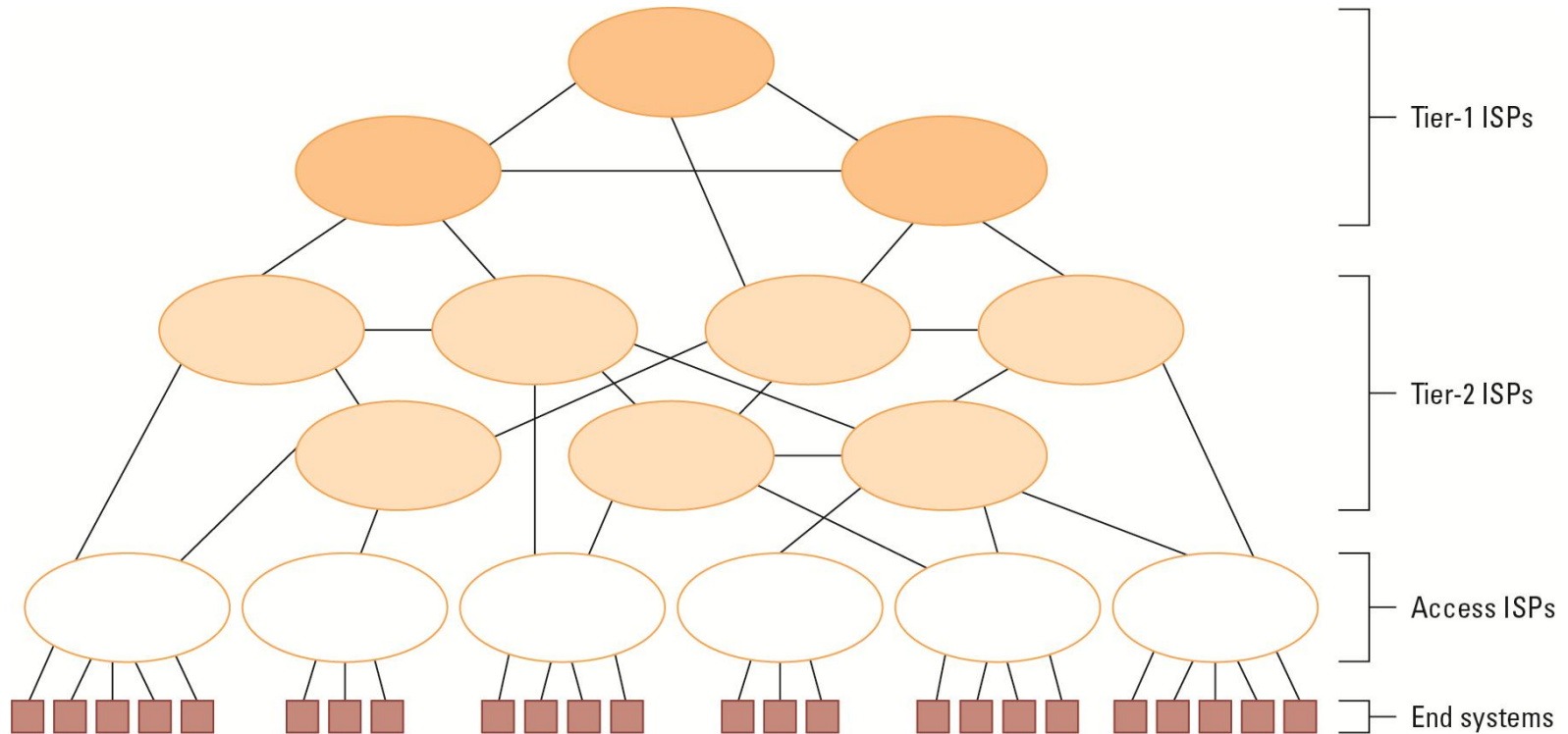
4.2 The Internet

- 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 outgoing 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 r7NJYAE1028071 Message accepted for delivery

QUIT

221 2.0.0 mail.tardis.edu closing connection

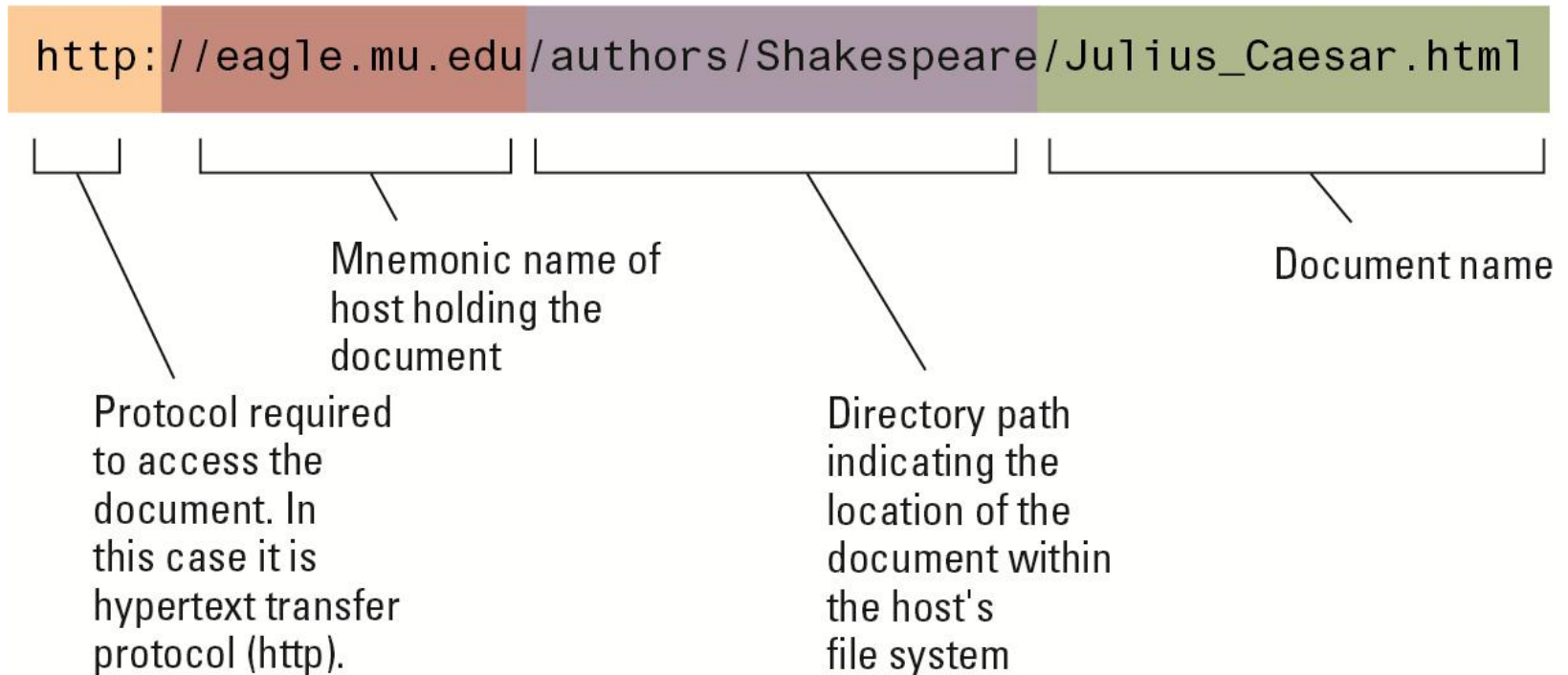
More Recent Applications

- 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 **URLs** 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.

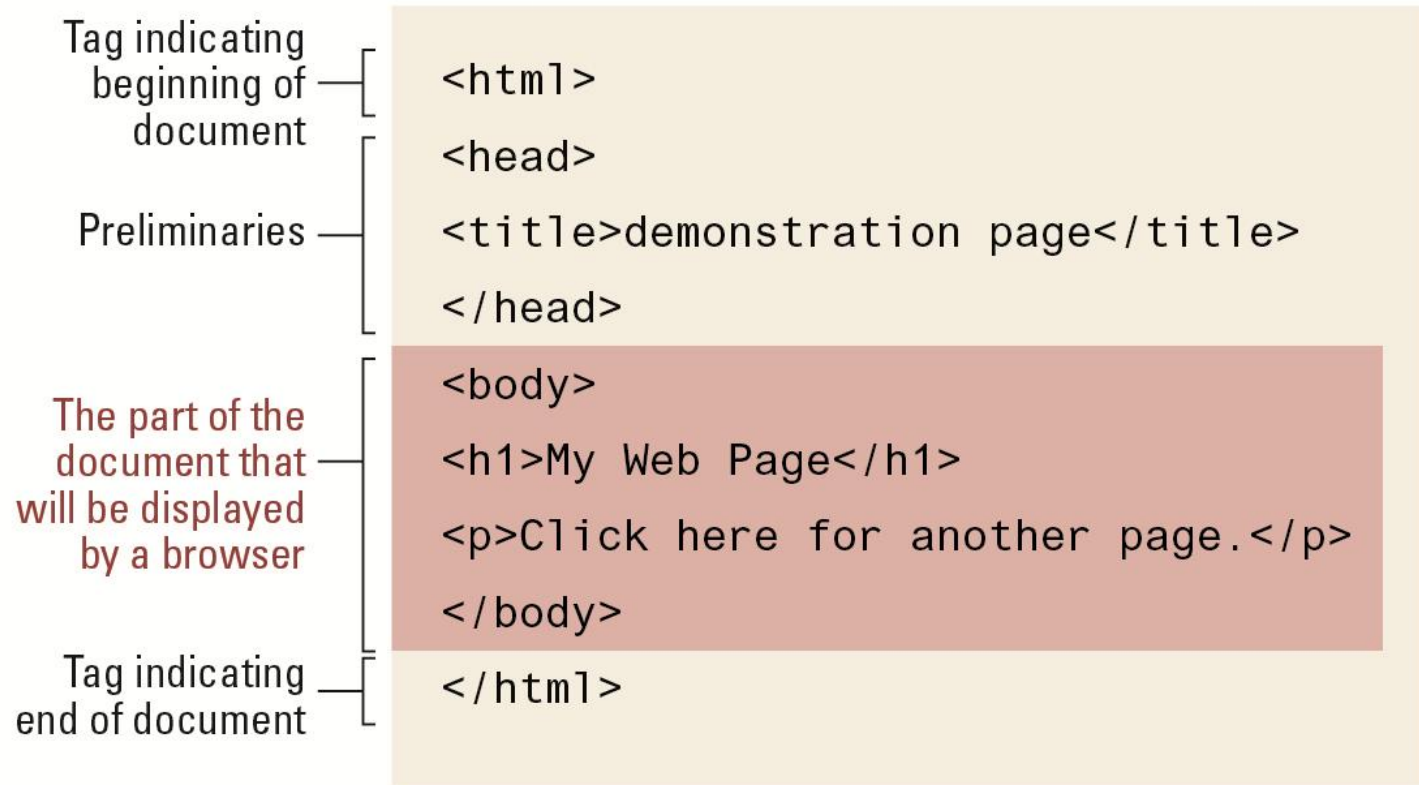


Figure 4.9 A simple webpage (continued)

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>
```

Anchor tag containing parameter

Closing anchor tag

Figure 4.10 An enhanced simple Web page (continued)

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



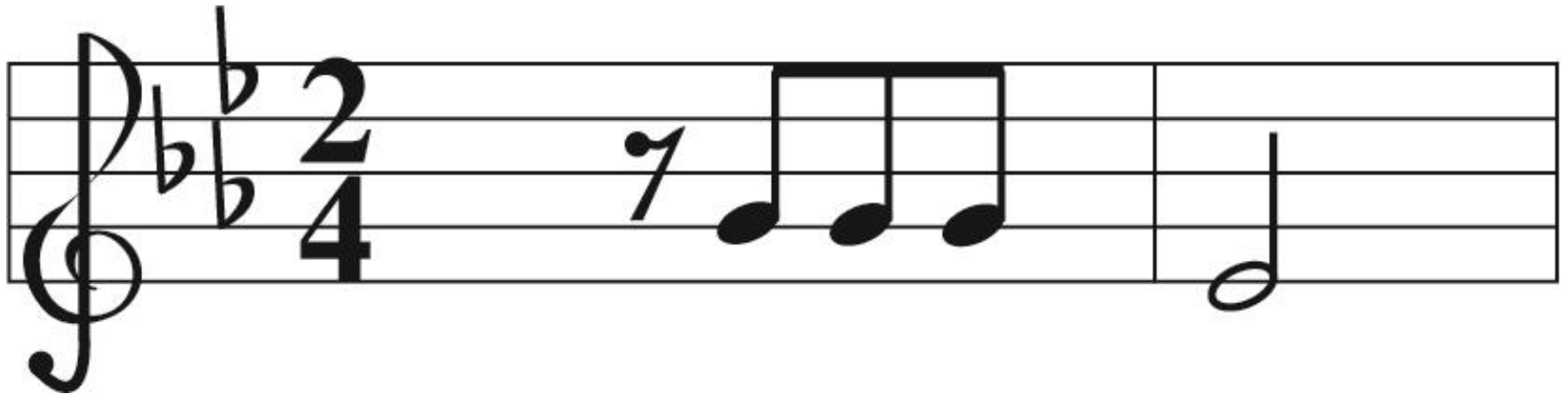
Extensible Markup Language (XML)

- 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



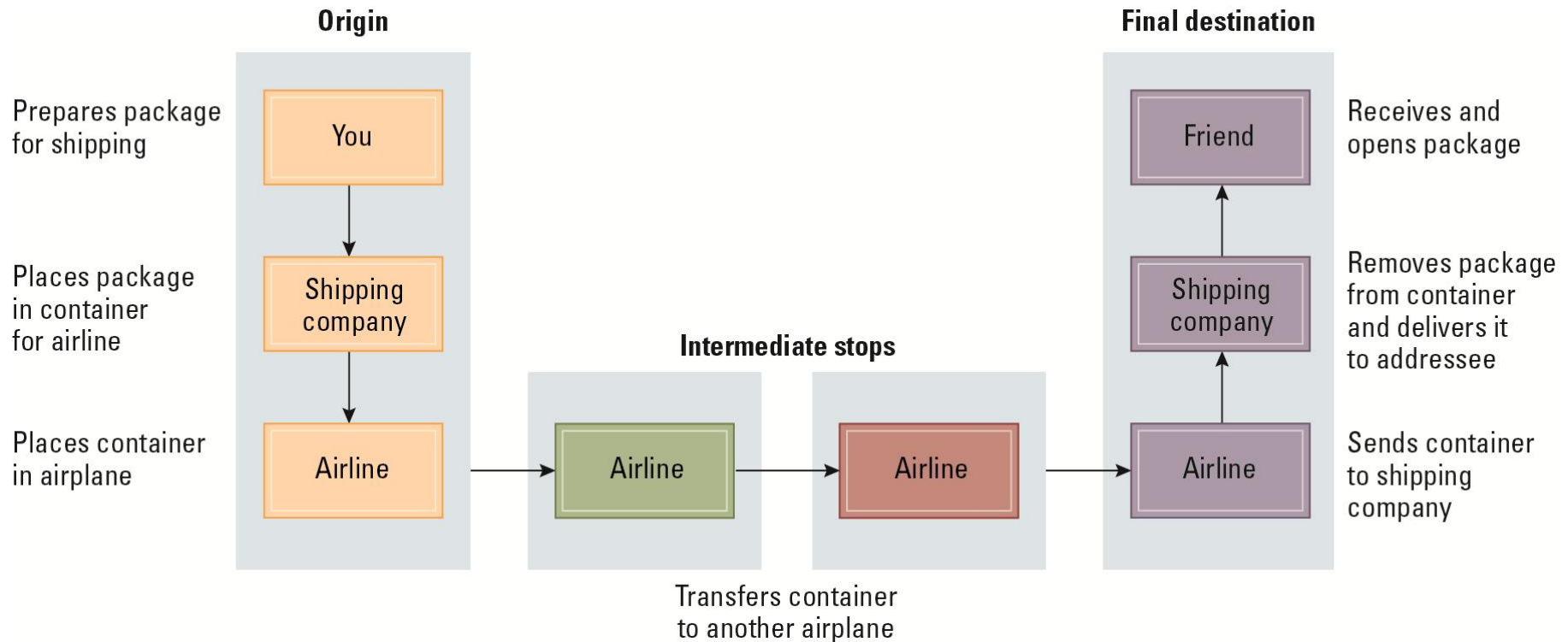
Client Side Versus Server Side

- 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

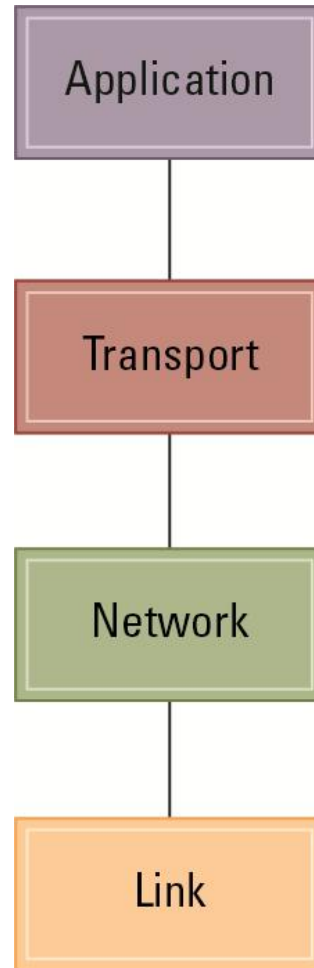
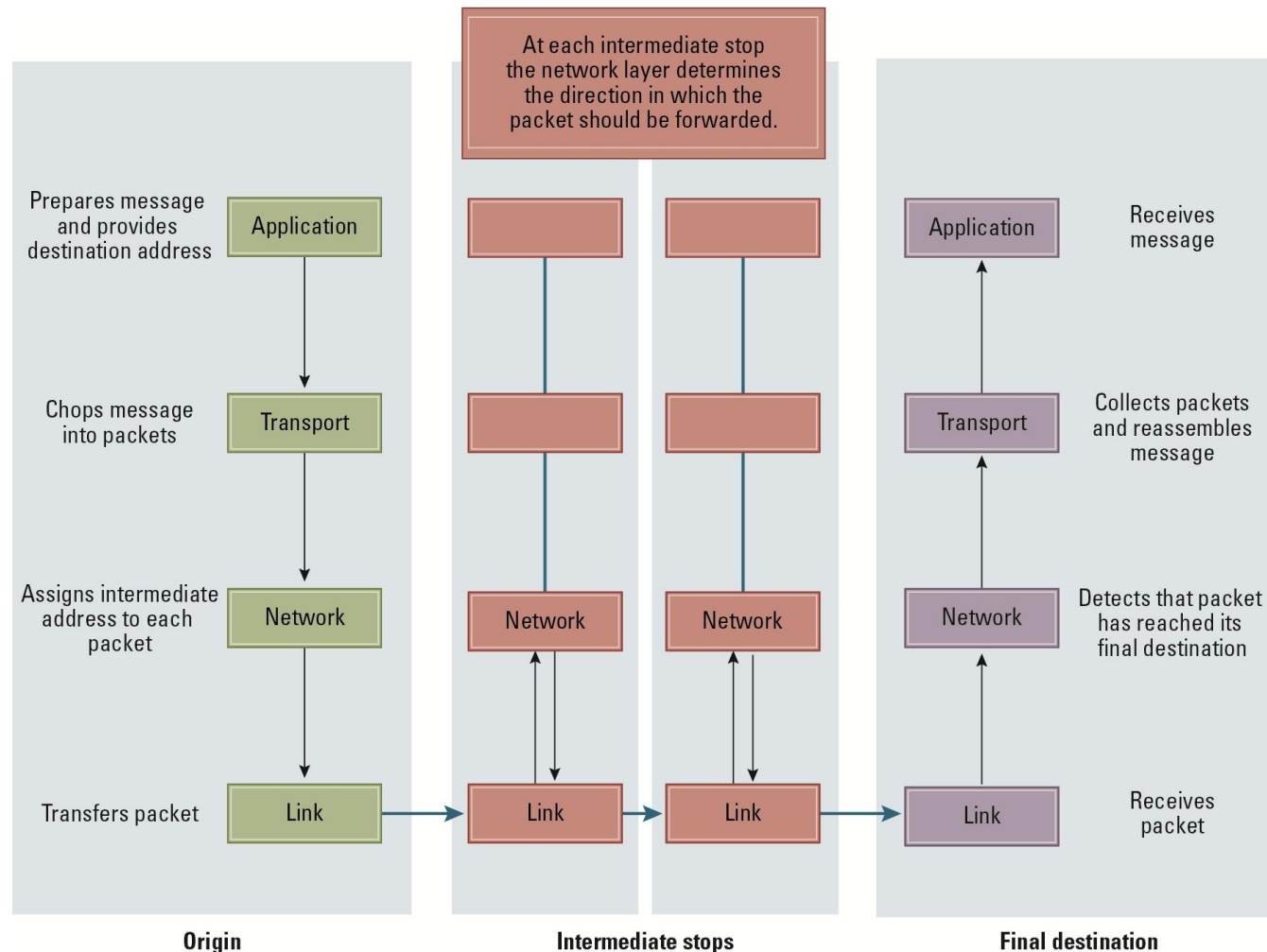


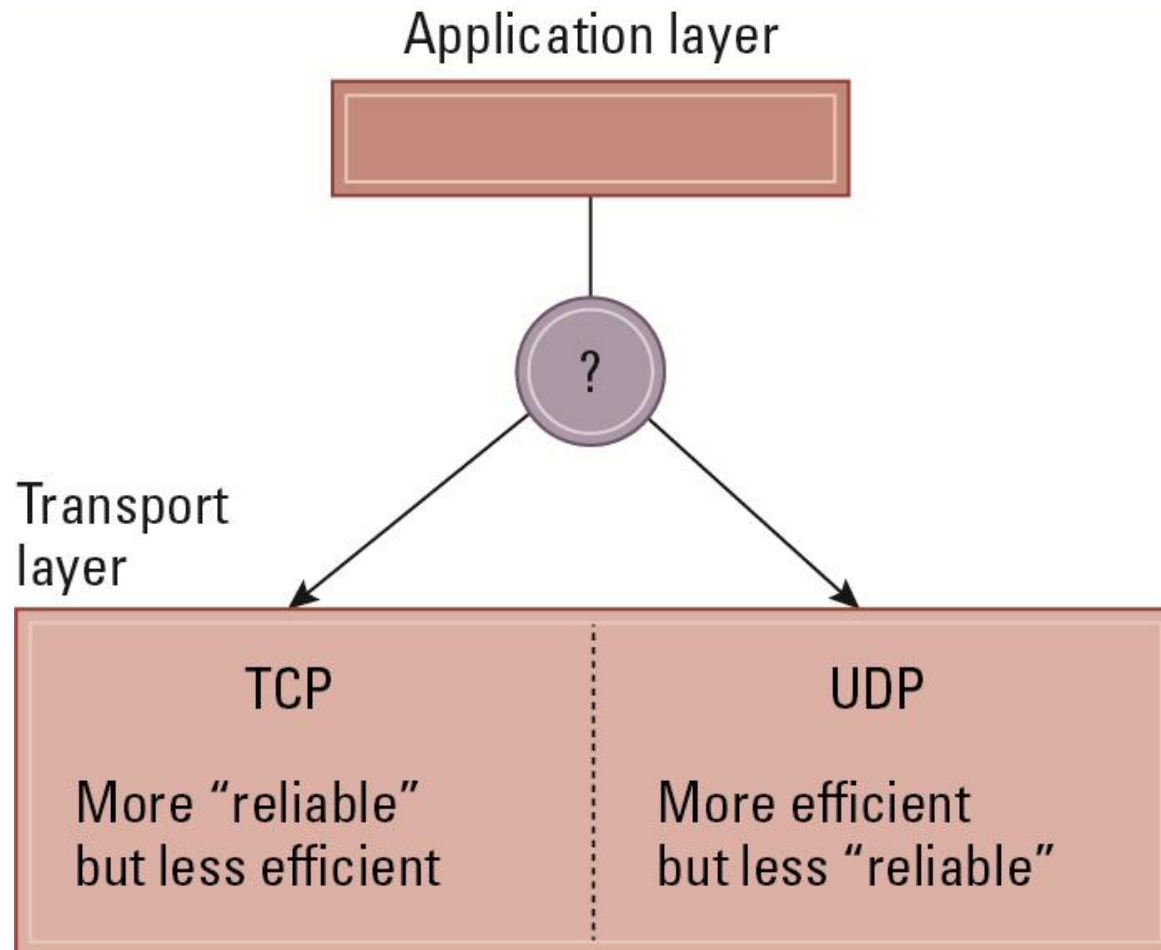
Figure 4.14 Following a message through the Internet



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

Client Script in Python

```
import socket  
Sock = socket.socket()  
Server_address
```

Server Script in Python

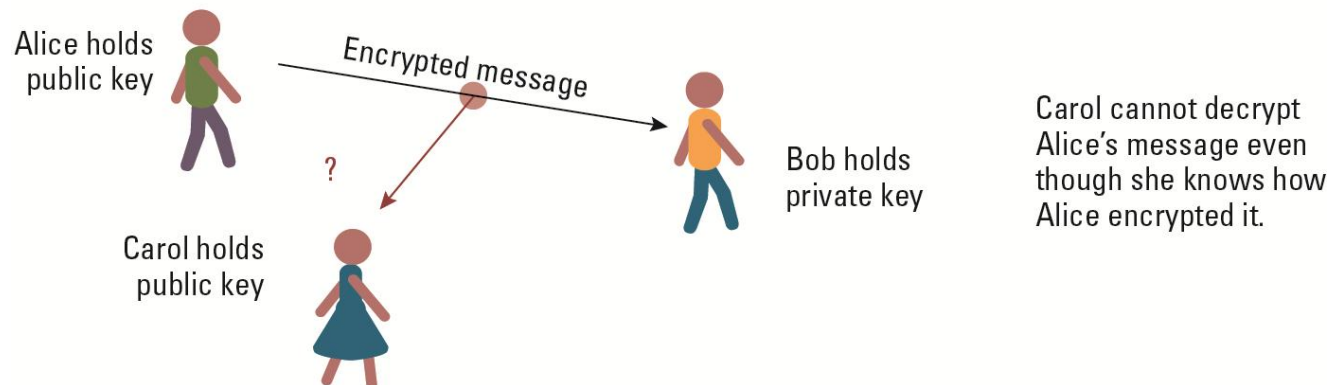
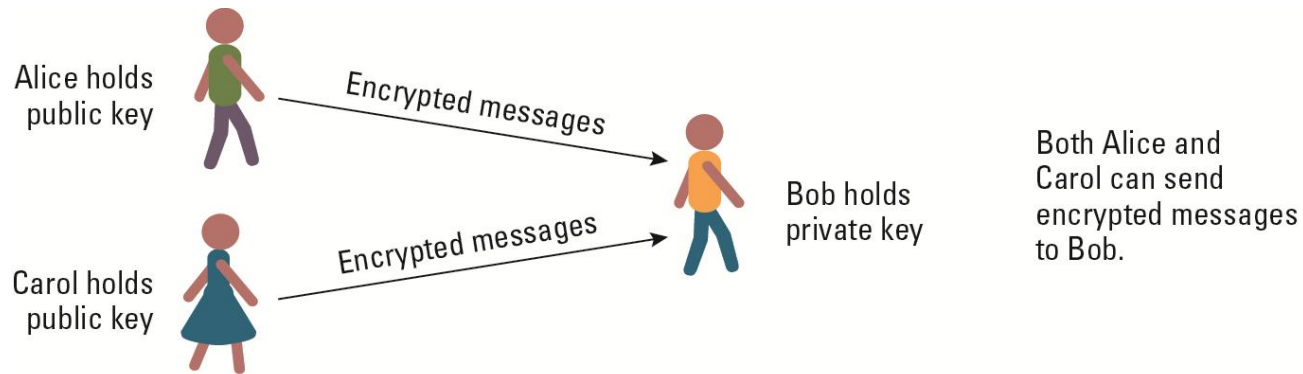
4.6 Cybersecurity

- 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



Legal Approaches to Network Security

- Computer Fraud and Abuse Act
- Electronic Communication Privacy Act
- USA PATRIOT Act
- Communications Assistance for Law Enforcement Act
- Anticybersquatting Consumer Protection Act

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