Chapter 4:
Networking and the Internet

Computer Science: An Overview
Twelfth Edition

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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 Security

Network Classifications

- Scope
  - Personal area network (PAN)
  - Local area network (LAN)
  - Metropolitan area (MAN)
  - Wide area network (WAN)
- Ownership
  - Closed versus open
- Topology (configuration)
  - Bus (Ethernet)
  - Star (Wireless networks with central Access Point)

Figure 4.1 Network topologies

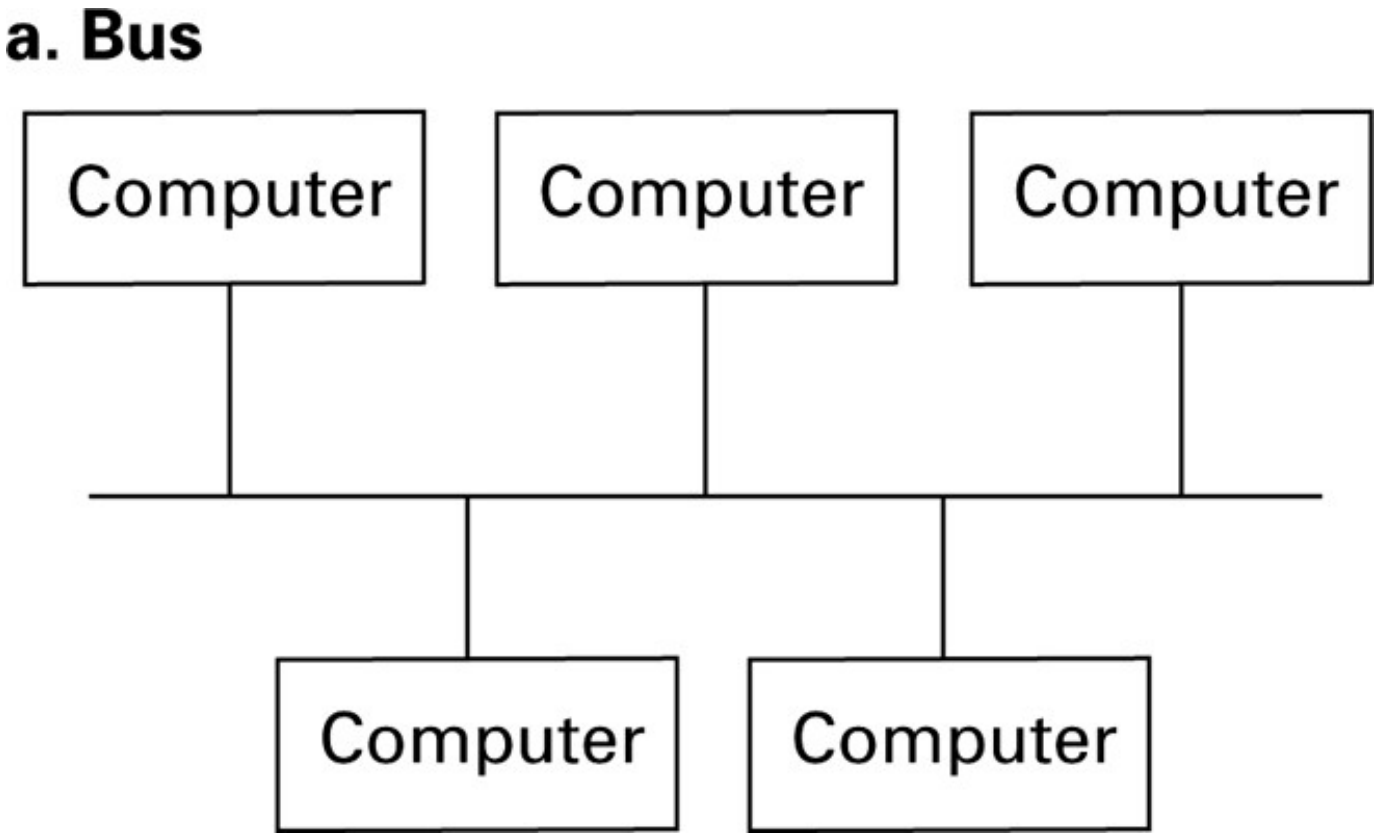
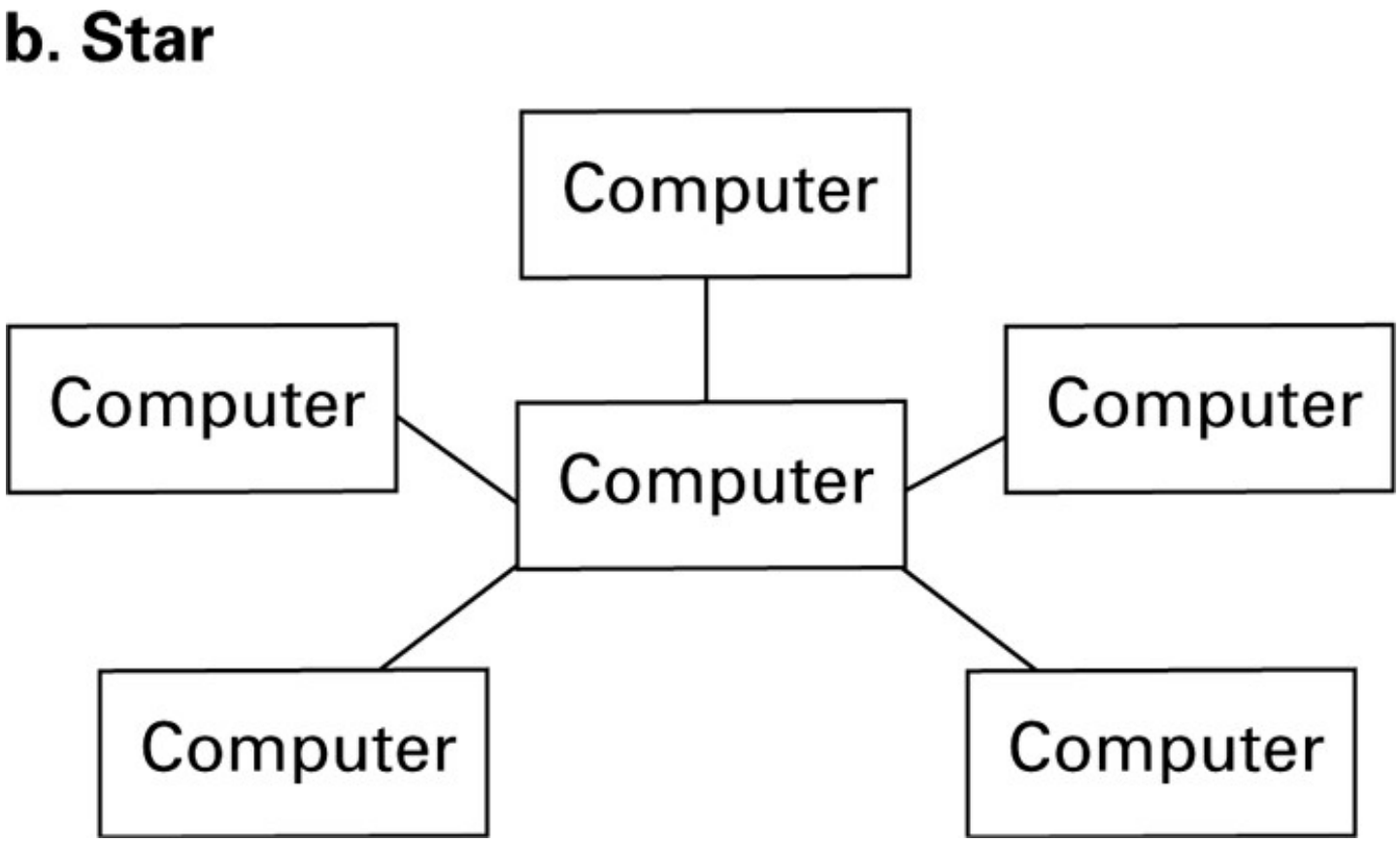


Figure 4.1 Network topologies (continued)



Protocols

- CSMA/CD Carrier Sense Multiple Access with Collision Detection
  - Used in Ethernet
  - Silent bus provides right to introduce new message
- CSMA/CA Carrier Sense Multiple Access with Collision Avoidance
  - Used in WiFi
  - Hidden terminal problem

CSMA/CD

Carrier Sense Multiple Access with Collision Detection

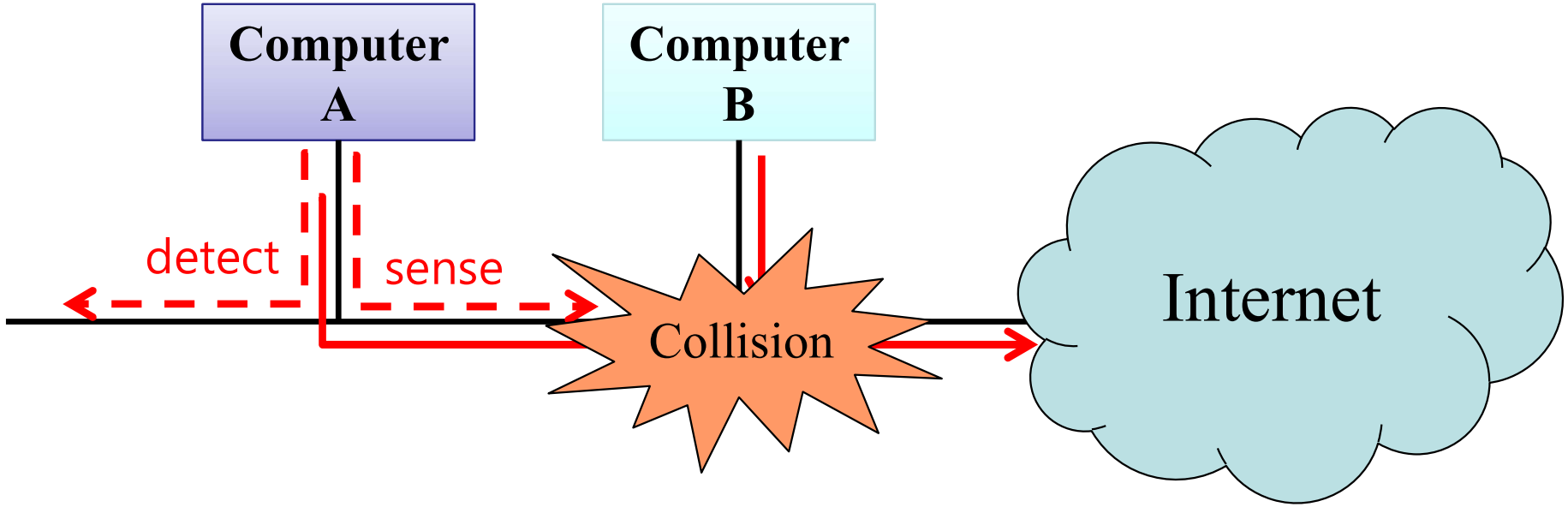


Figure 4.2 Communication over a bus network

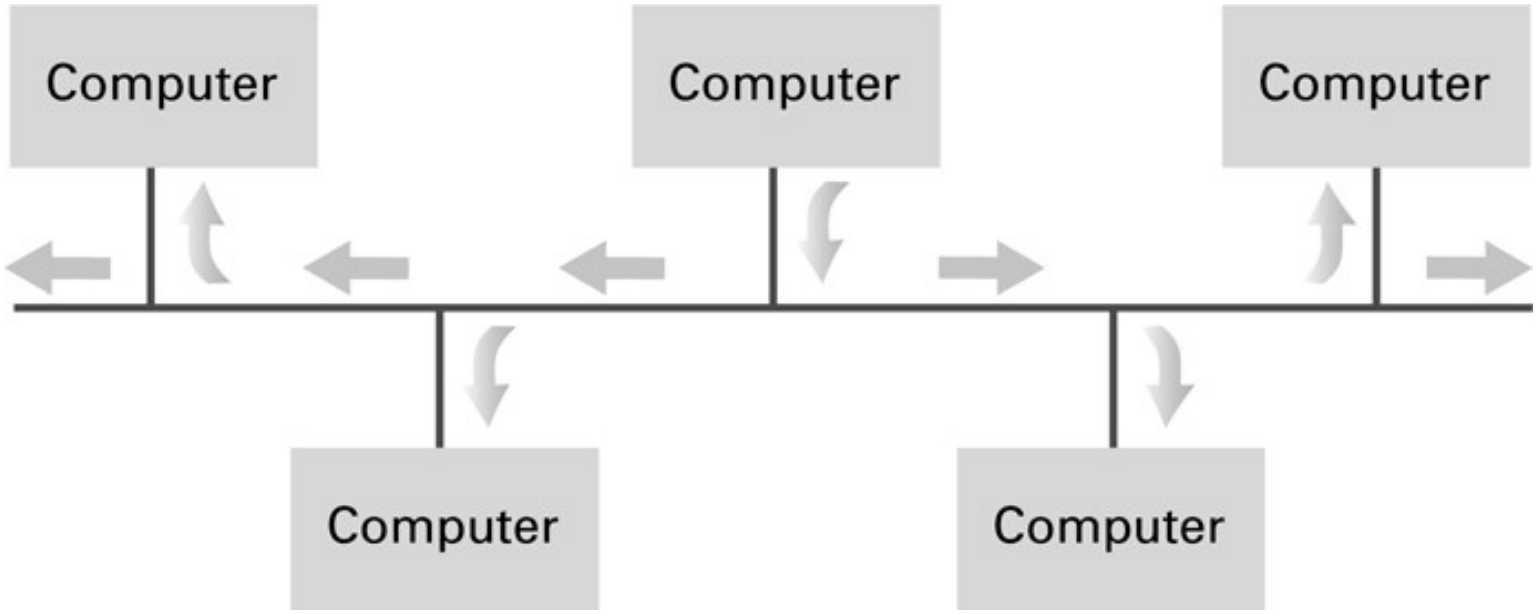


Figure 4.3 The hidden terminal problem

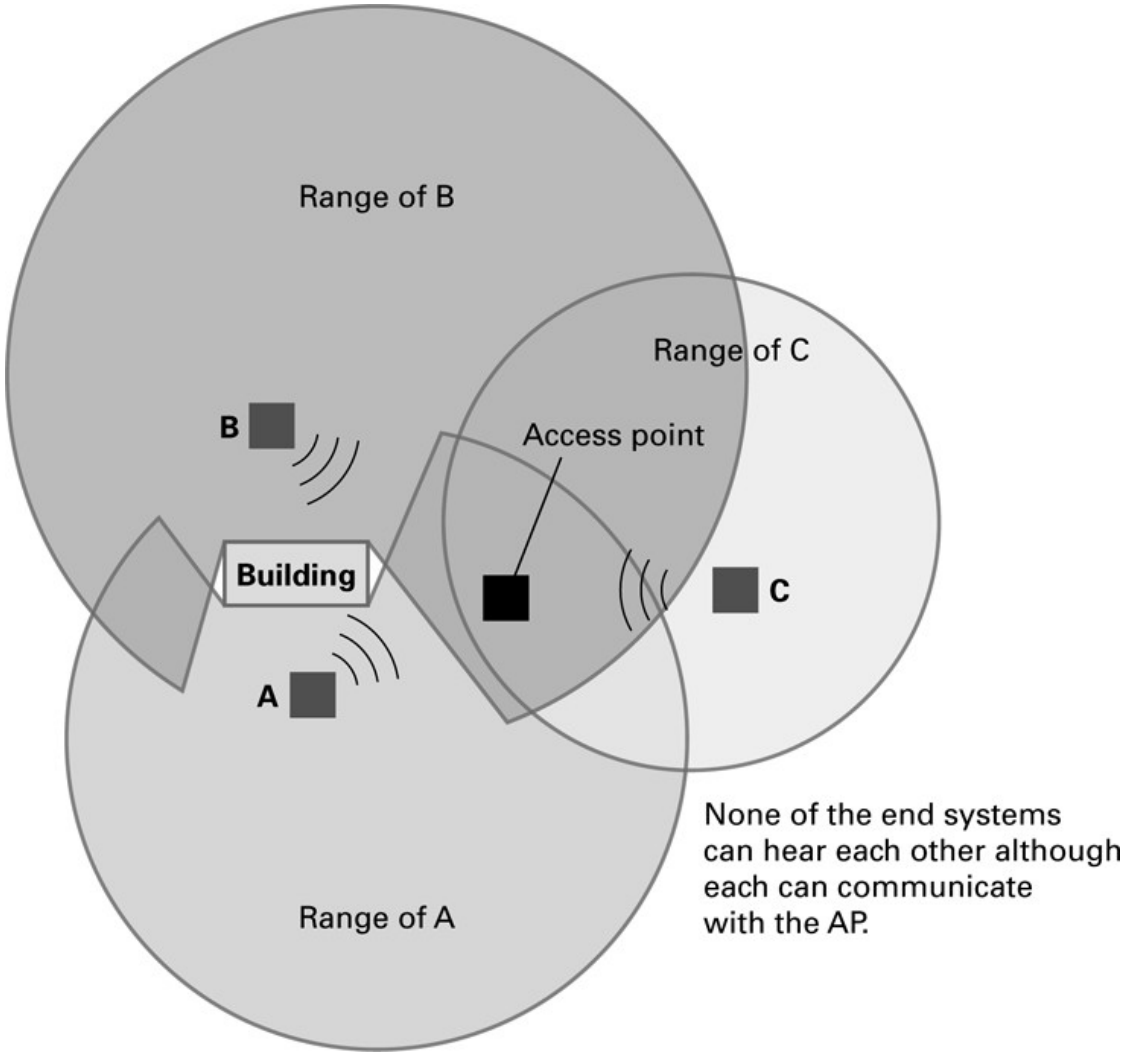
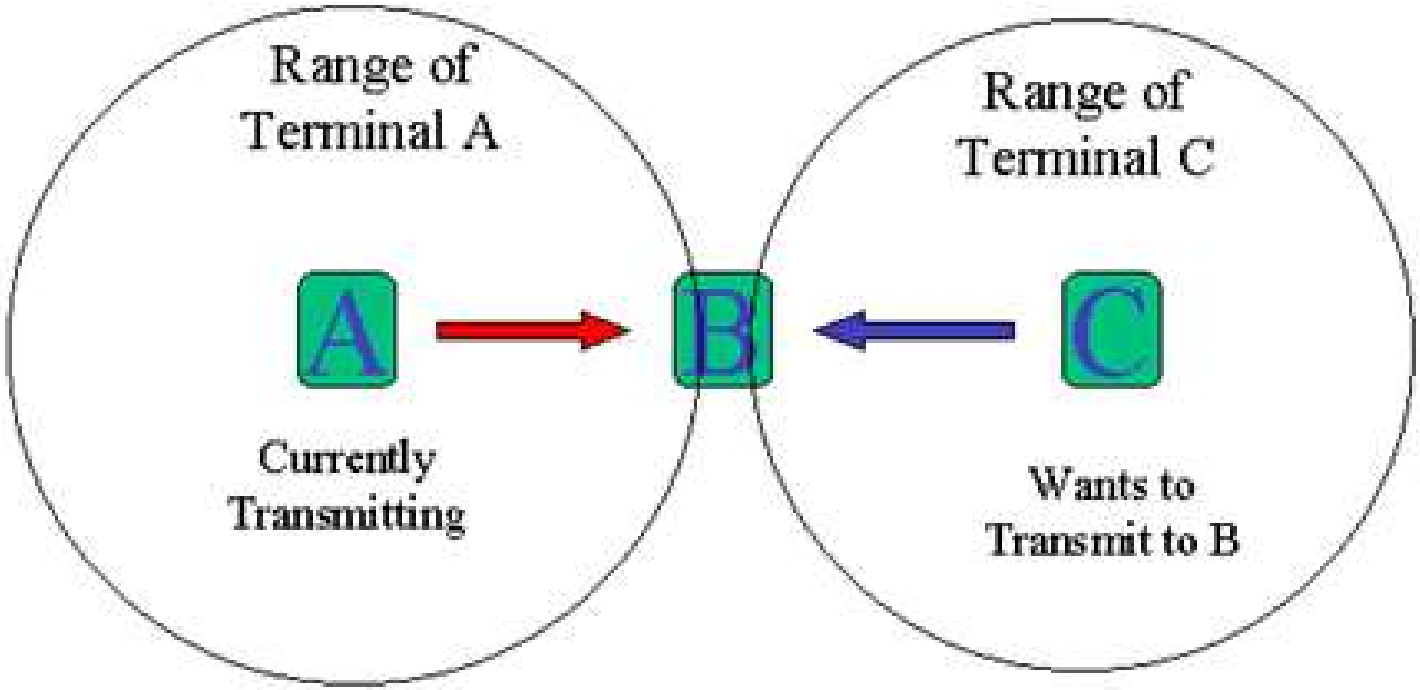


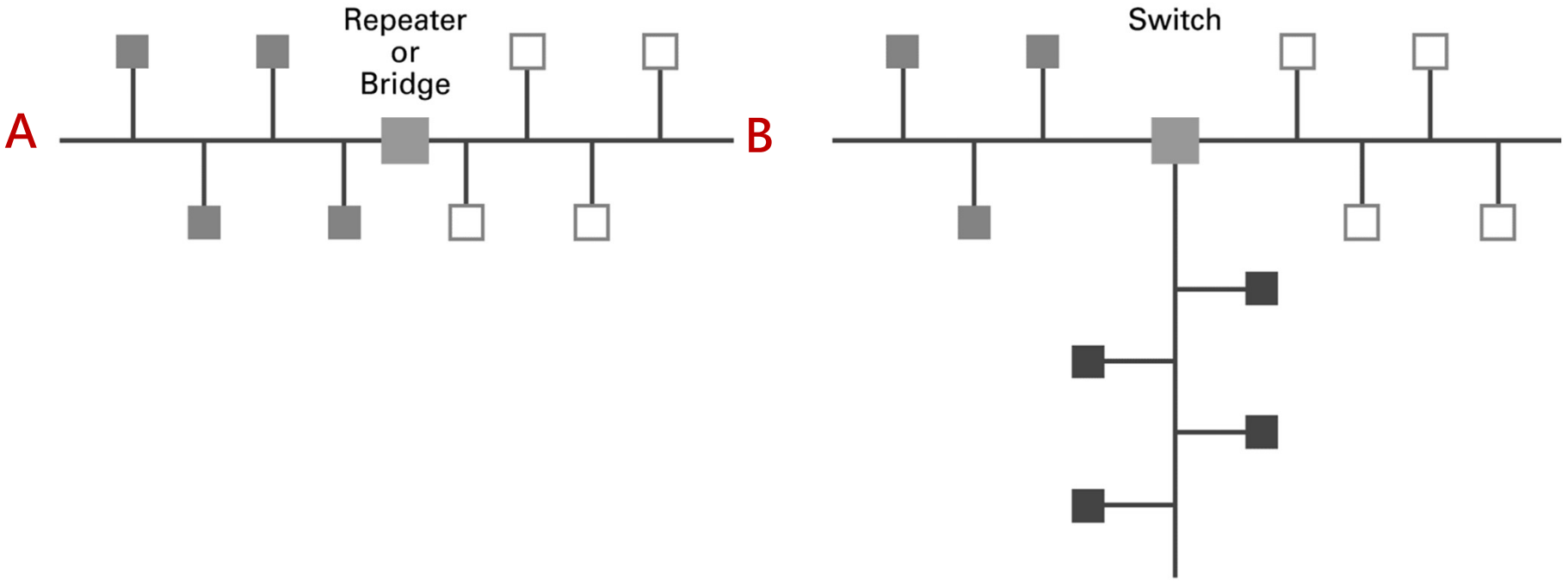
Figure 4.3 The hidden terminal problem



Connecting Networks

- **Repeater:** Extends a network
- **Bridge:** Connects two compatible networks
- **Switch:** Connects several compatible networks
- **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

Hub vs. Switch

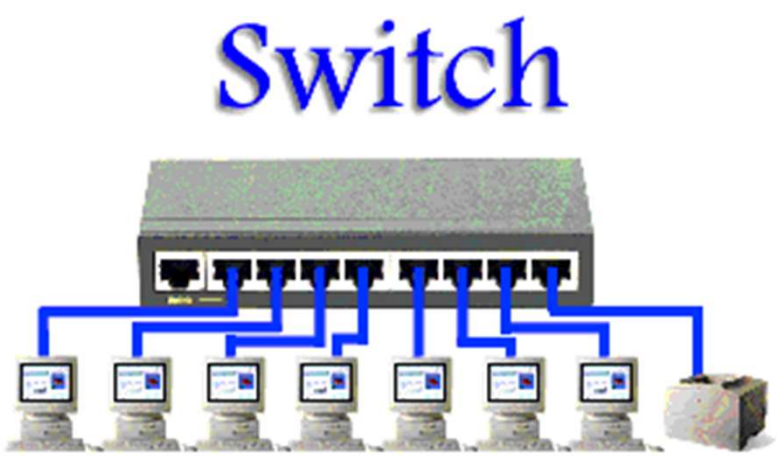


Figure 4.5 Routers connecting two WiFi networks and an Ethernet network to form an internet

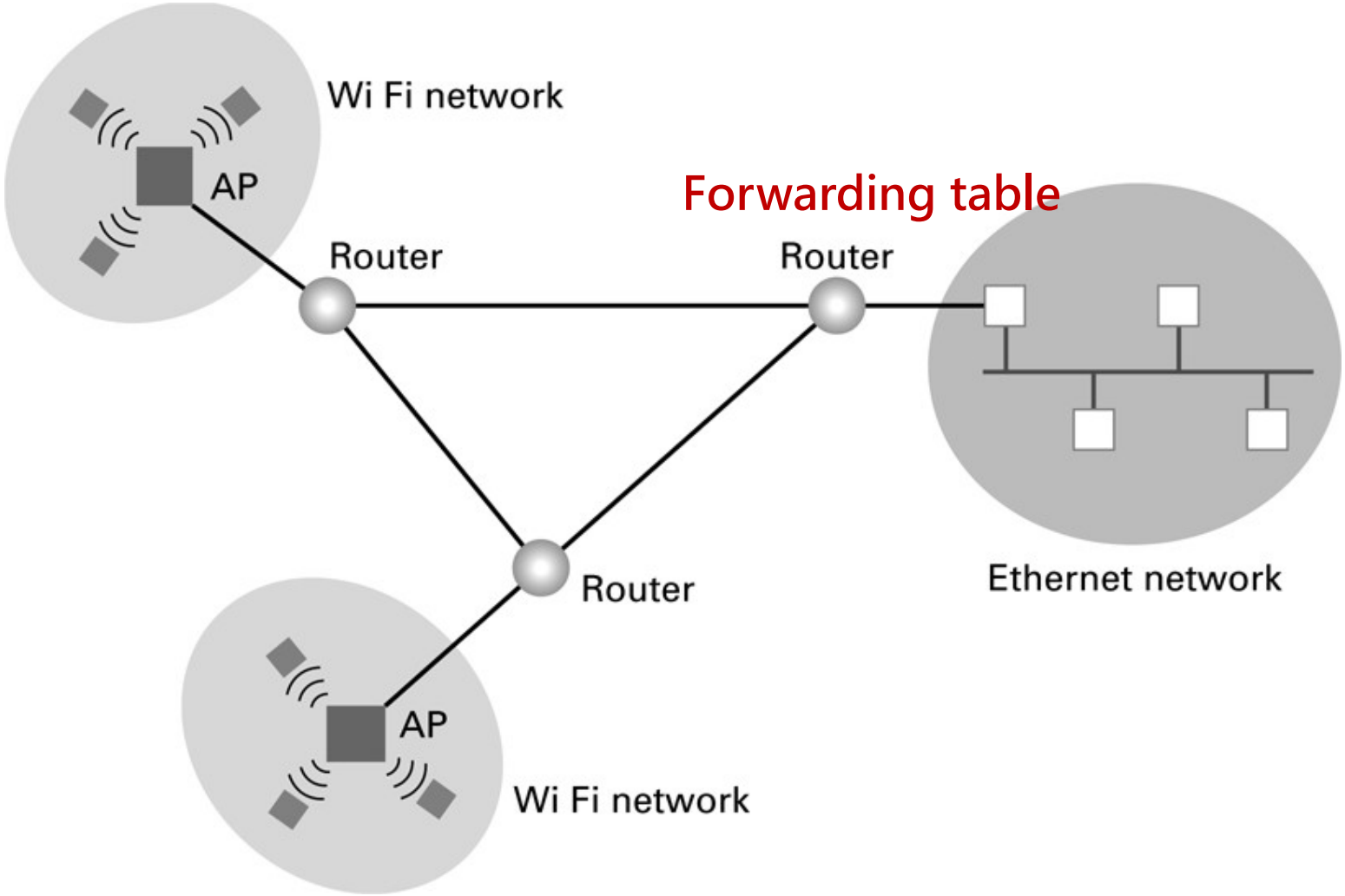
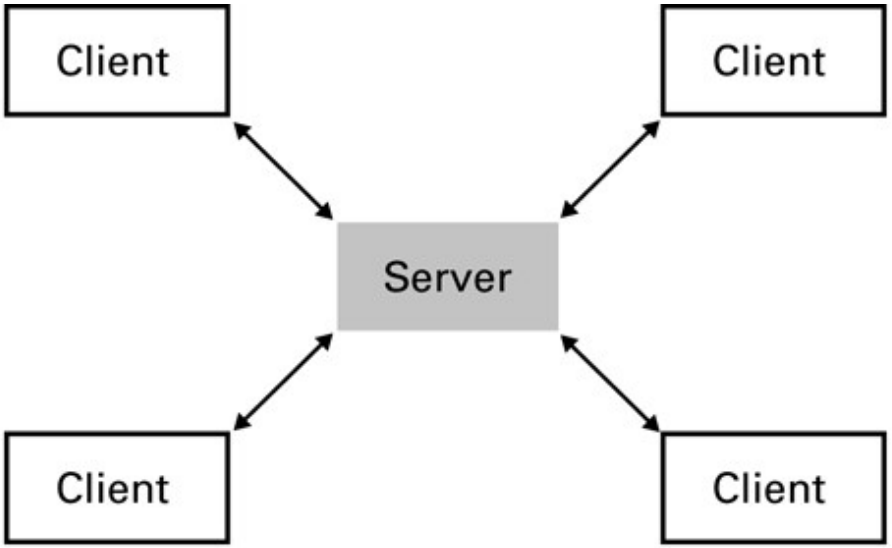


Figure 4.5 Routers connecting two WiFi networks and an Ethernet network to form an internet

Inter-process Communication

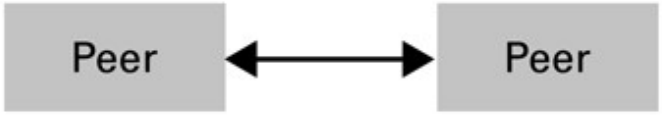
- Client-server
  - One server, many clients
  - Server must execute continuously
  - Client initiates communication
- Peer-to-peer (P2P)
  - Two processes communicating as equals
  - Peer processes can be short-lived

Figure 4.6 The client/server model compared to the peer-to-peer model



- Print server
- File server

a. Server must be prepared to serve multiple clients at any time.



- BT

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

Distributed Systems

- Systems with parts that run on different computers
  - Cluster computing
  - Grid computing (middleware)
  - Cloud computing
    - Amazon's Elastic Compute Cloud
    - Google Drive
      - Gmail
      - Google Doc

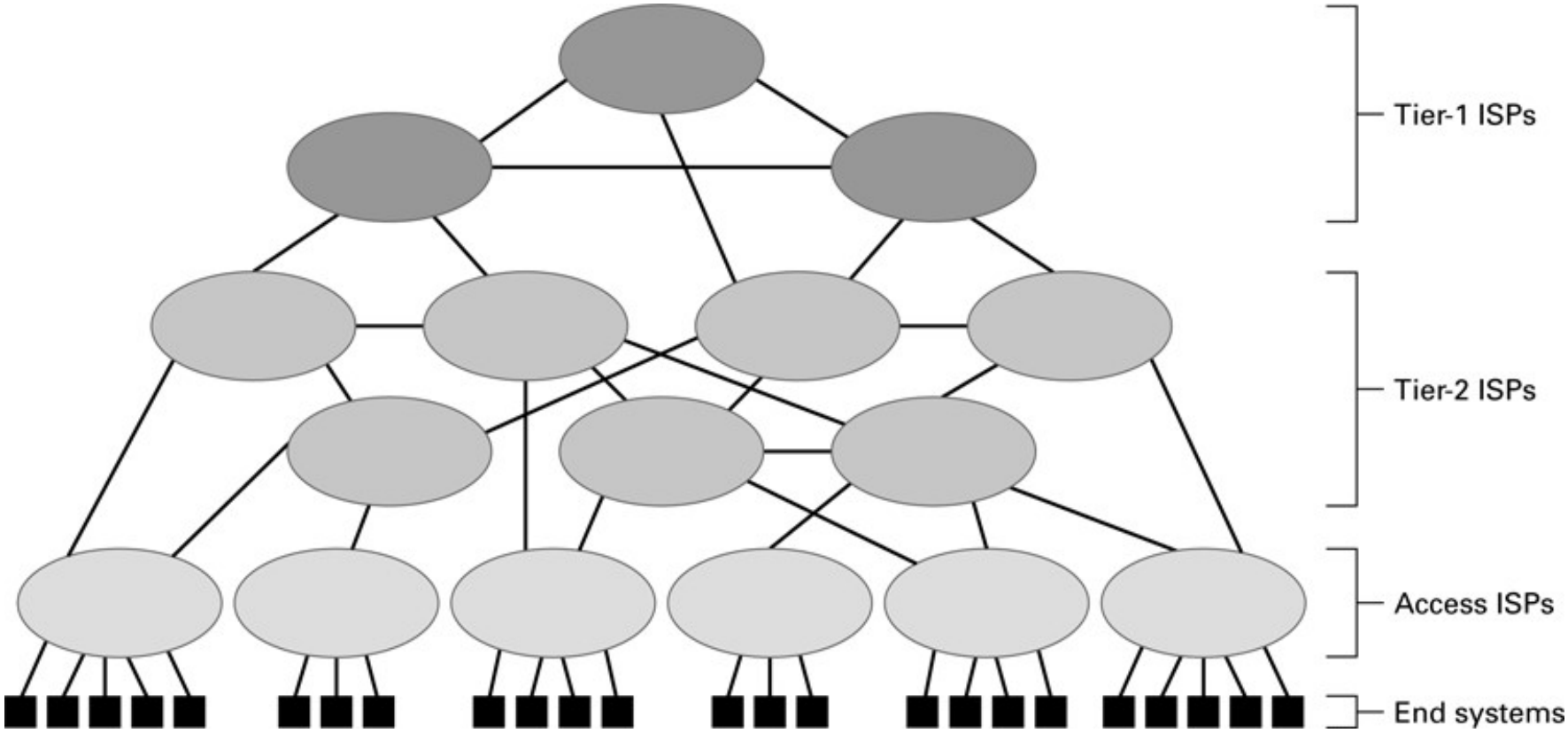
The Internet

- The Internet: An internet that spans the world
  - Original goal was to develop a means of connecting networks that would not be disrupted by local disasters
  - Today 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
  - Tier-2
- Access or tier-3 ISP: Provides connectivity to the Internet
  - Hot spot (wireless)
  - Telephone lines
  - Cable/Satellite systems DSL
  - Fiber optics

Figure 4.7 Internet Composition



Internet Addressing

128bits (IPv6): 2001:0db8:85a3:08d3:1319:8a2e:0370:7344

32bits (IPv4): 140.112.8.116

- IP address: pattern of 32 or 128 bits often represented in dotted decimal notation
- Mnemonic address:
  - Domain names iyte
  - Top-Level Domains .edu.tr .gov .com
- Domain name system (DNS)
  - Name servers
  - DNS lookup www.iyte.edu.tr

Internet Corporation for Assigned Names & Numbers (ICANN)

- Allocates 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 SSH (Secure Shell)
- 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

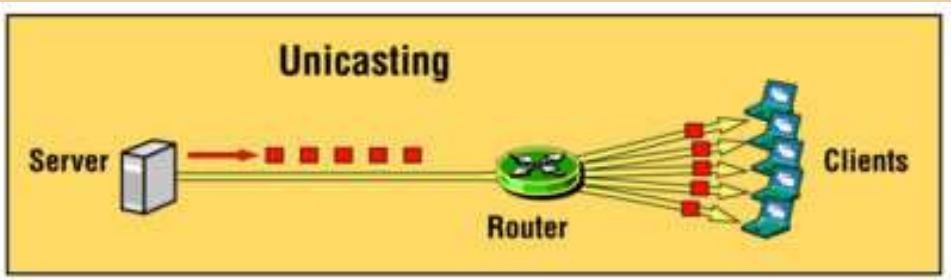
SMTP Simple Mail Transfer Protocol

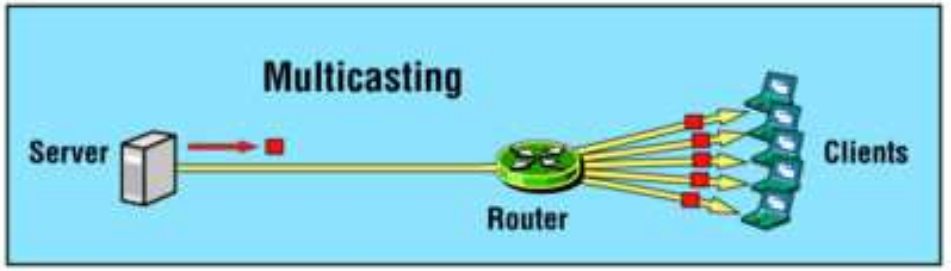
220 mail.tardis.edu SMTP Sendmail Gallifrey-1.0; Fri, 23 Aug 2413 14:34:10
HELO mail.skaro.gov
250 mail.tardis.edu Hello mail.skaro.gov, pleased to meet you
MAIL From: dalek@skaro.gov
250 2.1.0 dalek@skaro.gov... Sender ok
RCPT To: doctor@tardis.edu
250 2.1.5 doctor@tardis.edu... Recipient ok
DATA
354 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

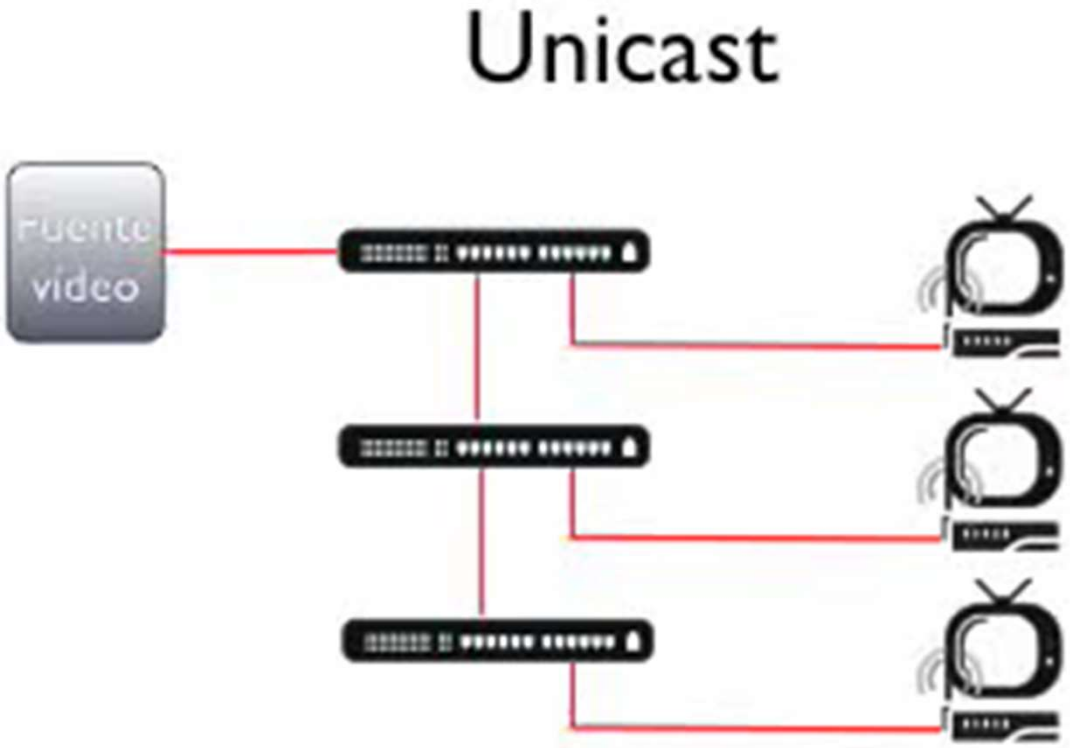
More Recent Applications

- Voice Over IP (VoIP) Skype. Hangouts
- Internet Multimedia Streaming
  - N-unicast
  - Multicast
  - On-demand streaming
  - Content delivery networks (CDNs)

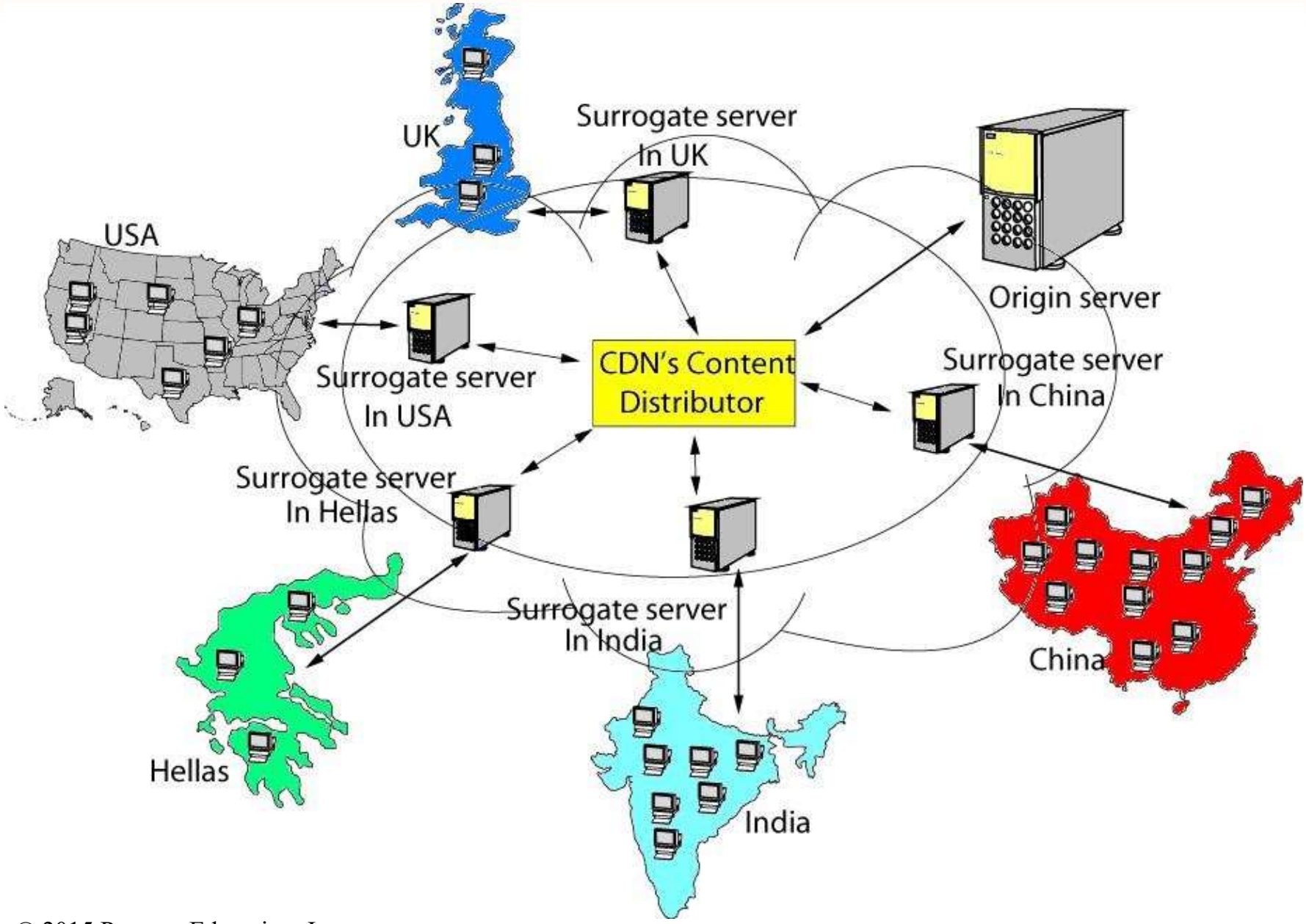
Unicast vs Multicast







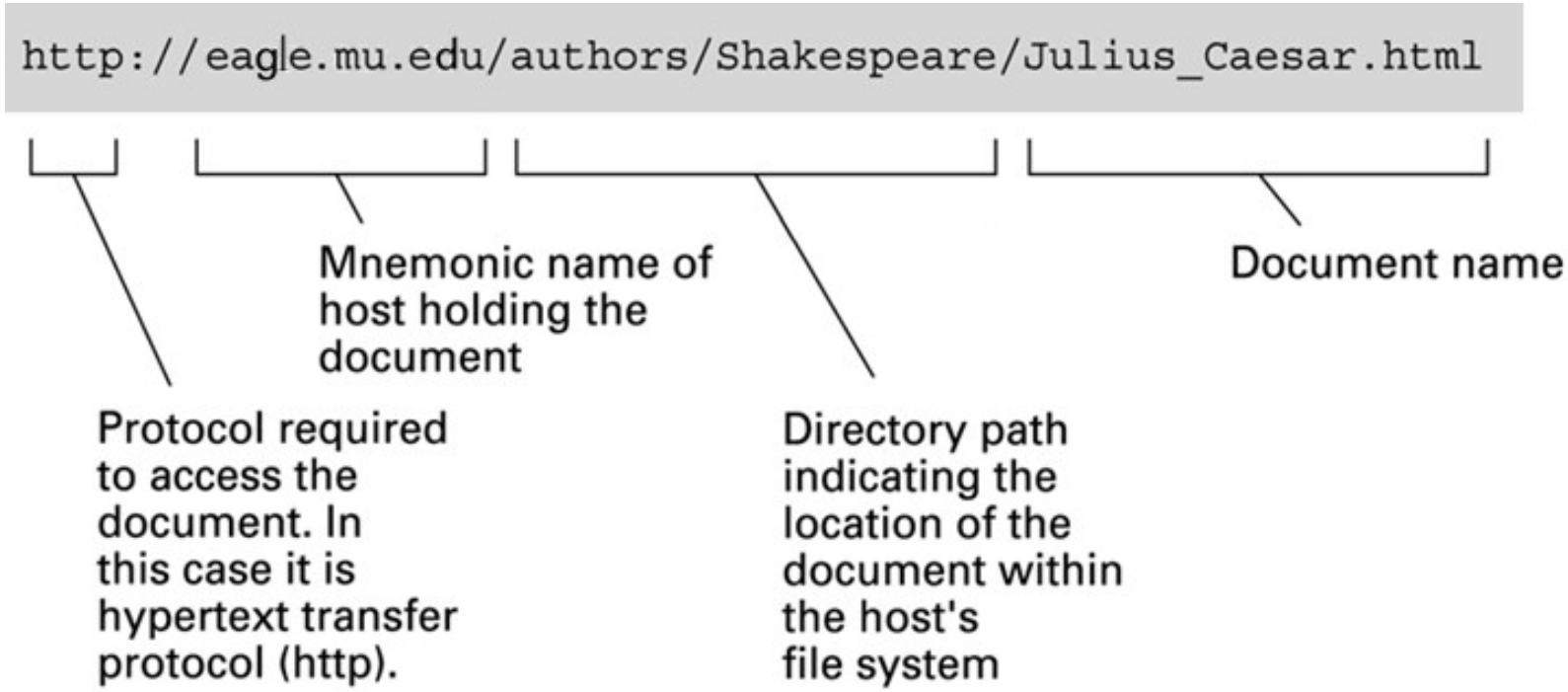
Content delivery networks (CDNs)



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.

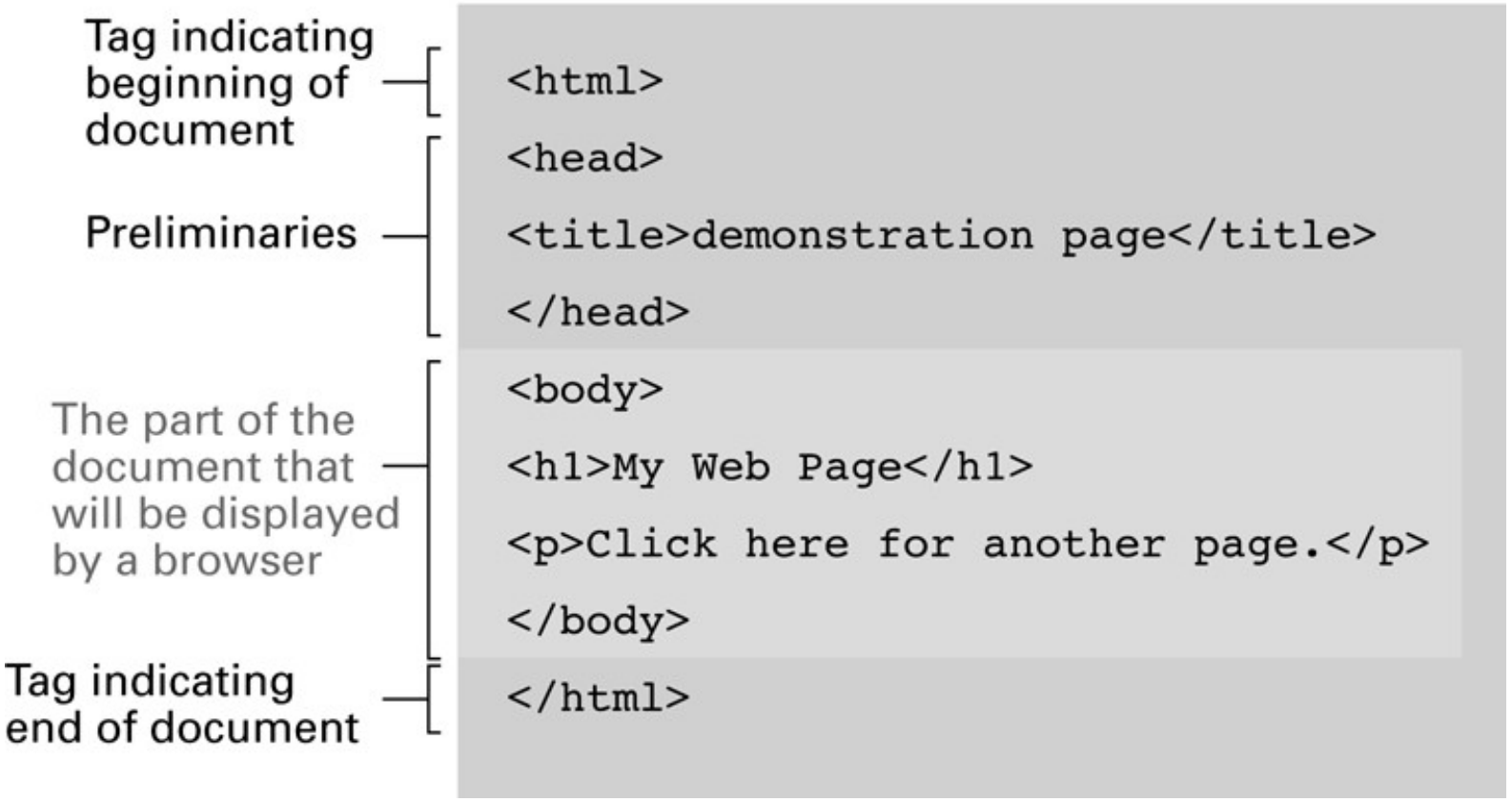


Figure 4.9 A simple webpage (continued)

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 SGML
  - Opens door to a World Wide *Semantic* Web

Using XML

<staff clef = “treble”> <key>C minor</key>

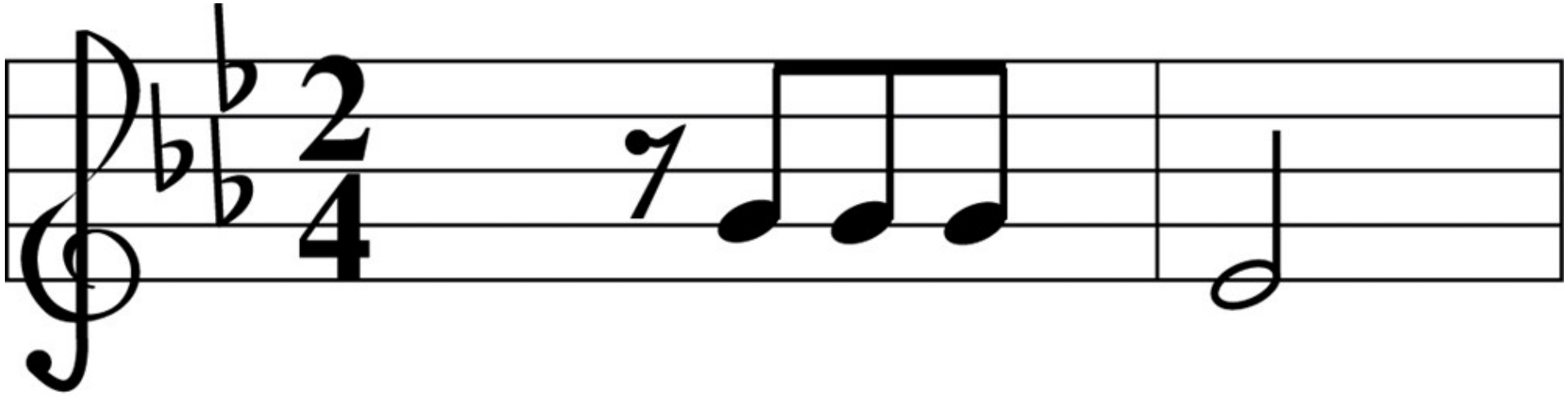
<time> 2/4 </time>

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

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

</staff>

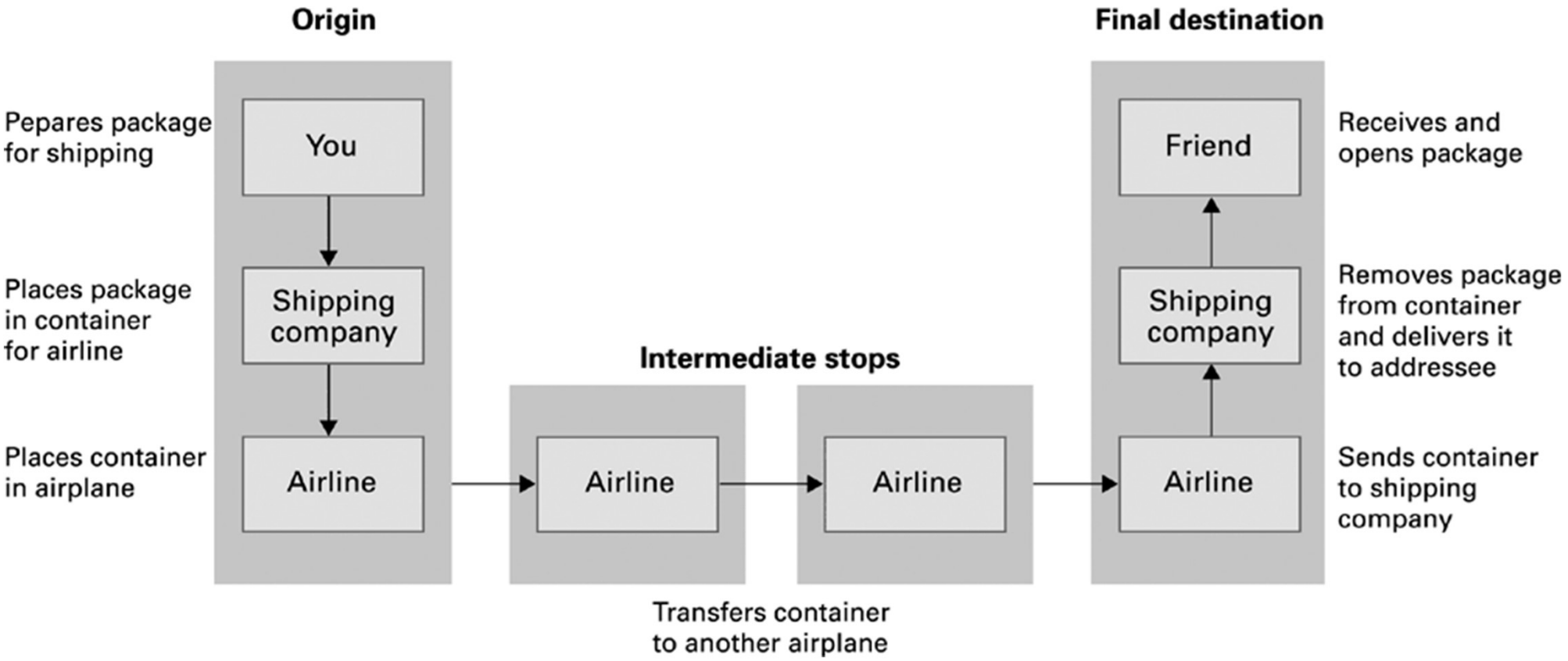
Figure 4.11 The first two bars of Beethoven's Fifth Symphony



Client Side Versus Server Side

- Client-side activities
  - Javascript
  - Macromedia Flash
- Server-side activities
  - Common Gateway Interface (CGI)
  - Servlets
  - JavaServer Pages (JSP) / Active Server Pages (ASP)
  - PHP

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

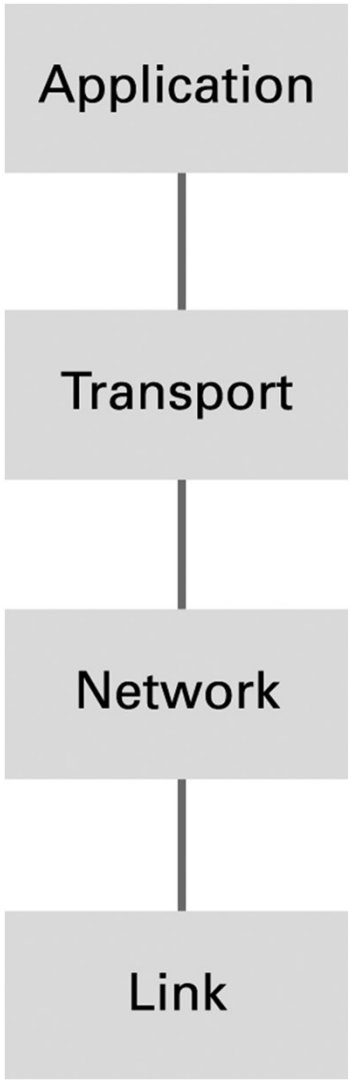
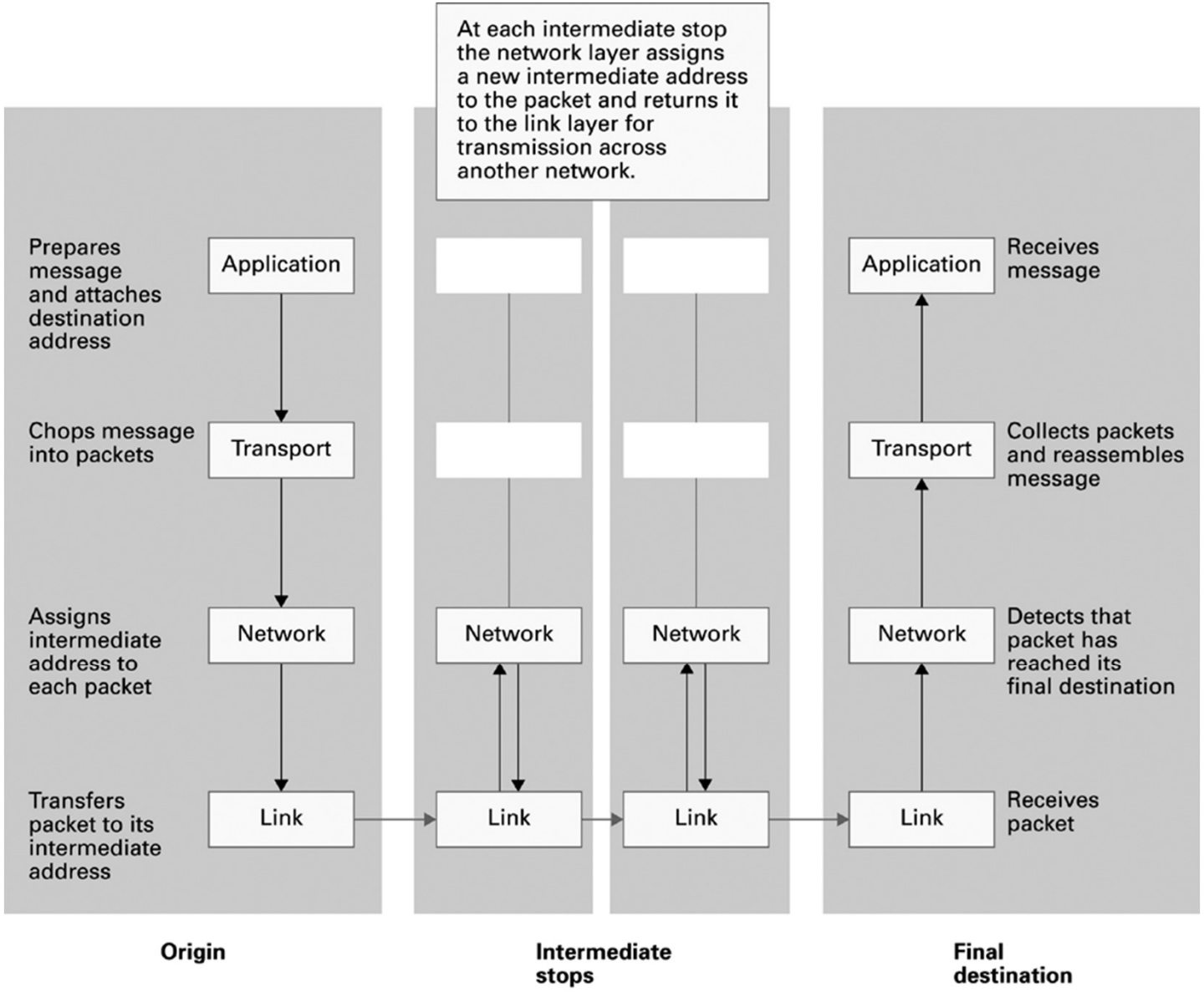


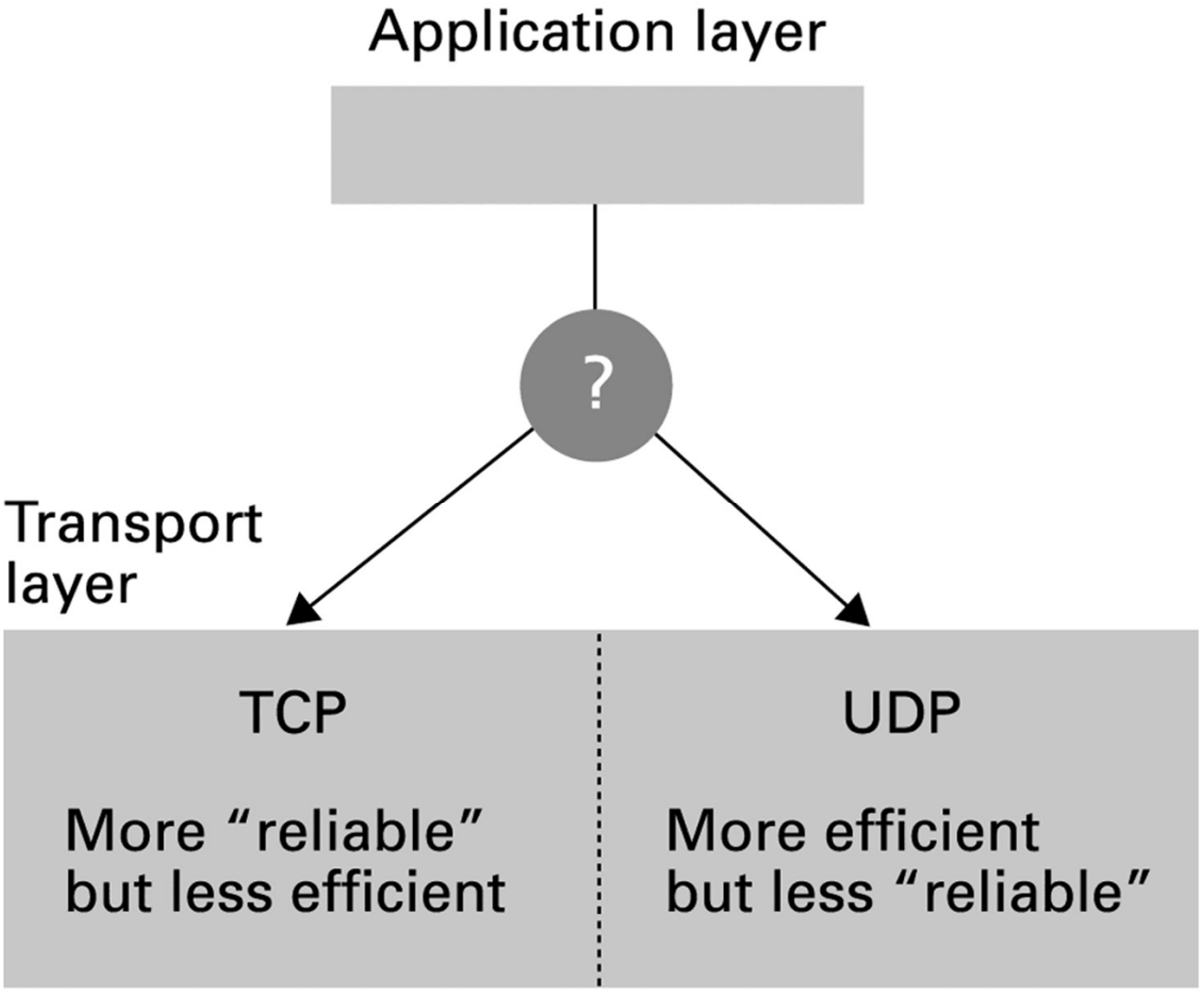
Figure 4.14 Following a message through the Internet



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



Security

- Attacks
  - Malware (viruses, worms, Trojan horses, spyware, phishing software)
  - Denial of service (DoS)
  - Spam
- Protection
  - Firewalls
  - Spam filters
  - Proxy Servers
  - Antivirus software

Encryption

- HTTPS and SSL
- Public-key Encryption
  - Public key: Used to encrypt messages
  - Private key: Used to decrypt messages
- Certificates and Digital Signatures
  - Certificate authorities

Figure 4.16 **Public-key encryption**