# Informatics
## The basics of Networking

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# Learning Objectives

- Tell whether a communication technology (Internet, radio, LAN, etc.) is synchronous or asynchronous; broadcast or point-to-point
- Explain the roles of Internet addresses, domain names, and DNS servers in networking
- Distinguish between types of protocols (TCP/IP and Ethernet)
- Describe how computers are interconnected by an ISP and by a LAN
- Distinguish between the Internet and the World Wide Web
- Explain file structure, and how to navigate up and down the hierarchy

# Comparing Communication Types

- To understand the Internet we need to cover some basic communication vocabulary:
  - Synchronous Communication
  - Asynchronous Communication
  - Broadcast
  - Communication
  - Multicast
  - Point-to-point communication

# General Communication

- **Synchronous communication:**
  - Both the sender and the receiver are active at the same time (think of talking on a telephone)

- **Asynchronous communication:**
  - The sending and receiving occur at different times (think of email and answering machines)

# General Communication

- Another property of communication concerns the number of receivers
- **Broadcast communication:** single sender and many receivers(radio and TV)
- **Multicast:** is many receivers, but usually a specific group (specialized topics)
- **Point-to-point communication:** one specific sender and one specific receiver (telephone call)

# Example of broadcast in internet

- Address Resolution Protocol (ARP) request. When a device wants to communicate with another device on the same local network (e.g., LAN), it needs to know the MAC address of the destination device. The device sends an ARP request to the broadcast address (FF:FF:FF:FF:FF:FF) asking "Who has the IP address x.x.x.x?".
- All devices on the same local network receive the broadcast message, but only the device that has the requested IP address will respond with its MAC address. The requesting device will then use this MAC address to communicate with the destination device.
- Another example of broadcasting on the internet is when a router sends routing updates to all devices on its directly connected networks. This allows all devices to learn about the network topology and update their routing tables accordingly.

# Example of multicast in internet

- Internet Group Management Protocol (IGMP). IGMP is used by devices on a local network to join or leave multicast groups, and by routers to learn which devices are interested in receiving multicast traffic.
- Multicasting is widely used for multimedia streaming applications such as video conferencing, online gaming, and live video broadcasting. For example, a video streamer may send a live video stream to a multicast group address. Users who want to watch the video can join the multicast group by sending an IGMP join message to the local router. The router will then forward the video stream to all devices that have joined the multicast group.
- Another example of multicasting on the internet is the Domain Name System (DNS). DNS queries are typically sent to a unicast IP address, but DNS servers can also respond to queries with a multicast response. This allows multiple devices on the same local network to receive the DNS response simultaneously, reducing network traffic and improving performance.

# Example of unicast in internet

- When you visit a website, your web browser sends a unicast request to the web server asking for the web page. The web server then sends a unicast response back to your computer with the requested web page.
- When you send an email, your email client sends a unicast message to the email server containing the recipient's email address and the message content. The email server then sends a unicast message to the recipient's email server, which in turn sends a unicast message to the recipient's email client.
- When you make a VoIP (Voice over IP) call, your device sends a unicast stream of voice data to the recipient's device, and the recipient's device sends a unicast stream of voice data back to your device.
- In all of these examples, the data is sent from one sender to one receiver using a unicast communication method.

# Internet's Communication Properties

- The Internet supports *point-to-point asynchronous* communication
- The Internet provides a general communication "fabric" linking all computers connected to it
- Computers and the network become a single medium

# Internet's Communication Properties

- The Internet is fast enough to mimic *synchronous* communication (like using a phone)
- *Multicasting* is also possible, allowing groups to communicate in chat rooms
- You can post video that can be accessed by anyone, as a form of broadcasting (compares with radio or television)

# Internet's Communication Properties

- The Internet is a universal communication medium
- The Internet also becomes more *effective* with each additional computer added
  - If *x* computers are already attached to the Internet, adding one more results in *x* potential new connections!

# Internet Schematic Diagram

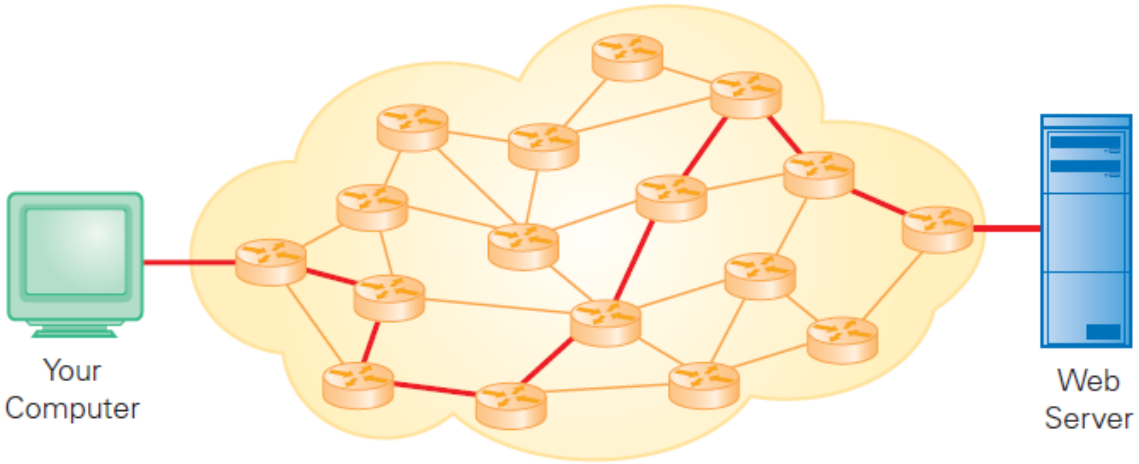



**Figure 3.1** A schematic diagram of the Internet.

# Client/Server Structure

- Most interactions over the Internet use the *client/server interaction* protocol:
  - When you click a Web link, your computer gets the page for you...beginning the client/server interaction
    - Your computer is the *client* computer and the computer with the Web page is the *server* (**Web server**)
    - The *client,* gets services from the *server*
  - When the page is returned, the operation is completed and the client/server relationship ends

# Basic Client/Server Interaction

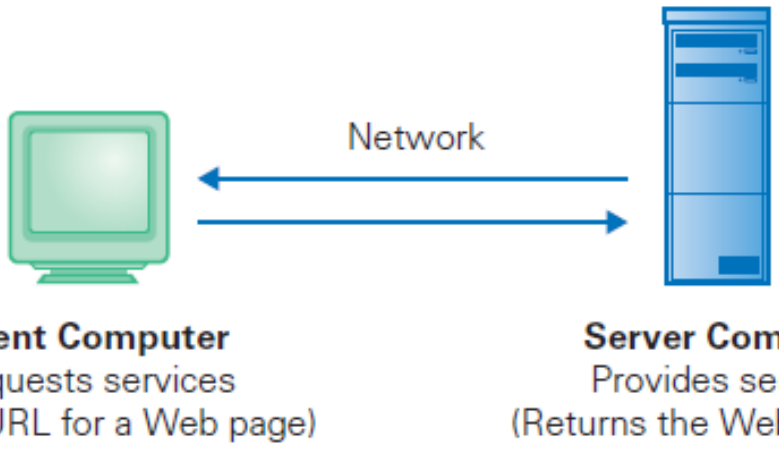



Figure 3.2 The basic client/server interaction, as illustrated by the browser (client) requesting Web pages provided by the Web server.

# Client/Server Structure

- The client/server structure is fundamental to Internet interactions
- A key aspect is that only a single service request and response are involved
- The *relationship* is very brief relationship, lasting from the moment the request is sent to the moment the service is received

# Many Brief Relationships

- This approach means that the server can handle many clients at a time
- For example, between two consecutive client requests from your browser (getting a page and asking for another) that server could have serviced hundreds of other clients
- The server is busy only for as long as it takes to perform your request

# Client/Server Relationships

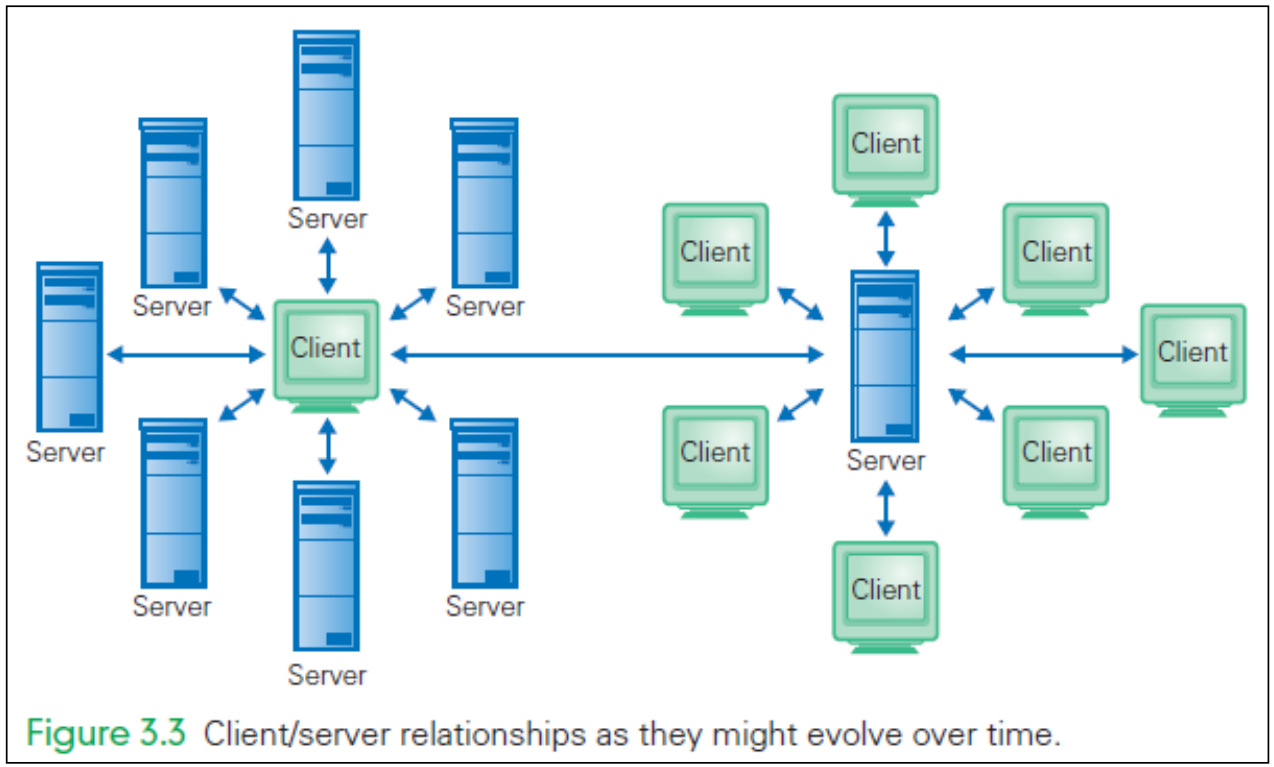



Figure 3.3 Client/server relationships as they might evolve over time.

# Getting More Connected

- The Internet is primarily a point-to-point asynchronous communication system
- Software has been built to implement the many forms of communication
- A video chat client seems to have a constant connection, but actually “slices up” the computer’s sound and video signals into into chunks, and sends each chunk separately

# Getting More Connected

- Content is transferred to the other party, whose client reassembles the sound and image for display
- This process relies on fast and reliable transmission to simulate a direct connection
- The Internet Protocol is generally fast and reliable enough to work

# Appearing to Stay Connected

- Even though users interact with a web site through multiple brief exchanges, many sites must give the appearance that these are part of a longer-lived connection
- When using a bank web site, your login interaction must be associated with your transactions
- When buying on-line, your purchases must be related to your shopping cart

# Appearing to Stay Connected

- Cookies
  - Server stores a small file on the client, that is returned with each request
  - Contains enough information to associate the interactions.
- URL Parameters
  - Information is added to the URL
  - You can see this in the URL created by a Google search

# Computer Addresses

- IP Addresses
  - Each computer connected to the Internet is given a unique address called its **IP address**
  - An IP address is a series of four numbers (one byte each) separated by dots
  - The range of each of these numbers (0–255) allows for billions of IP addresses
  - New IP addresses are in short supply

# Computer Addresses

- Each message on the Internet is called an *IP packet*.
- Each packet is sent to a particular IP address.
- Each packet may take a different route to reach that address.
- A tool called *Traceroute* can display this route

# Traceroute

**Traceroute**

Tracing route to 192.33.92.189

| Hop | Time | Host | IP | Locations |
|---|---|---|---|---|
| 1 | 0.692 | 10.0.0.1 | 10.0.0.1 | Local (CSE) |
| 2 | 3.074 | 10.20.62.254 | 10.20.62.254 | Local (UW?) |
| 3 | 5.035 | r2-l3tca-cr2.nextweb.net | 216.237.3.33 | Irvine, CA |
| 4 | 10.195 | ge-6-15.car2.Tustin1.Level3.net | 4.79.142.41 | Tustin, CA |
| 5 | 159.713 | vl-3202-ve-134.ebr2.Tustin1.Level3.net | 4.69.160.17 | Tustin, CA |
| 6 | 167.65 | ae-7-7.ebr3.LosAngeles1.Level3.net | 4.69.153.225 | Los Angeles |
| 7 | 190.5 | ae-12-12.ebr3.LosAngeles1.Level3.net | 4.69.132.82 | Los Angeles |
| 8 | 185.48 | ae-81-81.csw3.Washington1.Level3.net | 4.69.134.138 | Washington, DC |
| 9 | 170.699 | ae-72-72.ebr2.Washington1.Level3.net | 4.69.134.149 | Washington, DC |
| 10 | 170.967 | ae-42-42.ebr2.Paris1.Level3.net | 4.69.137.53 | Paris, FR |
| 11 | 166.41 | ae-9-9.car1.Lyon1.Level3.net | 4.69.134.49 | Lyon, FR |
| 12 | 162.49 | ae-5-5.car1.Geneva1.Level3.net | 4.69.137.81 | Geneva, CH |
| 13 | 171.875 | DANTE.car1.Geneva1.Level3.net | 213.242.73.74 | Geneva, CH |
| 14 | 170.299 | swiLS2-10GE-1-3.switch.ch | 130.59.37.2 | Zurich, CH |
| 15 | 184.92 | swiEZ2-10GE-1-1.switch.ch | 130.59.36.206 | Zurich, CH |
| 16 | 170.094 | rou-gw-rz-tengig-to-switch.ethz.ch | 192.33.92.1 | ETH |
| 17 | 190.544 | rou-fw-rz-rz-gw.ethz.ch | 192.33.92.169 | Local (ETH) |
| 21 | N/A | 192.33.92.189 | 192.33.92.189 | |

**Figure 3.4** A packet's route from the University of Washington, Seattle, to **ethz.ch**, the Swiss National Technical University in Zurich (note that the figure doesn't show the local hops 18–20). Try it: **whatismyipaddress .com/traceroute-tool.**

# TCP/IP

- TCP/IP Postcard Analogy
  - The Internet is like sending a novel to your publisher using postcards
  - The novel is broken into small units that fit on a postcard
  - The “postcards” are numbered to indicate where each belongs in the novel
  - As each postcard is completed, it is mailed

# TCP/IP

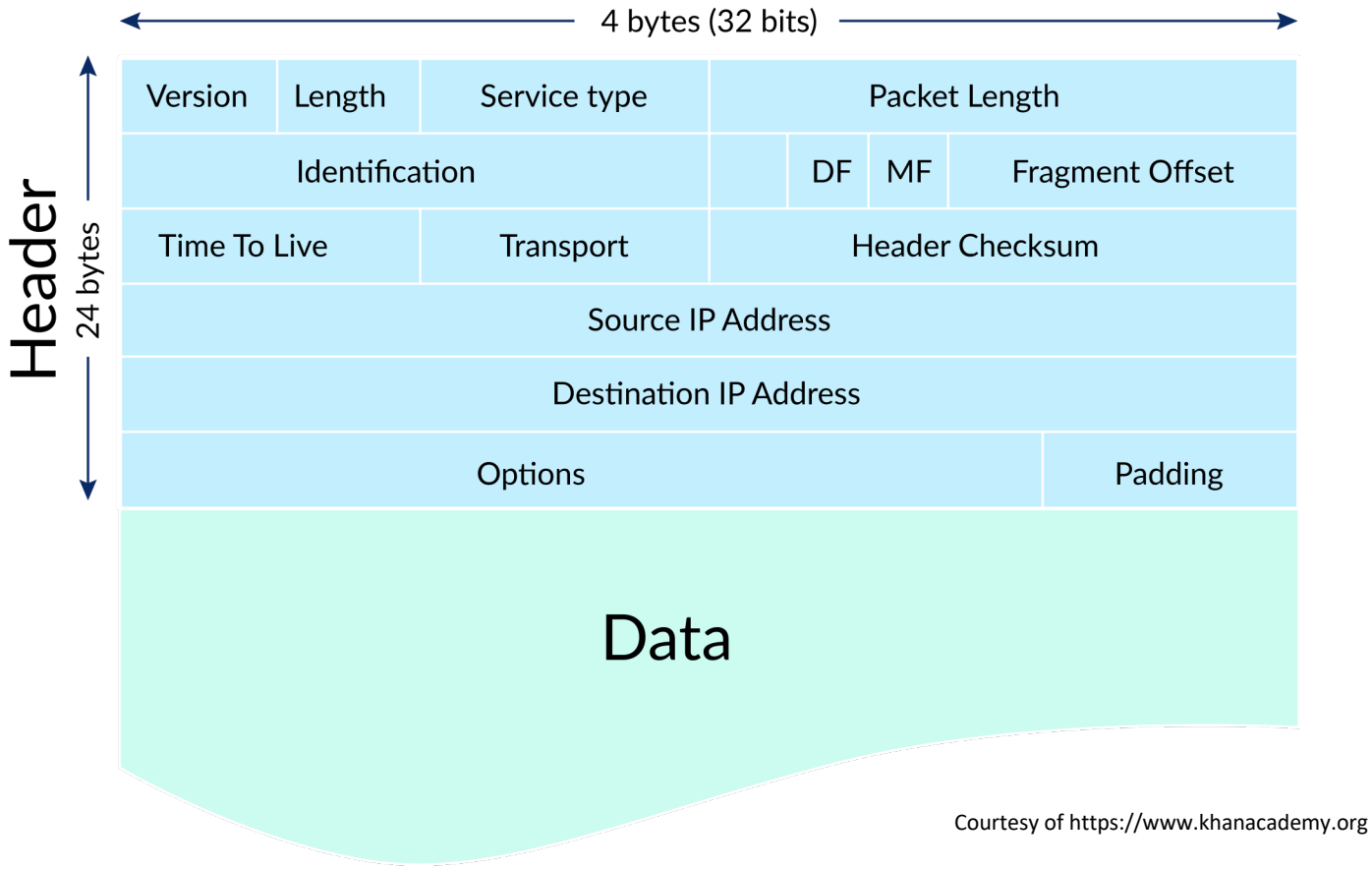
- TCP/IP Postcard Analogy
  - Sooner or later, your publisher receives the postcards, but not necessarily in sequential order
  - Nor do they take the same route
  - The cards are finally arranged in order
  - These “postcards” are the ***IP packets***
    - They hold
      - one unit of information (the *payload*)
      - the *header*, containing all the informations necessary for the transimssion

# IP Packet – what's in the **header**

All the information necessary to:

- identify the payload
- forward it from the sender to the receiver,
- allow the receiver to collect the payloads of different packets and rebuild the original file
- inform the sender of the success/failure of the transmission

# IP Packet – what's in the **header**




Courtesy of https://www.khanacademy.org

# Packets Are Independent

- Because each packet can take a different route, congestion and service interruptions do not delay transmissions
  - Each TCP/IP packet is *independent*
- The TCP/IP protocol works under adverse conditions
  - If traffic is heavy and the packet progress is slow, the protocol allows the packet to be thrown away

# Packets Are Independent

- If a packet is killed for whatever reason, the recipient will request a resend
- Packets can arrive out of order because they take different routes

# Far and Near: WAN and LAN

- The Internet is a collection of **wide area networks (WAN**)
  - These are networks that are not geographically close
- The Internet is a collection of point-to-point channels
  - Meaning packets must visit a sequence of computers before they reach their destination

# Far and Near: WAN and LAN

- A **local area network (LAN)** connects computers that are geographically close
  - Usually they can be linked by a single cable or pair of wires
- **Ethernet** is the main technology for local area networks
  - Used for connecting all the computers in a lab or building

# Ethernet

- The physical setup for an Ethernet network is a wire, wire pair, or optical fiber, called the **channel**
- Engineers “tap” into the channel to connect a computer:
  - This allows it to send a signal or an electronic pulse or light flash onto the channel
  - All computers, including the sender, can detect the signal

# Ethernet Party Analogy

- To understand how an Ethernet network works, consider this:
  - A group of friends is standing around at a party telling stories.
  - While someone is telling a story, everyone is listening.
  - When the story is over, there may be a pause before the next one speaks
  - Then, someone typically just begins talking and the cycle starts again

# Ethernet Party Analogy

- Now, insert *computer* instead of *friend*:
  - A group of computers is standing around at a party telling stories.
  - While a computer is telling a story, every computer is listening
  - When the story is over, there may be a pause before the next computer speaks
  - Then, a computer typically just begins talking and the cycle starts again

# Ethernet Party Analogy

- We assumed that all “friends” were equal
  - No had a more important status
  - Everyone spoke with the same voice
- There are differences, however:
  - Only one computer typically keeps the transmitted information
  - This broadcast medium is being used for *point-to-point* communication

# Ethernet Party Analogy

- A computer wants to transmit a message:
  - It starts sending signals and also starts listening to see if the message it gets is the one it sent
  - If it is, the computer knows it's the only computer sending, and it completes the transmission
  - If it isn't, (we call this situation "collision") the computer stops transmitting immediately

# Ethernet Party Analogy

- If the the transmission had to stop (because some other computer was sending in the same time):
  - The senders waits a random amount of time and tries to send again
  - Probably they will wait different amounts of time, so one will go first and the other will wait
  - If there is another collision, the process repeats

# Connecting to the Internet

- Today there are two basic methods:
  1. Connection via an Internet service provider (ISP)

  1. Connection provided by a campus or enterprise network

- Most of us use both kinds of connections

# 1. Connections by ISP

- Most home users connect to the Internet by ISPs
  - These are companies that sell connections to the Internet
- The company places a modem at your house
  - Modems convert the bits a computer outputs into a form that is compatible with the carrier

# 1. Connections by ISP

1. The signals are sent to the carrier's business
2. They are converted (via modem) into a form for the server that connects to the Internet via the Internet Gateway

- Digital subscriber line (DSL or ADSL) and cable (TV) are two common providers
- Your smart phone also has a modem for connecting to network

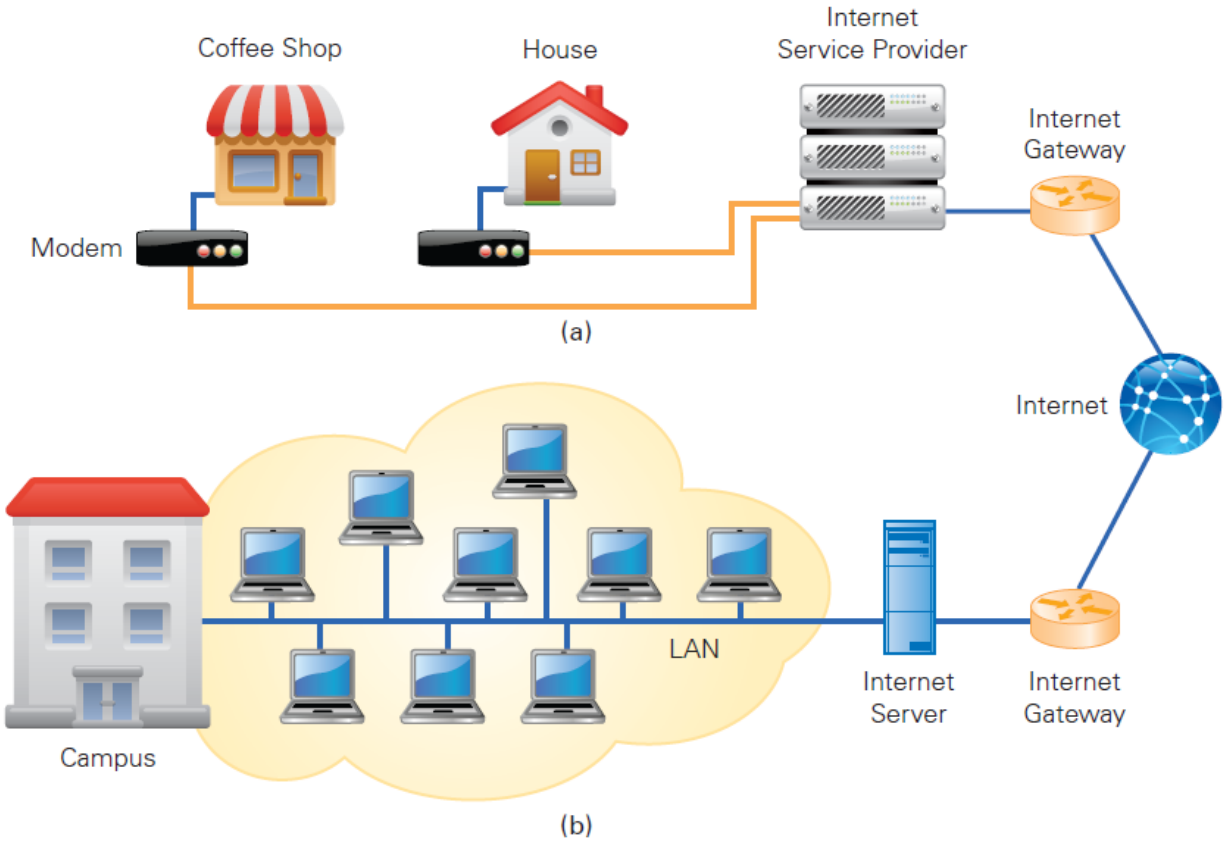



**Figure 3.6** Schematic diagram of connecting to the Internet. (a) An ISP's modem converts the computer's bits to signals the carrier's technology (phone lines, cable, microwave, etc.) can use; their servers connect to the Internet gateway. (b) On campus (or at another enterprise), the local network's server connects directly to the Internet gateway.

# 2. Enterprise Network Connections

- The other way to connect is as a user of a larger networked organization (school, business, or governmental unit)
- A LAN connects computers within the organization
- The LAN is connected to the Internet by a gateway

# Wireless Networks

- Variation of a LAN connection
- Referred to by its protocol name ***802.11***
- The router is:
  - Physically connected to an ISP's modem
  - Connected to the Internet
  - Capable of *broadcasting* **and** *receiving* signals, usually radio frequency (rf ) signals

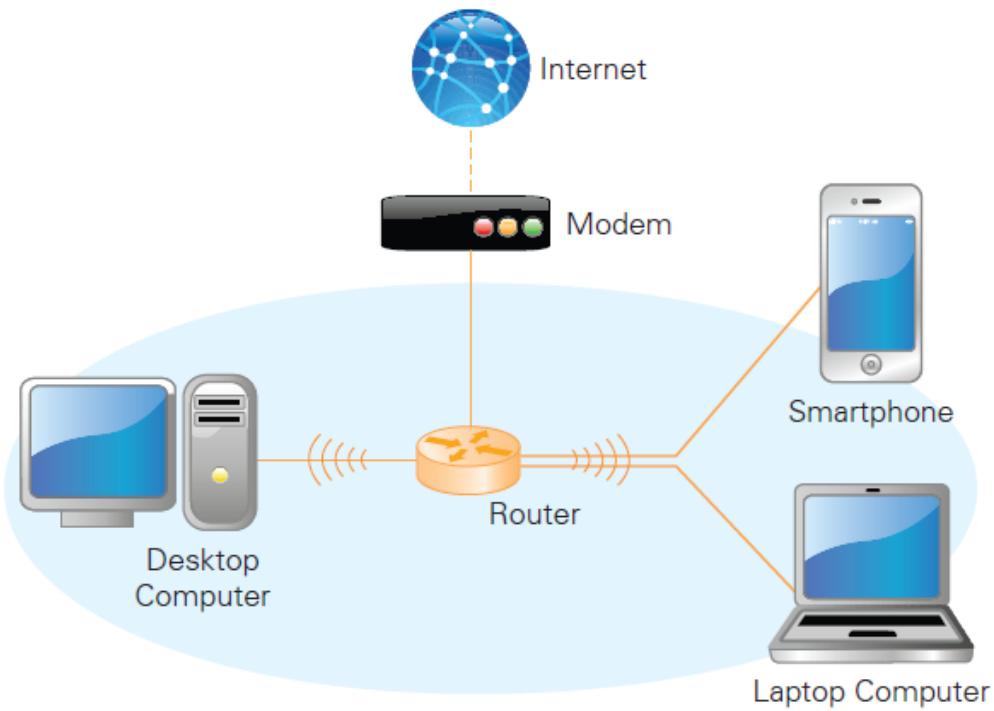



**Figure 3.7** Standard Wi-Fi network configuration. A wireless router is connected via the modem to the ISP's Internet modem; laptops and other wireless-enabled devices connect by radio signals to the router.

# Computer Addresses

- Domain Names
  - It is hard to remember the numeric IP address of all the computers we communicate with
  - The Internet uses human-readable symbolic names for computers that are based on a hierarchy of *domains*
  - A **domain** is a related group of networked computers

# Computer Addresses

- Domain Names
  - Example: **spiff.cs.washington.edu**
  - The name of the computer is **spiff**
  - it is part of the Computer Science and Engineering Department domain (**cs**)
  - it is part of the University of Washington domain (**washington**)
  - it is part of the educational domain (**edu**)

# Computer Addresses

- The example shows a hierarchy of domains
- Each is a member of the next larger domain
- edu is a peer of other top-level domains such as com
- *These* names are symbolic and meaningful, making them easier to read than numbers (and easier to remember)

# The .edu Domain

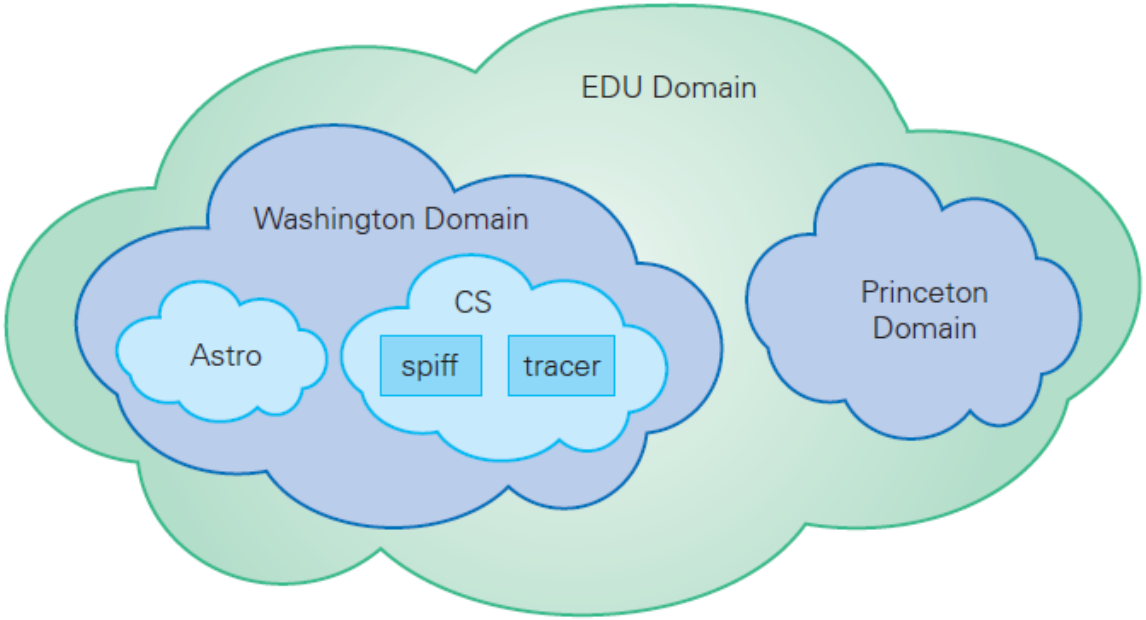



**Figure 3.8** Two ways to think of the Internet domain hierarchy.

# The .edu Domain

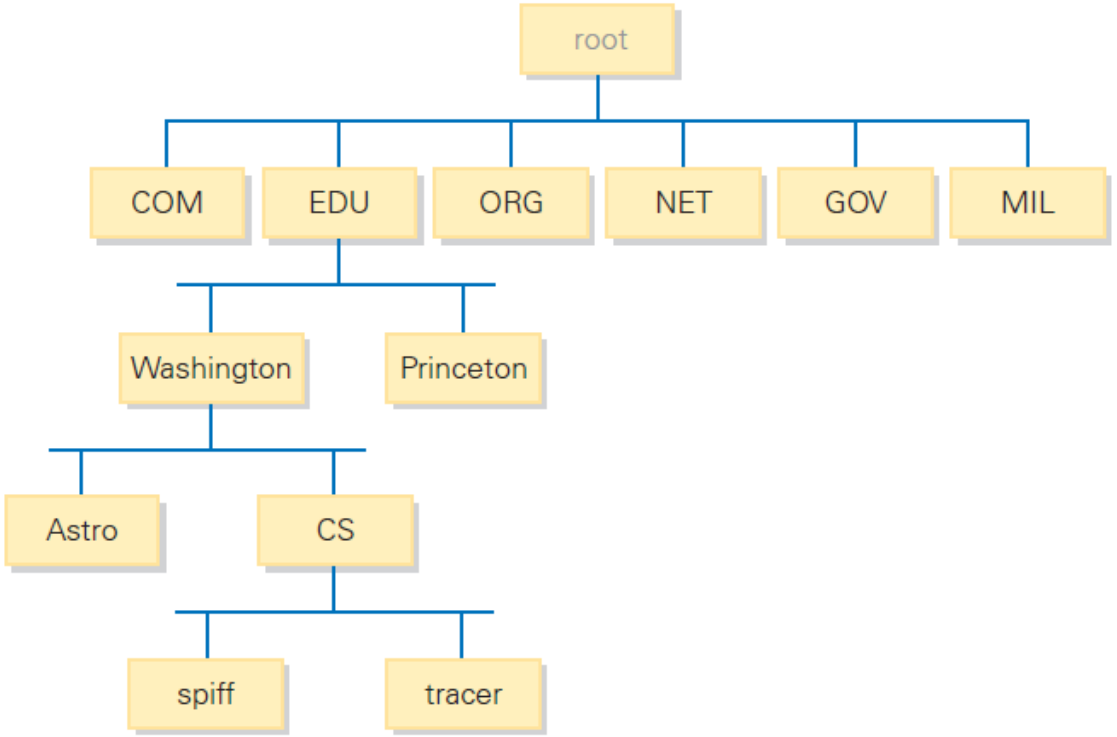



**Figure 3.8** Two ways to think of the Internet domain hierarchy.

# DNS Servers

- The **Domain Name System (DNS)** translates the hierarchical, human-readable names into the four-number IP address
- Every Internet host knows the IP address of its nearest **DNS name server**
- Whenever the hierarchical symbolic name is used to send information to a destination, your computer asks the DNS server to look up the corresponding IP address

# DNS Servers

- The server you ask may not know the answer. No DNS server knows all the hostnames on the Internet
- Each domain has an *authoritative name server*, that knows the computers its domain
- There are *root name servers* that know the authoritative server for each top-level domain
- To search for a name, work through the domains down from the top

# DNS Lookup

- Your computer asks the nearest DNS server to translate a name, say **www.airandspace.si.edu**
- That local server asks a root name server for the IP address of the **edu** authoritative name server
- Next it asks that edu server for the **si** authoritative name server
- Then it asks the **si** server for the **airandspace** server, that asks for the IP address of **www**
- The administrator of each DNS server makes sure it has a list of root servers to get started

# DNS Lookup

- Caching
  - The local name server remembers the result of a lookup for a while
  - Skips the lookup if it already knows the answer
- Redundancy
  - There are 13 root name servers
  - share load
  - one might crash

# Top-Level Domains

- **Top-level domain** names (**TLDs)**:
  - .edu for educational groups
  - .com for commercial enterprises
  - .org for organizations
  - .net for networks
  - .mil for the military
  - .gov for government agencies

# Top-Level Domains

- The top-level domains were expanded to include biz, info, name, travel, and others
- The full list can be found at www.icann.org (ICANN is Internet Corporation for Assigned Names and Numbers)
- The original top-level domains listed all apply to organizations in the United States.

# Top-Level Domains

- There is also a set of two-letter country designators (ca (Canada), uk (United Kingdom), fr (France), de (Germany, as in Deutschland), etc.)
- These allow domain names to be grouped by their country of origin.

Table 3.1 Top-level country domain names.

| Code | Country Name | Code | Country Name | Code | Country Name | Code | Country Name |
|---|---|---|---|---|---|---|---|
| AF | Afghanistan | DK | Denmark | LS | Lesotho | LC | Saint Lucia |
| AL | Albania | DJ | Djibouti | LR | Liberia | WS | Samoa |
| DZ | Algeria | DM | Dominica | LY | Libya | SM | San Marino |
| AS | American Samoa | DO | Dominican Republic | LI | Liechtenstein | ST | Sao Tome and Principe |
| AD | Andorra | EC | Ecuador | LT | Lithuania | SA | Saudi Arabia |
| AO | Angola | EG | Egypt | LU | Luxembourg | SN | Senegal |
| AI | Anguilla | SV | El Salvador | MO | Macao | RS | Serbia |
| AQ | Antarctica | GQ | Equatorial Guinea | MK | Macedonia | SC | Seychelles |
| AG | Antigua and Barbuda | ER | Eritrea | MG | Madagascar | SL | Sierra Leone |
| AR | Argentina | EE | Estonia | MW | Malawi | SG | Singapore |
| AM | Armenia | ET | Ethiopia | MY | Malaysia | SX | Sint Maarten (Dutch Part) |
| AW | Aruba | FK | Falkland Islands | MV | Maldives | SK | Slovakia |
| AU | Australia | FO | Faroe Islands | ML | Mali | SI | Slovenia |
| AT | Austria | FJ | Fiji | MT | Malta | SB | Solomon Islands |
| AZ | Azerbaijan | FI | Finland | MH | Marshall Islands | SO | Somalia |
| BS | Bahamas | FR | France | MQ | Martinique | ZA | South Africa |
| BH | Bahrain | GF | French Guiana | MR | Mauritania | GS | S Georgia S Sandwich Islands |
| BD | Bangladesh | PF | French Polynesia | MU | Mauritius | SS | South Sudan |
| BB | Barbados | GA | Gabon | MX | Mexico | ES | Spain |
| BY | Belarus | GM | Gambia | FM | Micronesia | LK | Sri Lanka |
| BE | Belgium | GE | Georgia | MD | Moldova | SD | Sudan |
| BZ | Belize | DE | Germany | MC | Monaco | SR | Suriname |
| BJ | Benin | GH | Ghana | MN | Mongolia | SZ | Swaziland |
| BM | Bermuda | GI | Gibraltar | ME | Montenegro | SE | Sweden |
| BT | Bhutan | GR | Greece | MS | Montserrat | CH | Switzerland |
| BO | Bolivia | GL | Greenland | MA | Morocco | SY | Syria |
| BA | Bosnia and Herzegovina | GD | Grenada | MZ | Mozambique | TW | Taiwan |
| BW | Botswana | GP | Guadeloupe | MM | Myanmar | TJ | Tajikistan |
| BV | Bouvet Island | GU | Guam | NA | Namibia | TZ | Tanzania |
| BR | Brazil | GT | Guatemala | NR | Nauru | TH | Thailand |
| BN | Brunei Darussalam | GG | Guernsey | NP | Nepal | | |
| BG | Bulgaria | GN | Guinea | NL | Netherlands | | |
| | | GW | Guinea-Bissau | NC | New Caledonia | | |
| | | GY | Guyana | NZ | New Zealand | | |

Table 3.1 Top-level country domain names.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BF | Burkina Faso | HT | Haiti | NI | Nicaragua | TG | Togo |
| BI | Burundi | HN | Honduras | NE | Niger | TK | Tokelau |
| KH | Cambodia | HK | Hong Kong | NG | Nigeria | TO | Tonga |
| CM | Cameroon | HU | Hungary | NU | Niue | TT | Trinidad and Tobago |
| CA | Canada | IS | Iceland | NF | Norfolk Island | TN | Tunisia |
| CV | Cape Verde | IN | India | MP | Mariana Islands | TR | Turkey |
| KY | Cayman Islands | ID | Indonesia | NO | Norway | TM | Turkmenistan |
| CF | Central African Republic | IR | Iran | OM | Oman | TC | Turks and Caicos Islands |
| TD | Chad | IQ | Iraq | PK | Pakistan | TV | Tuvalu |
| CL | Chile | IE | Ireland | PW | Palau | UG | Uganda |
| CN | China | IM | Isle of Man | PS | Palestine | UA | Ukraine |
| CX | Christmas Island | IL | Israel | PA | Panama | AE | United Arab Emirates |
| CC | Cocos (Keeling) Islands | IT | Italy | PG | Papua New Guinea | GB | United Kingdom |
| CO | Colombia | JM | Jamaica | PY | Paraguay | US | United States |
| KM | Comoros | JP | Japan | PE | Peru | UY | Uruguay |
| CG | Congo | JE | Jersey | PH | Philippines | UZ | Uzbekistan |
| CD | Congo, Drc | JO | Jordan | PN | Pitcairn | VU | Vanuatu |
| CK | Cook Islands | KZ | Kazakhstan | PL | Poland | VE | Venezuela |
| CR | Costa Rica | KE | Kenya | PT | Portugal | VN | Viet Nam |
| CI | CÔTE D'Ivoire | KI | Kiribati | PR | Puerto Rico | VG | Virgin Islands, British |
| HR | Croatia | KP | Korea, DPR | QA | Qatar | VI | Virgin Islands, U.S. |
| CU | Cuba | KR | Korea | RE | Réunion | EH | Western Sahara |
| CW | Curaçao | KW | Kuwait | RO | Romania | YE | Yemen |
| CY | Cyprus | KG | Kyrgyzstan | RU | Russia | ZM | Zambia |
| CZ | Czech Republic | LA | Lao | RW | Rwanda | ZW | Zimbabwe |
| | | LV | Latvia | SH | Saint Helena | | |
| | | LB | Lebanon | KN | Saint Kitts and Nevis | | |

# The World Wide Web

- ***Some*** computers connected to the Internet are **Web servers**
  - Computers programmed to send files to browsers running on other computers connected to the Internet.
- These Web servers and their files comprise the ***World Wide Web (WWW)***

# The World Wide Web

- Those files may be Web pages
- Web servers store and send other kinds of files, too
- The files are often used to:
  - Enhance the Web page (images or animations)
  - Help with other Web services (play audio or video)

# Requesting a Web Page

- Web requests use client/server interaction
- Requesting a Web page means your browser is a *client* asking for a file from a Web *server*
- The file can be found in looking at the ***URL*** (Universal Resource Locator)
- Web browsers and Web servers both “speak” the *HTTP* protocol

# Requesting a Web Page

**http**://**www.cs.washington.edu**/**homes/snyder/index.html**

- The **URL** has three main parts:
  - **Protocol:** tells the computers how to fetch the file
  - **Server computer's name:** or the server name in the domain hierarchy
  - **Page's pathname:** tells the server what file (page) is requested and where to find it

# Get It Right

- An incorrect host name will cause DNS to find the wrong server, or return an error
- An error in the path will cause the web server to get the wrong page or return an error
- Administrators may arrange that a wrong URL redirects to a corrected one

# Describing a Web Page

- Servers do not store Web pages in the form seen on our screens
- The pages are stored as a *description of how they should appear on the* screen.
- The browser receives the description/source file and creates the Web page image that is described

# Describing a Web Page

- There are two advantages to storing and sending the source rather than the image itself:
  1. A description file usually requires less information
  2. The browser can adapt the source image to your computer more easily

```
<!doctype html>
<html>
<head> <title> Alto Computer </title>
  <meta charset="UTF-8" />
  <style>
    body {background-color : white; font-family:Helvetica}
  </style>
</head>
<body>
  <img style="float:right" src="alto.jpg" alt="Alto Personal Computer"
       height="300"/>
  <h1>Alto, <br/>A Computer of Note</h1>
    <p>The Alto was the first networked personal computer. It was invented
    at the Xerox Palo Alto Research Center (PARC) by the team of Ed McCreight,
    Chuck Thacker, Butler Lampson, Bob Sproull and Dave Boggs to explore
    office automation. Altos were the first production computers to have a
    bit-mapped display, windows and a mouse. Ethernet technology, also
    invented at PARC, was first used to connect Altos.</p>
    <p>Though Xerox was unable to market the Alto -- they cost $32,000
    in 1979 -- the computer impressed many others who did push the technologies.
    For example, Apple Computer co-founder Steve Jobs was so impressed when
    he saw the Alto, he created the revolutionary Apple Macintosh in its image.</p>
  </body>
</html>
```

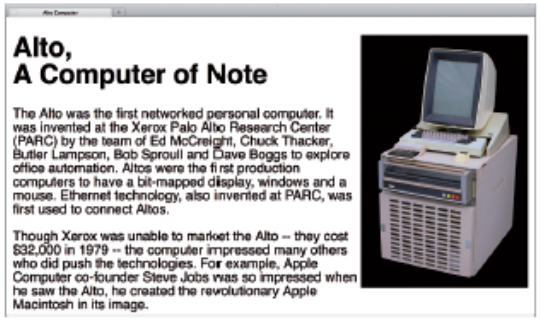



**Figure 3.11** A Web page and the HTML source that produced it. Notice that an additional image file, **alto.jpg**, is also required to display the page.

# The Internet and the Web

- Some Web servers have www as part of their domain name, some don’t
- Some Web servers seem to add the www if you leave it out
- Some Web servers work either way (both www.moma.org and moma.org display the same Web site)
- When is the www required and when is it optional?

# File Structure

- Folders
  - named collection of files or other folders (or both)
  - also called a directory

# File Structure

- Directory Hierarchy
  - called the ***file structure of the computer*** and forms the **directory hierarchy**
- Think of any hierarchy as a tree
  - folders are the branch points
  - files are the leaves

# File Structure

- Directory Hierarchy
  - All hierarchies have branch points and leaves
  - Hierarchy trees are often drawn sideways or upside down
  - Two terms are standard, however:
    1. ***Down*** in the hierarchy means into subfolders (towards the leaves)
    2. ***Up*** in the hierarchy means into folders (toward the root)

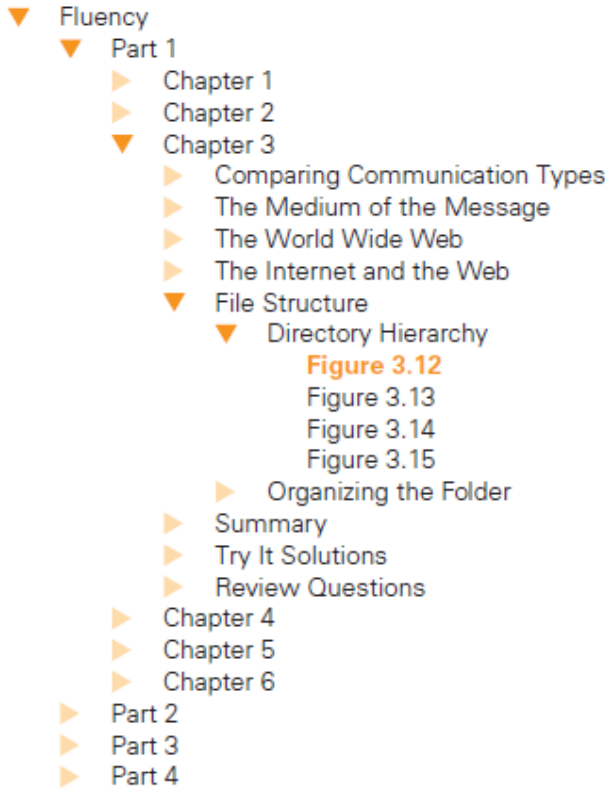



**Figure 3.12** The hierarchy of this book highlighting the path to this figure; downward-pointing triangles are expanded; right-pointing triangles are not.

# File Structure

- Part of the directory hierarchy is shown in the pathnames of this URL:
  http://www.nps.gov/yell/photosmultimedia/webcams.htm
- The page is specified by the ***pathname*** that tells the computer how to navigate through the directory hierarchy to the file
- Each time there is a slash (/), we move into a subfolder or to the file
- We go *down* in the hierarchy

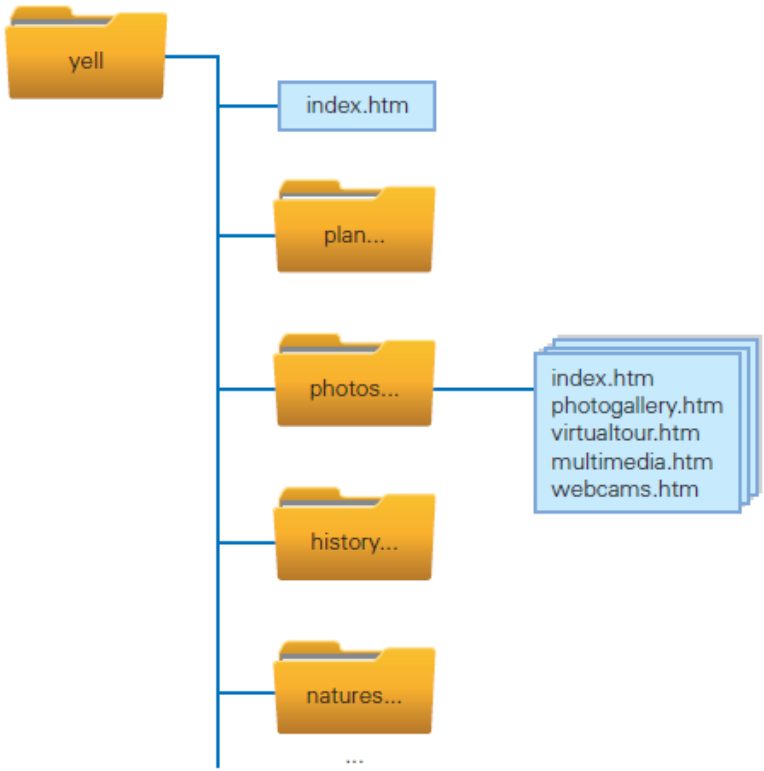



**Figure 3.14** Top-level structure of the Yellowstone folder for the NPS Web server.

# Organizing the Folder

- Normally, the last item in the sequence is a file name
- This is not always necessary or true
- When a URL ends in a slash, the last item is a folder name, and the server delivers a particular file from it, usually index.htm or index.html
  - The index.html file exists only if it was built

# Organizing the Folder

- Why have a hierarchy?
  - Most people build hierarchies to organize their own thinking and work
  - Directories cost nothing
  - There is no reason not to use them
  - It is highly recommended

# Summary

- In this chapter we discussed the basics of networking, including the following:
  - Basic types of communication: point-to-point, multicast, broadcast, synchronous, and asynchronous
  - Networking, including IP addresses, domains, IP packets, IP protocol, WANS and LANS, Ethernet protocol, ISPs, enterprise networks, and wireless networks

# Summary

- In this chapter we discussed the basics of networking, including the following:
  - The difference between the Internet and the World Wide Web
  - File hierarchies