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!
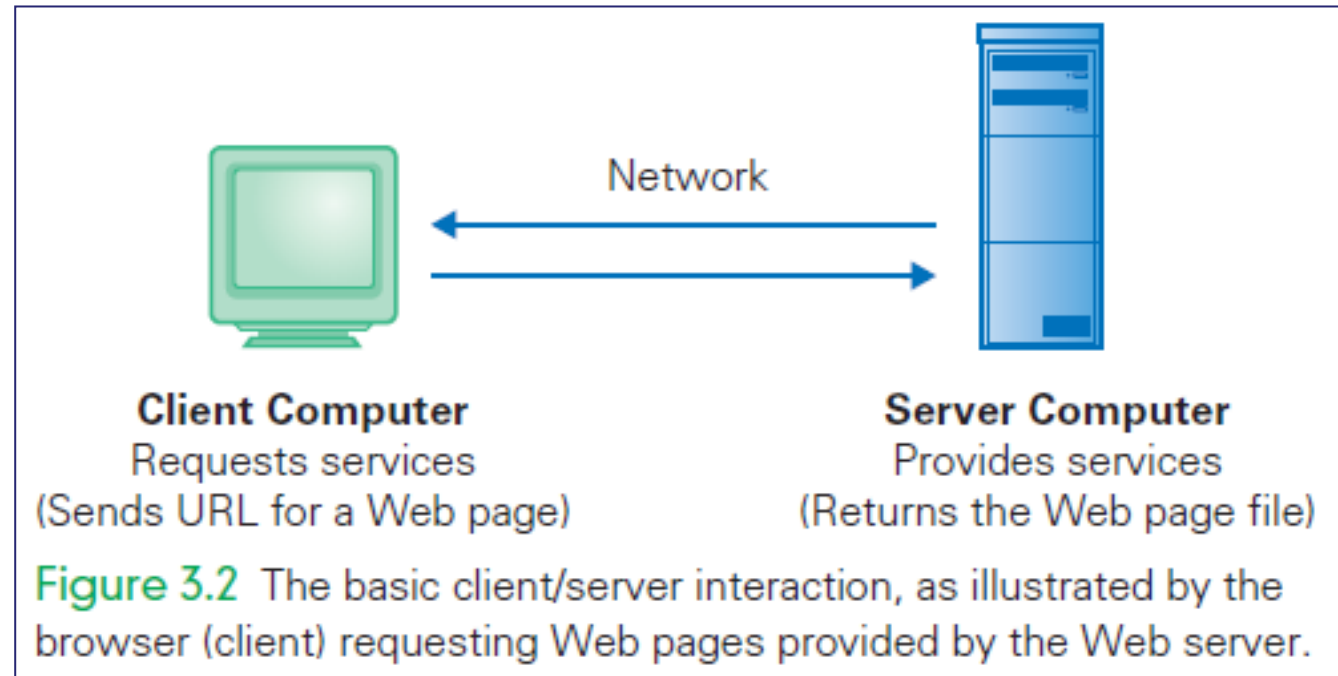
Internet Schematic Diagram
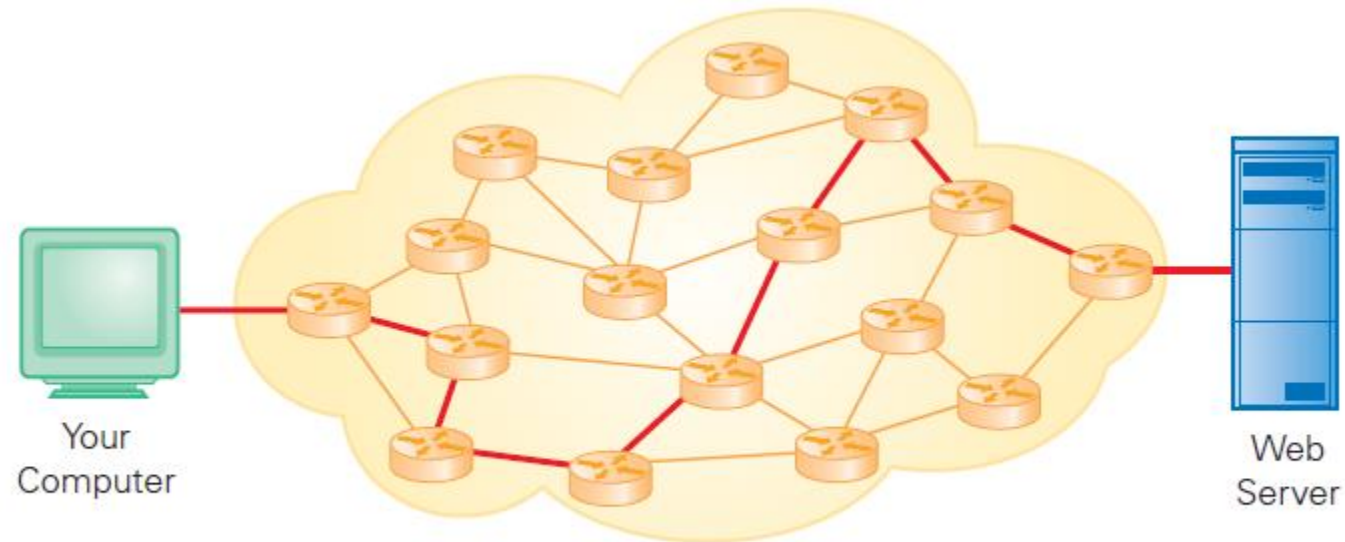
Figure 3.1 A schematic diagram of the Internet.

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

Network

Client Computer
Requests services
(Sends URL for a Web page)

Server Computer
Provides services
(Returns the Web page file)

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.
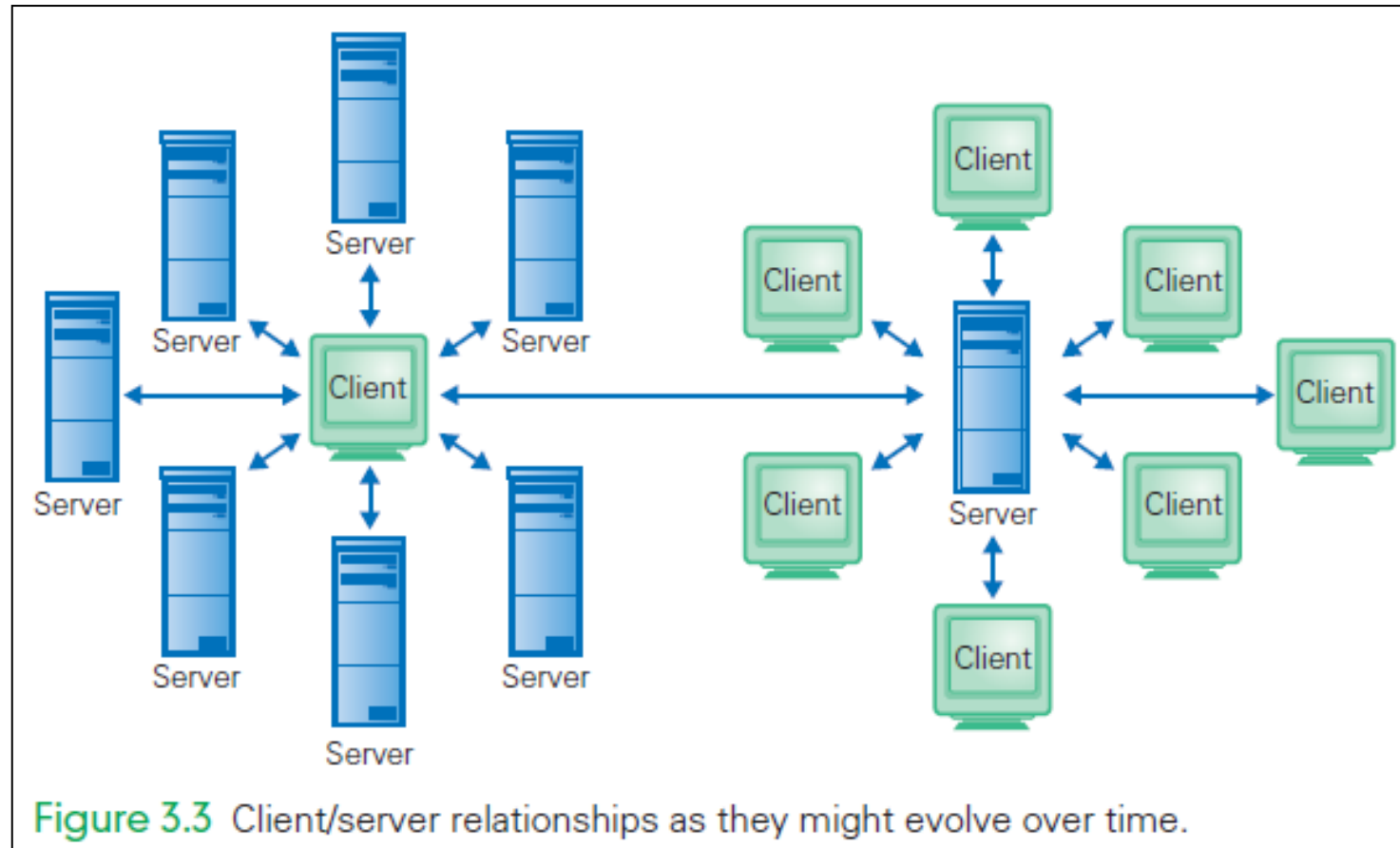
Getting More Connected

- 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
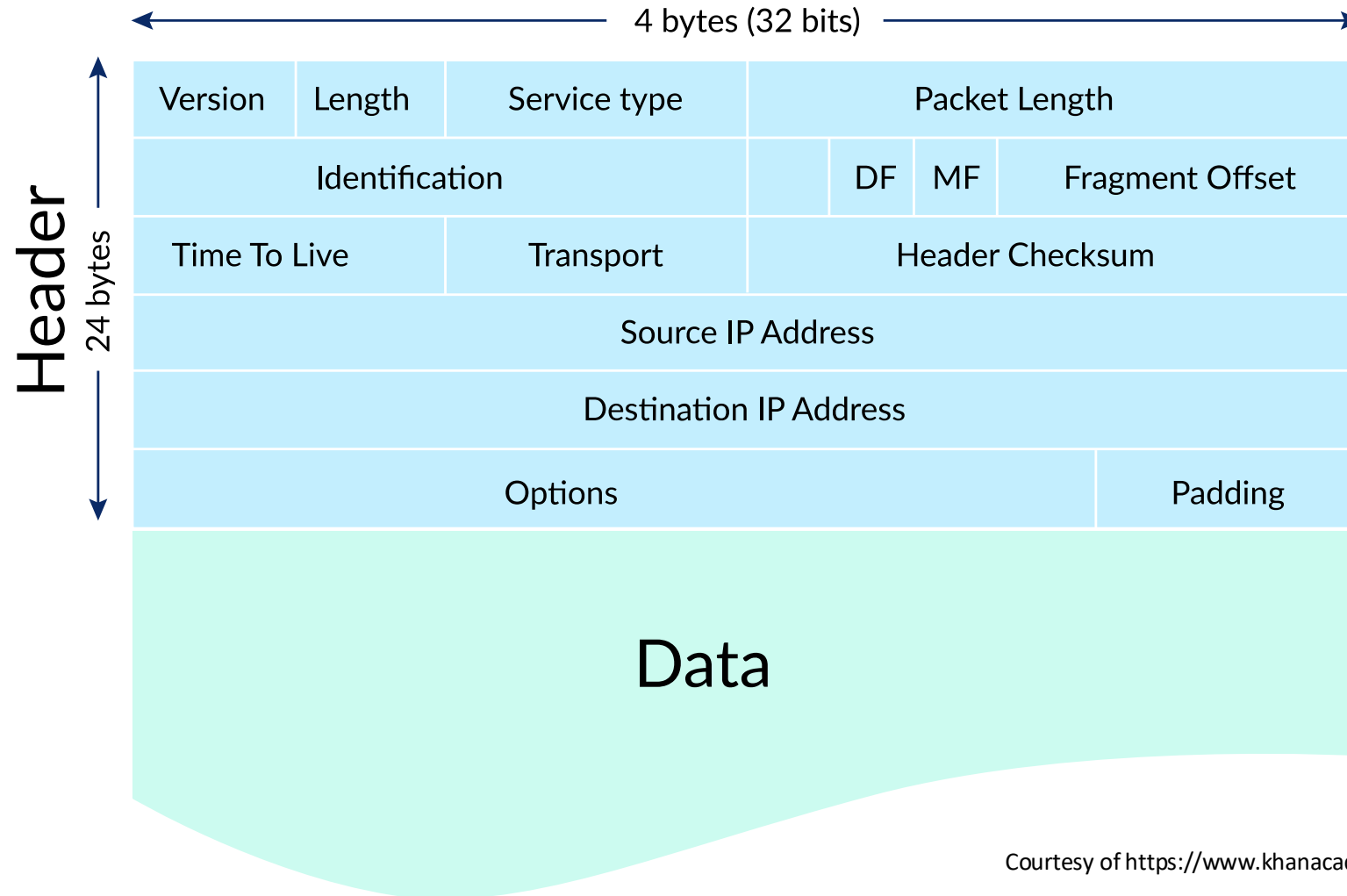 – As each postcard is completed, it is mailed

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**

4 bytes (32 bits)

Version	Length	Service type	Packet Length		
Identification			DF	MF	Fragment Offset
Time To Live		Transport	Header Checksum		
Source IP Address					
Destination IP Address					
Options				Padding	

Header — 24 bytes

Data

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 at the same time):
  - The senders wait a random amount of time and try to send again
  - Probably they will wait different amounts of time, so one will go first, and the others will wait
  - If there is another collision, the process is repeated

Connecting to the Internet

- Today there are two basic methods:

  1. Connection via an Internet service provider (ISP)

  2. Connection provided by a campus or enterprise network

- Most of us use, in different moments, both kinds of connections
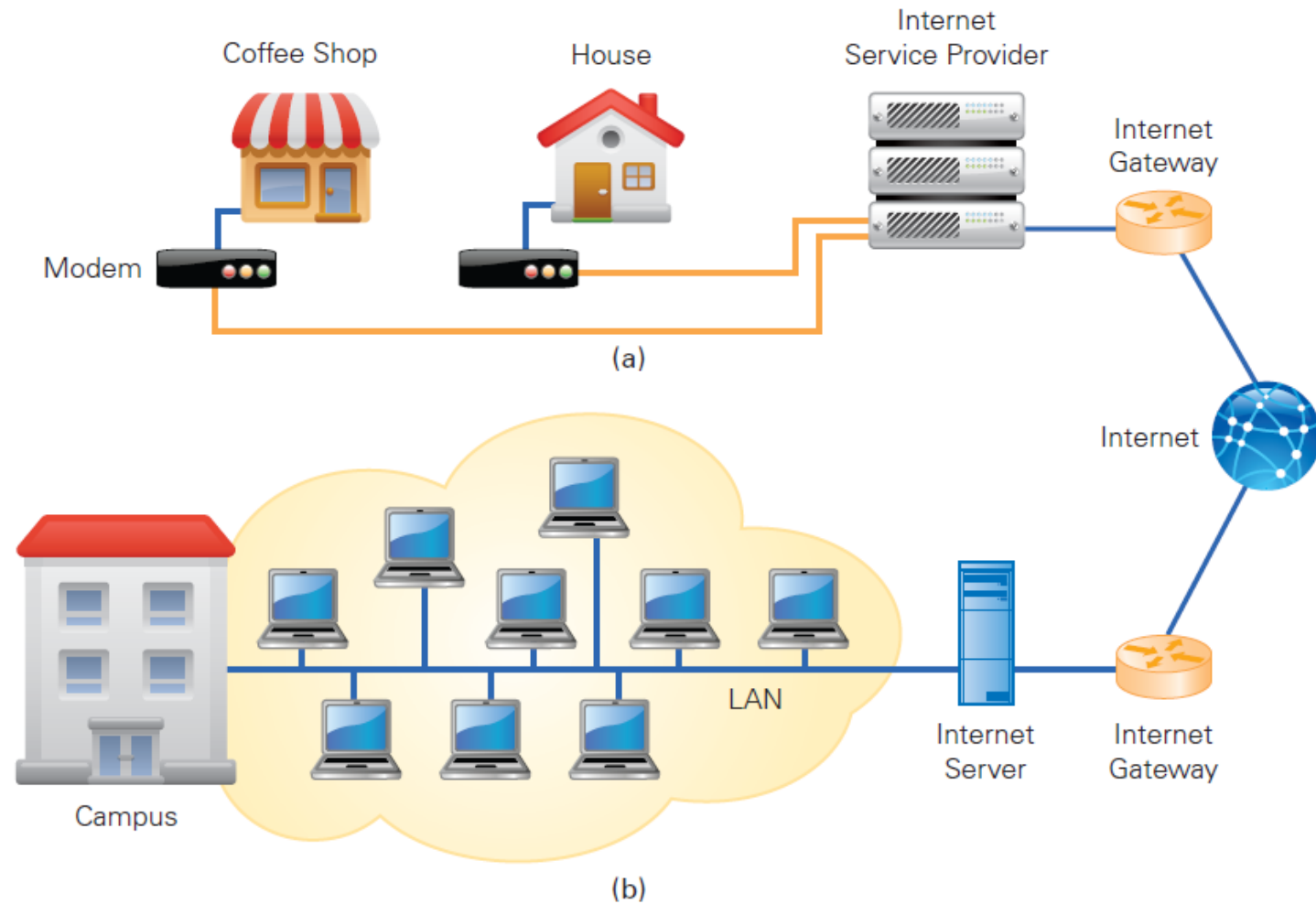
1. Connections by ISP

- 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

Coffee Shop

House

Internet
Service Provider

Internet
Gateway

Modem

(a)

Internet

Campus

LAN

Internet
Server

Internet
Gateway

(b)

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

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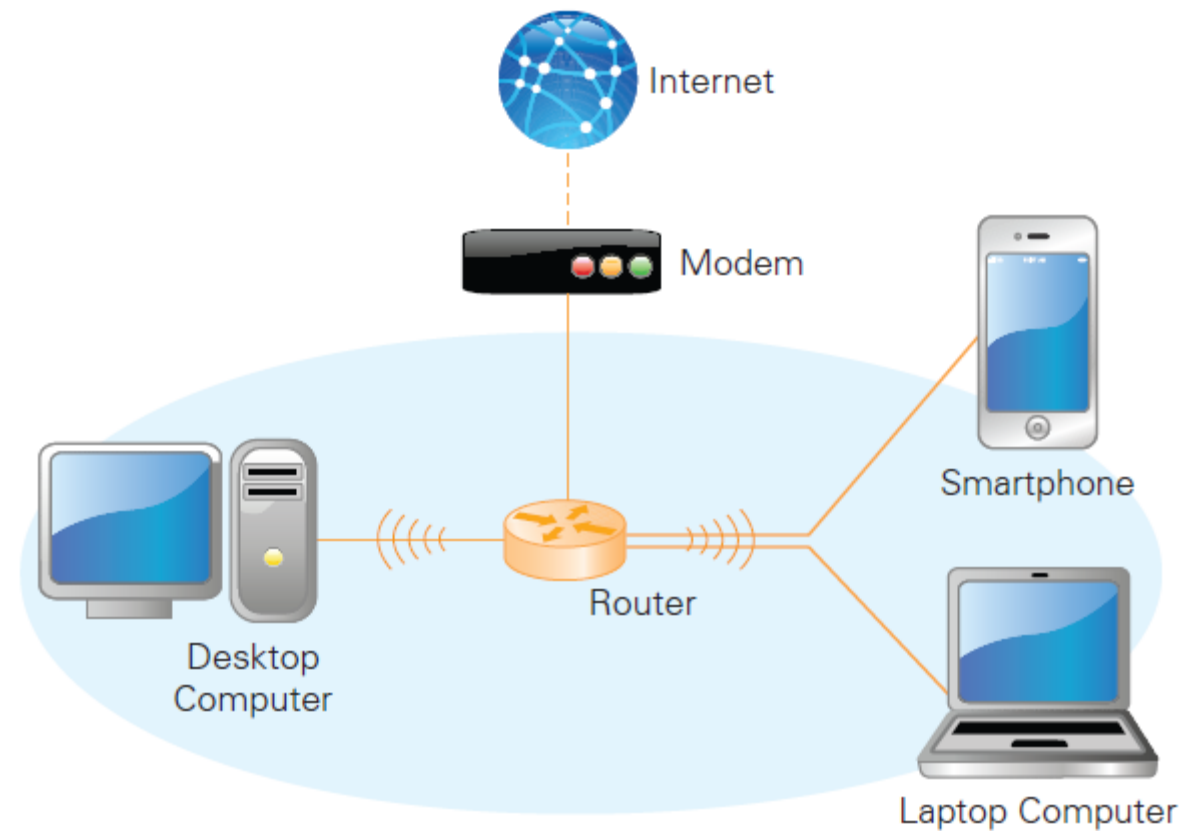
Figure 3.7 Standard Wi-Fi network configuration. A wireless router is connected via the modem to the ISP's Internet modem; laptops and other wireless-enabled devices connect by radio signals to the router.

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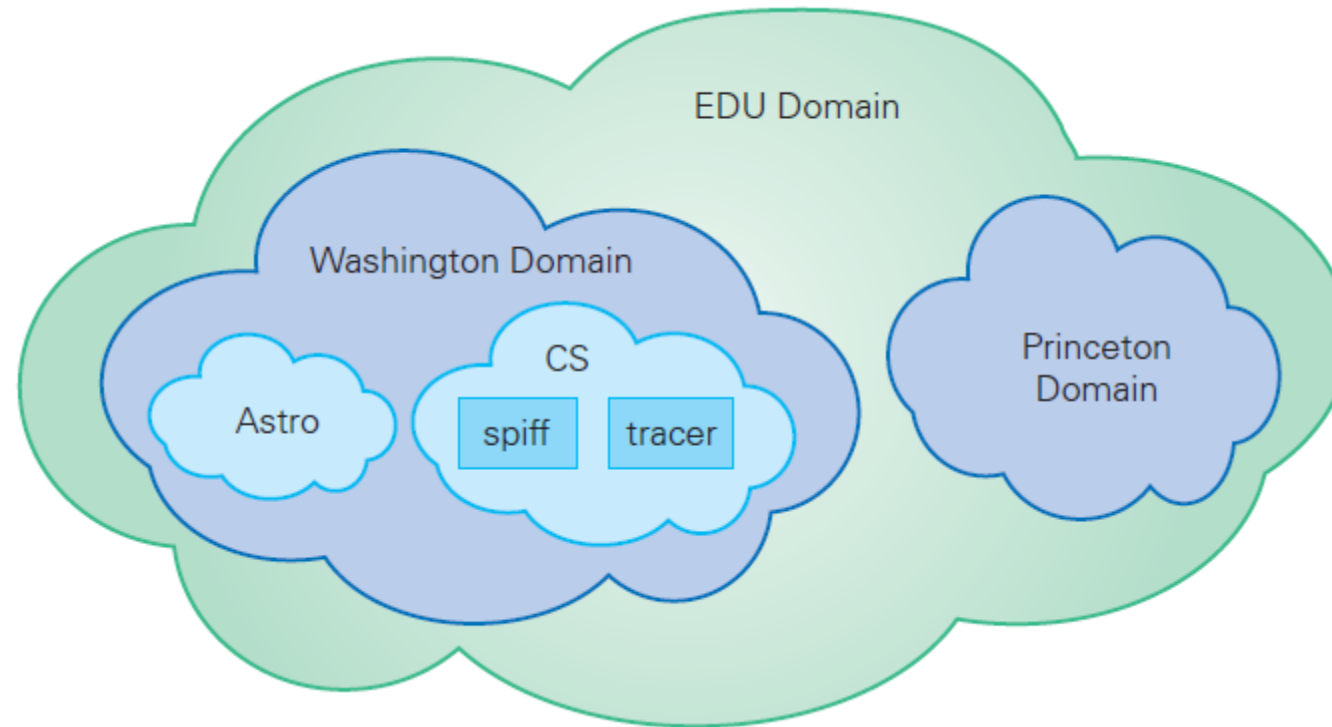
Figure 3.8 Two ways to think of the Internet domain hierarchy.

Text in figure:

EDU Domain

Washington Domain

CS

Astro

spiff   tracer

Princeton Domain

The .edu Domain
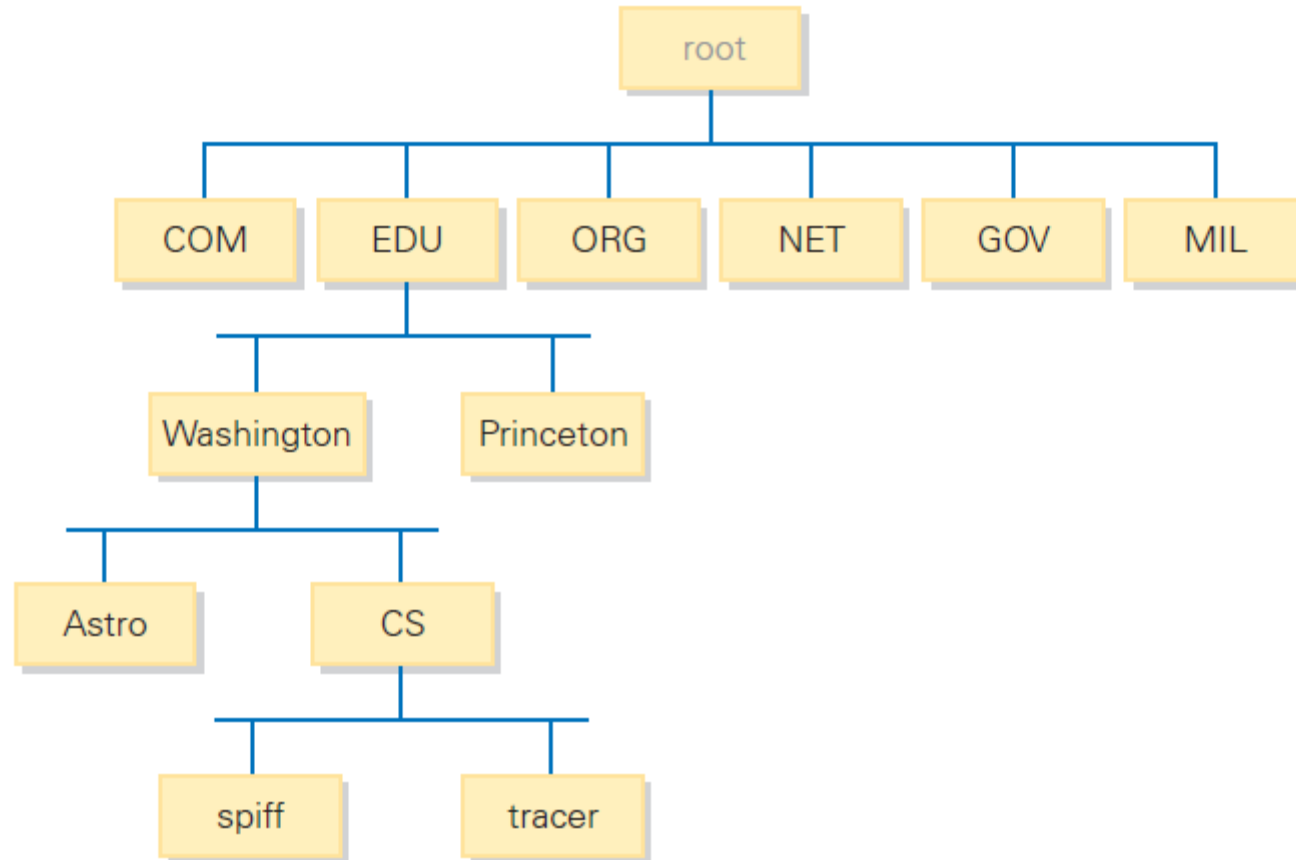
Figure 3.8 Two ways to think of the Internet domain hierarchy.

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

Table 3.1 Top-level country domain names.

BF	Burkina Faso	HT	Haitı	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		
CL	Chile	IE	Ireland	PW	Palau	TV	Tuvalu
CN	China	IM	Isle of Man	PS	Palestine	UG	Uganda
CX	Christmas Island	IL	Israel	PA	Panama	UA	Ukraine
CC	Cocos (Keeling) Islands	IT	Italy	PG	Papua New Guinea	AE	United Arab Emirates
		JM	Jamaica	PY	Paraguay	GB	United Kingdom
CO	Colombia	JP	Japan	PE	Peru	US	United States
KM	Comoros	JE	Jersey	PH	Philippines	UY	Uruguay
CG	Congo	JO	Jordan	PN	Pitcairn	UZ	Uzbekistan
CD	Congo, Drc	KZ	Kazakhstan	PL	Poland	VU	Vanuatu
CK	Cook Islands	KE	Kenya	PT	Portugal	VE	Venezuela
CR	Costa Rica	KI	Kiribati	PR	Puerto Rico	VN	Viet Nam
CI	CÔTE D'Ivoire	KP	Korea, DPR	QA	Qatar	VG	Virgin Islands, British
HR	Croatia	KR	Korea	RE	Réunion	VI	Virgin Islands, U.S.
CU	Cuba	KW	Kuwait	RO	Romania	EH	Western Sahara
CW	Curaçao	KG	Kyrgyzstan	RU	Russia	YE	Yemen
CY	Cyprus	LA	Lao	RW	Rwanda	ZM	Zambia
CZ	Czech Republic	LV	Latvia	SH	Saint Helena	ZW	Zimbabwe
		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

```html
<!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>
```
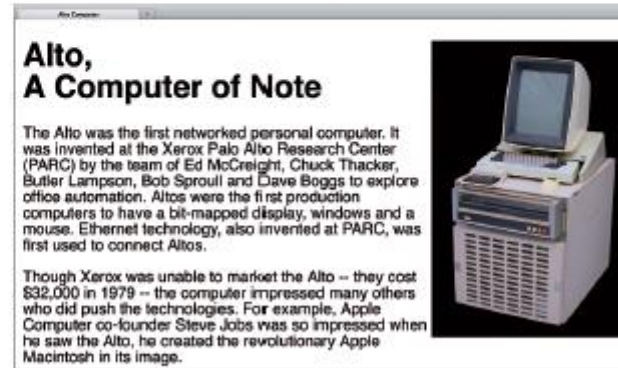

Figure 3.11 A Web page and the HTML source that produced it. Notice that an additional image file, **alto.jpg**, is also required to display the page.

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)
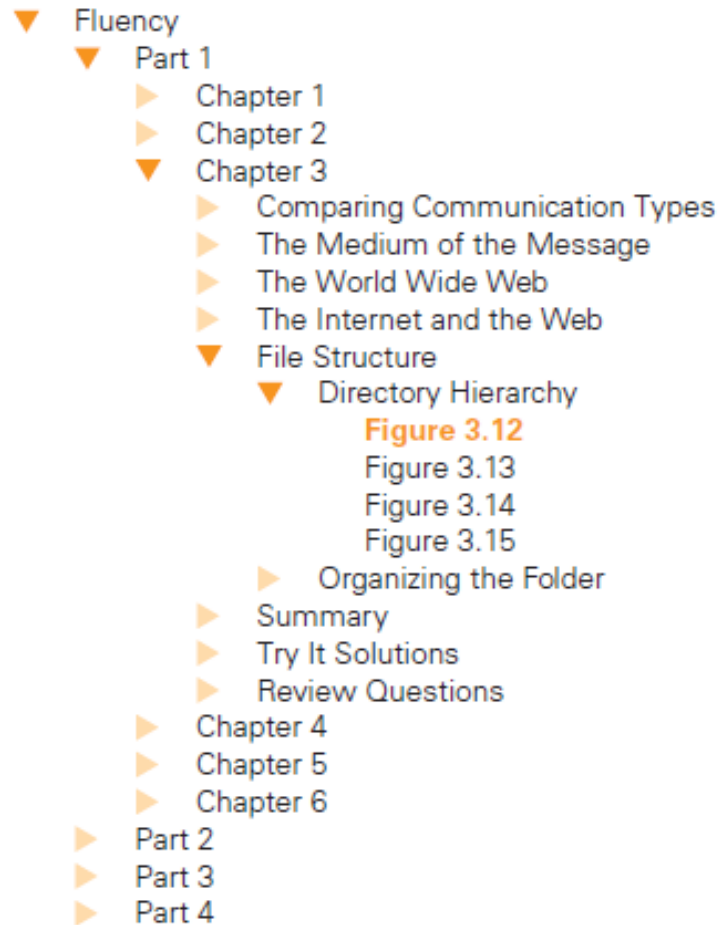- When is the www required and when is it optional?

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)

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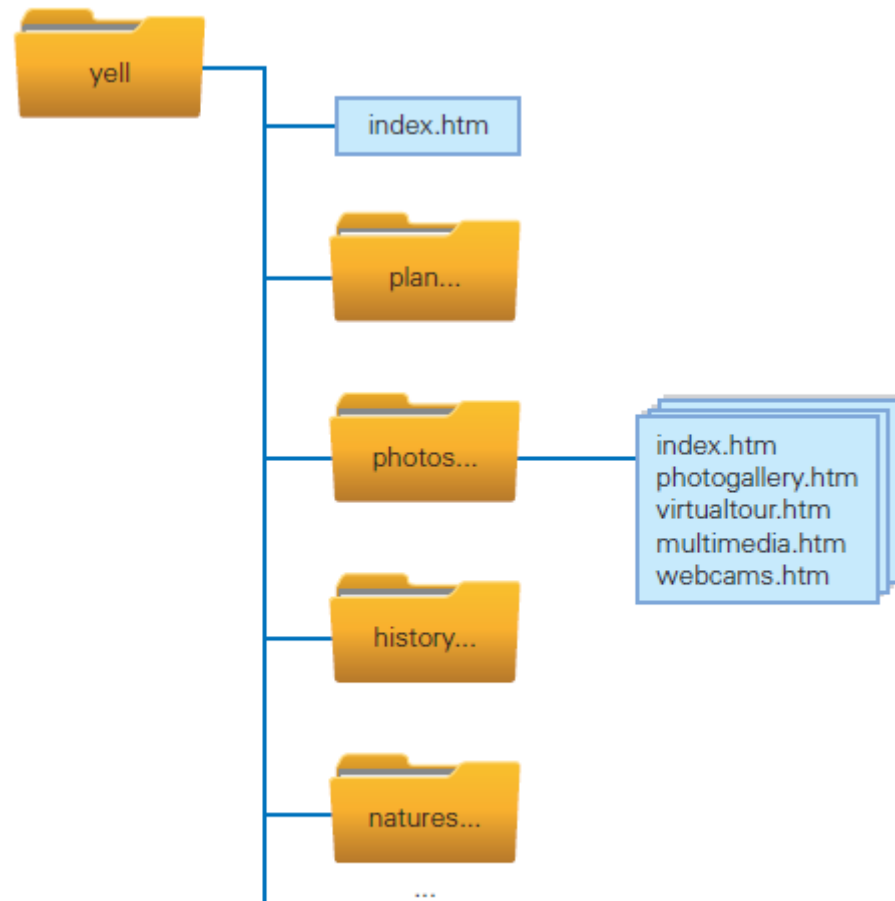
Figure 3.14 Top-level structure of the Yellowstone folder for the NPS Web server.

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