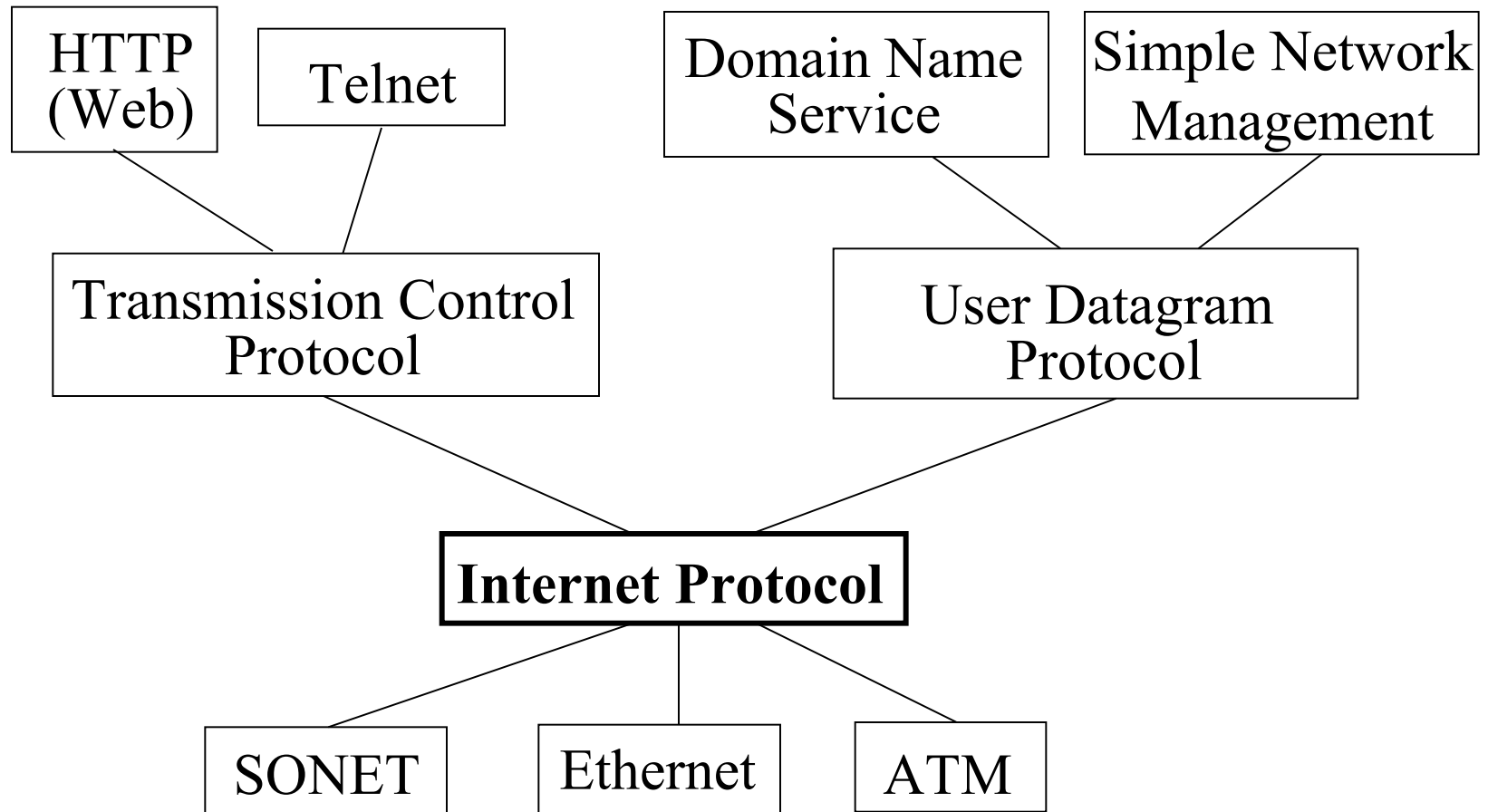# CPSC156: The Internet
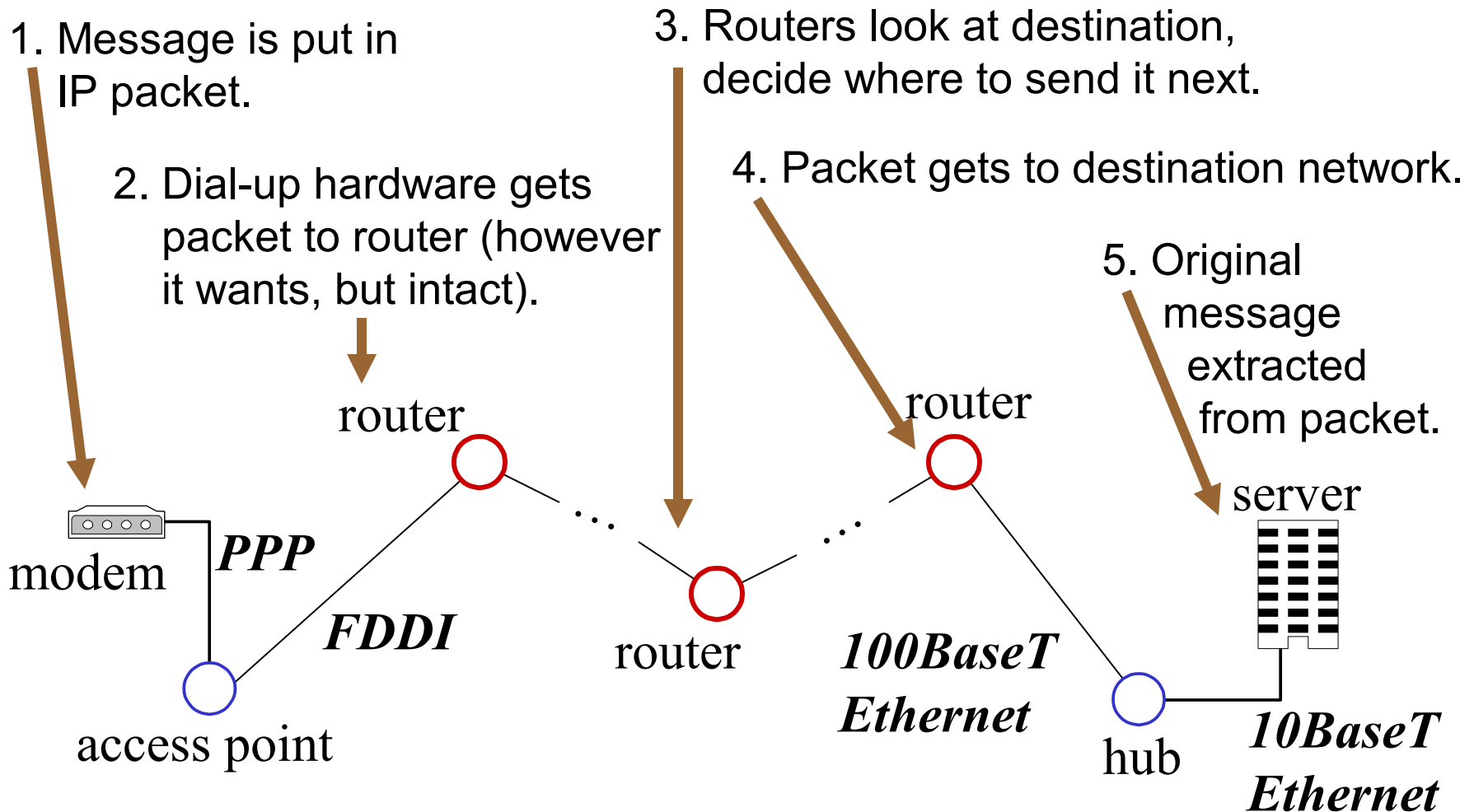# Co-Evolution of Technology and Society

Lecture 3: January 23, 2007

More about Internet Layers

and "the Web"

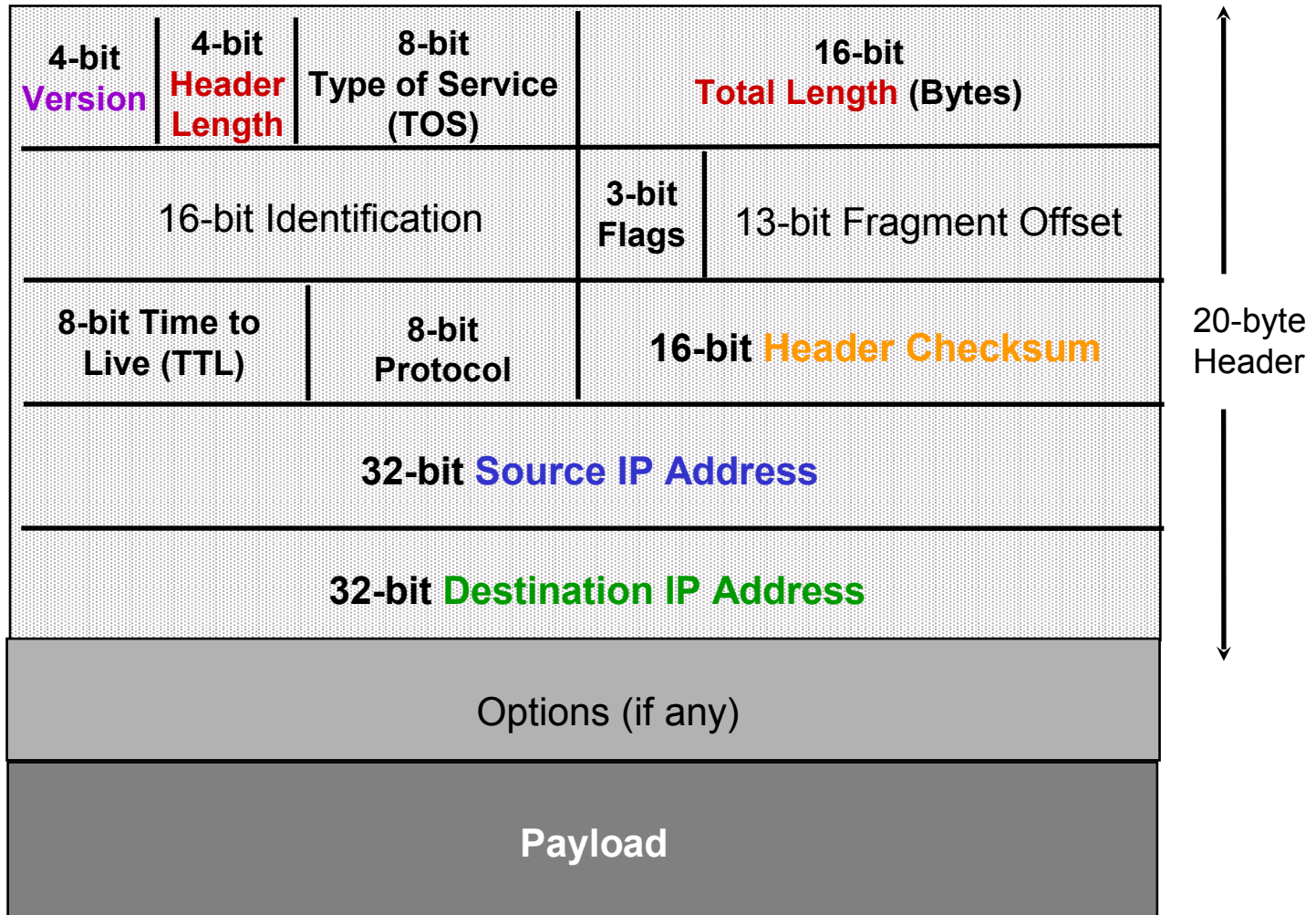# Layering in the IP Protocols

The Role of the IP Layer

- **Internet Protocol (IP)**: gives a standard way to "package" messages across different hardware types.

1. Message is put in IP packet.

2. Dial-up hardware gets packet to router (however it wants, but intact).

3. Routers look at destination, decide where to send it next.

4. Packet gets to destination network.

5. Original message extracted from packet.

router

PPP

modem

FDDI

access point

router

router

100BaseT Ethernet

hub

server

10BaseT Ethernet

IP Connectionless Paradigm

- No error detection or correction for packet data
  - Higher-level protocol can provide error checking

- Successive packets may not follow the same path
  - Not a problem as long as packets reach the destination

- Packets can be delivered out-of-order
  - Receiver can put packets back in order (if necessary)

- Packets may be lost or arbitrarily delayed
  - Sender can send the packets again (if desired)

- No network congestion control (beyond "drop")
 - Send can slow down in response to loss or delay

IP Packet Structure

4-bit Version	4-bit Header Length	8-bit Type of Service (TOS)	16-bit Total Length (Bytes)		
16-bit Identification			3-bit Flags	13-bit Fragment Offset	
8-bit Time to Live (TTL)		8-bit Protocol	16-bit Header Checksum		
32-bit Source IP Address					
32-bit Destination IP Address					
Options (if any)					
Payload					

20-byte Header

Main IP Header Fields

- **Version number** (e.g., version 4, version 6)
- **Header length** (number of 4-byte words)
- **Header checksum** (error check on header)
- **Source** and **destination** IP addresses
- Upper-level protocol (e.g., TCP, UDP)
- **Length** in bytes (up to 65,535 bytes)
- IP options (security, routing, timestamping, etc.)
- TTL (prevents messages from looping around forever; packets "die" if they "get lost")

Connecting Networks
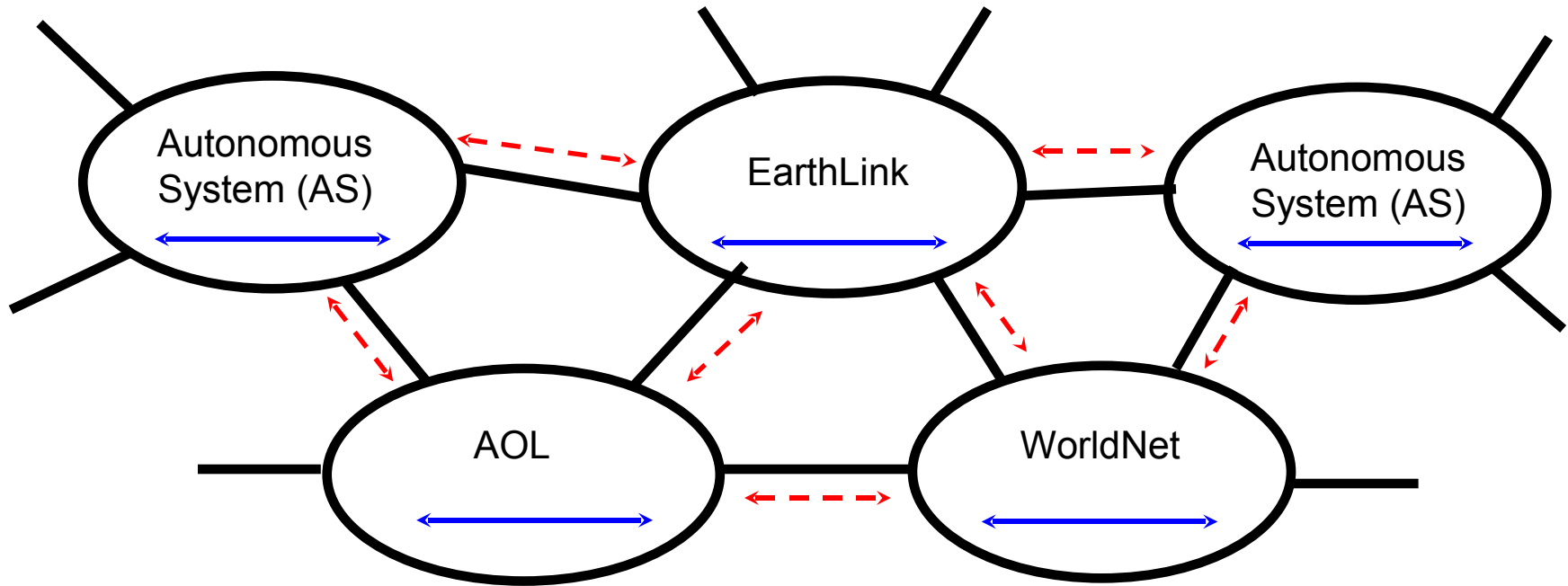
Autonomous System: A collection of IP subnets and routers
under the same administrative authority.

——————   Interior Routing Protocol (e.g., Open Shortest Path First)

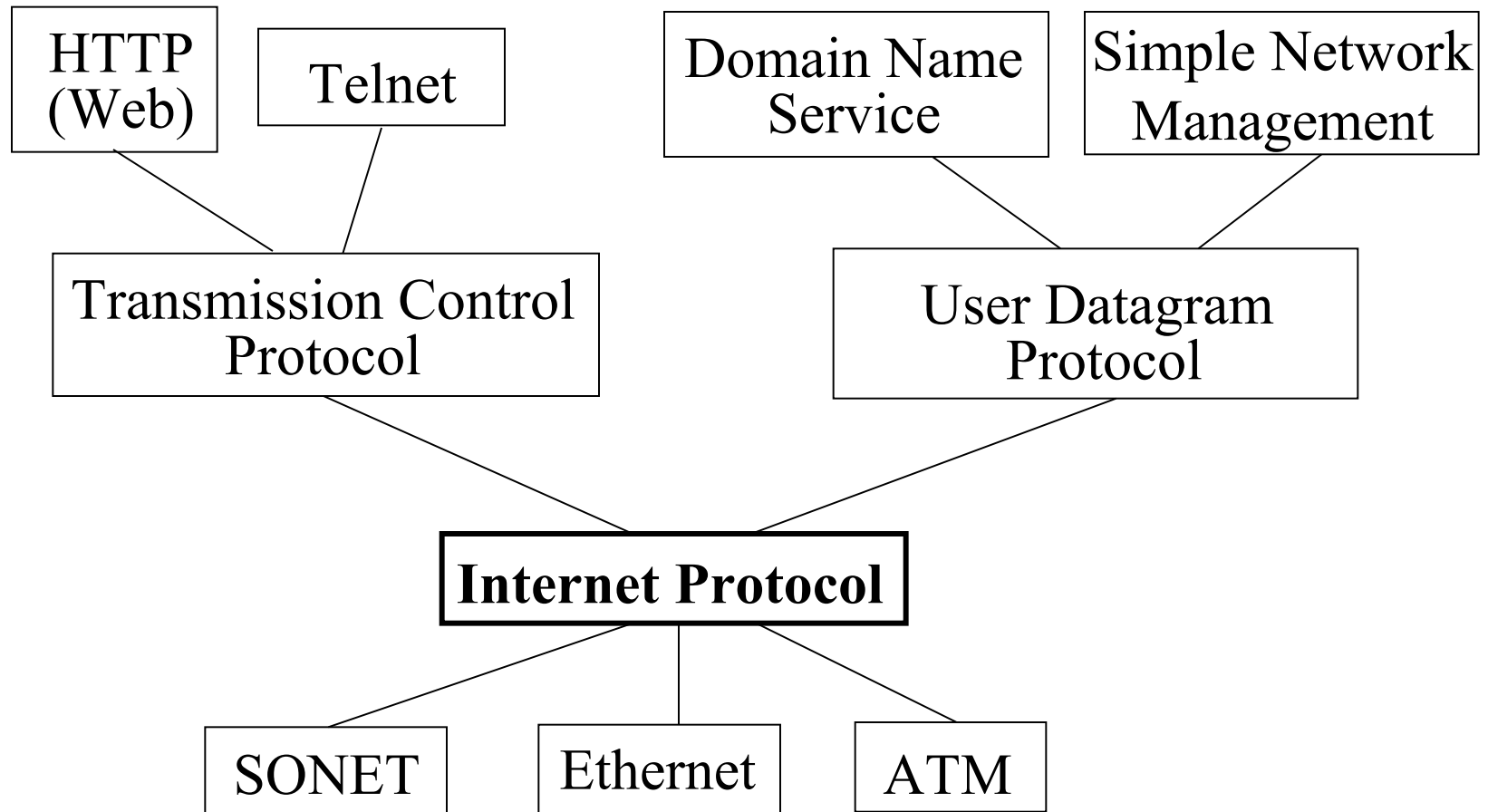- - - - - - - -   Exterior Routing Protocol (e.g., Border Gateway Protocol)

Where to Go Next

- Routers contain a **forwarding table** that pairs destination with next hop (on what physical wire to send msg.).

- The table gets populated with information learned **internally** (*e.g.,* OSPF) and **externally** (*e.g.,* BGP).

- OSPF and BGP are protocols that communicate *knowledge about destinations* between routers.

Getting from A to B: Summary

- Need IP addresses for:
  - Self (to use as source address)
  - DNS Server (to map names to addresses)
  - Default router to reach other hosts (e.g., gateway)
- Use DNS to get destination address
- Pass message through TCP/IP handler
- Send it off! **Routers** will do the work:
  - Physically connecting different networks
  - Deciding where to next send packets

Layering in the IP Protocols

HTTP
(Hypertext Transfer Protocol)

- Standard protocol for web transfer

- "Request-response" interaction between clients and servers

- Request methods: GET, HEAD, PUT, POST, DELETE,...

- Response: Status line + additional info (*e.g.*, a web page)

Example of a request line:

```
<form action="http://lab.zoo.cs.yale.edu/cs156/cgi-
   bin/sendform.cgi" method="post">
```

HTML (Hypertext Markup Language)

- Language in which web pages are written
- Contains formatting commands
- Tells browser what to display and how to display

```
<TITLE> Welcome to Yale </TITLE>
```
- The title of this page is "Welcome to Yale"

```
<B> Great News! </B>
```
- Set "**Great News!**" in boldface

```
<A HREF="http://www.cs.yale.edu/index.html">
Yale Computer Science Department </A>
```
- A link pointing to the web page
http://www.cs.yale.edu/index.html with the text
"Yale Computer Science Department" displayed.

What does "http://www.cs.yale.edu/index.html" mean?

Protocol	Host, Domain Name	Local File
http	www.cs.yale.edu	index.html

Simple HTML Commands

Lastname:

`<input type="text" name="lastname"><br>`

Firstname:

`<input type="text" name="firstname"`

`id="firstname"><br>`

Lastname: _____

Firstname: _____

`<input type="submit" value="submit form"><br>`

Submit form

The WWW Revolution

- Late 1990: WWW, HTTP, HTML, "Browser" invented by Tim Berners-Lee at CERN.
- Mid-1994: Mosaic Communications founded (later renamed to Netscape Communications).
- 1995: "Browsing" has become a universal pastime. IE ships with Windows 95.
- New businesses (*e.g.*, portal companies) enabled.
- Old businesses (*e.g.*, book selling) revolutionized.
- Triumph of Internet architecture and ethos: layering, "stupid network," open standards.

Web Brought Us E-Commerce

Electronic commerce is a set of technologies, applications, and business processes that link business, consumers, and communities

- – For buying, selling, and delivering products and services
- – For integrating and optimizing processes within and between participant entities

E-Commerce, cont.

- Information is anything that can be digitized, *i.e.*, encoded as bits. Examples include books, magazines, movies, music, web pages, software, and databases.
- Information industries are those that produce information goods and/or deliver information services.
- Networked industries are those that rely on customers' interaction. Networks can be real (as in the telecomm industry) or virtual (as in the PC-software industry).

The Internet is "an Interesting and Productive Forum" for Business

- Netscape
- Napster
- LimeWire
- KaZaa
- Amazon
- bn.com
  (Barnes & Noble)

- VeriSign
? Covisint
- eBay
- Google
- Yahoo
- AOL
- MSN (Microsoft)

The Internet is *Not* a Miraculous Forum for Business

In CPSC155 (Spr '01), but not in CPSC156 (Fall '03): Intertrust, Exodus, Ariba, OpenMarket, Pets.com,... In for historical interest: Netscape and Napster

"The Internet Boom": c. 1997 – c. 2001 (now called "first boom")

Existing Business Models for Information Products

- **Fee models**: Subscription purchase, Single-transaction purchase, Single-transaction license, Serial-transaction license, Site license, Payment per electronic use

- **Advertising models**: Combined subscription and advertising income, Advertising income only

- **"Free" distribution models**: Free distribution (no hidden motives), Free samples (*e.g.,* coming attractions), Free first version, Free information when you buy something else (complementary products, bundling)

Less Traditional Business Models for Information Products

- **Extreme customization**: Make the product so personal that few people other than the purchaser would want it.
- Provide a **large product in small pieces**, making it easy to browse but difficult to get in its entirety.
- **Give away digital content** because it **complements** (and increases demand for) the traditional product.
- Give away the product, **sell the service contract.**
- Allow free distribution of the product but **request payment** (Shareware).
- Position the product for **low-priced, mass market distribution.**

Network Effects

- A product or service exhibits network effects if its value to any single user is strongly positively correlated with the total number of users. Communication products and services are prime examples.
- Network-effected products and services exhibit long lead times followed by explosive growth. Example: Fax invented in 1843, offered by AT&T in 1925, and widely adopted in 1980s.
- "Network-effected" ≠ "mass-market"
* Network effects cut both ways!

Lock-in and Switching Costs

- Information industries often involve systems of interoperating components and durable complementary assets. Prime examples are Intel processors, Windows PC Platform, and numerous PC application programs.
- Often leads to technology lock-in and high switching costs
- Modular architectures and open standards are mitigating forces.
- "Network effects" ≠ "Strong lock-in"
- "High market share" ≠ "High switching costs"

Discussion Points

- Have *you* been forced by network effects and systems effects to pay high switching costs?

- Do information industries have too much power over consumers?

- Note failed attempts to force switching: Quadraphonic sound, (Landline) Picture Phones, DAT, "Trusted Systems," …

- Note current attempt: HD DVD formats

Textbook Case: Netscape

- **Late 1990**: WWW, HTTP, HTML, "Browser" invented by Tim Berners-Lee

- **Mid-1994**: Mosaic Communications founded (later renamed to Netscape Communications)

- **Summer of 1995**: Market share 80%+

- **August 1995**: Windows 95 released with Internet Explorer

- **January 1998**: Netscape announced that its browser would thereafter be **free**; the development of the browser would move to an **open-source** process.

Estimated Market Share of Netscape
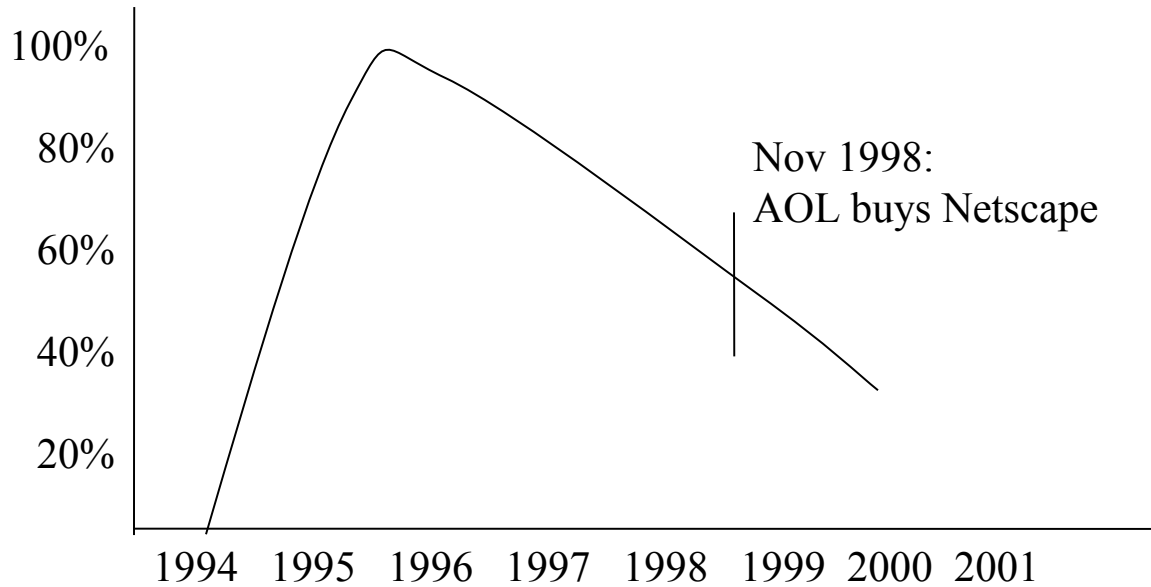
NOTE: data are from different sources and not exact

Perfectly Captures the *Essence* of the First Boom

- Enormous power of Internet architecture and ethos (*e.g.*, layering, "stupid network," open standards)
- <u>Must</u> bring new technology to market quickly to build market share
- Internet *is* the distribution channel.
  - First via FTP, then via HTTP (using Netscape!)
  - Downloadable version available free <u>and</u> CD version sold

Uses Many "Information Business Models"
(esp. those that involve making money by "giving away" an information product)

Complementary products (esp. server code)

- Bundling
  - Communicator includes browser, email tool, collaboration tool, calendar and scheduling tool, *etc.* One "learning curve," integration, compatibility, *etc.*

- Usage monitoring
  - Data mining, strategic alliances
  - "Installed base" ≠ "Active installed base"

Browser as "Soul of the Internet"

- "New layer" (Note Internet architectural triumph!)
- Portal business
  - Early "electronic marketplace"
  - Necessity of strategic alliances
  - "Positive transfers" to customers
- (Temporarily?) Killed R&D efforts in user interfaces

Pluses and Minuses of Network Effects

+ Initial "Metcalf's Law"- based boom

+ Initial boom <u>accelerated</u> by bundling, complementary products, etc.

− Network effects $\neq$ strong lock in
high market share $\neq$ high switching costs

− Network effects are strong for "browser" but weak for any particular browser.

Assignments

First written assignment has been posted on the course website. It's due Feb. 1, 2007.

Read the Wikipedia entry on ICANN (pointer on course website).