



Computer Networks



Introduction

- The next “Great Revolution” -
Computer Networks- computers connected together for exchanging information
- Our “information-oriented” society - applications in education, commerce, research, politics, entertainment, etc.

Typical Network Uses

- **Resource sharing** - sharing of physical resources (such as printers, files, databases)
- **Information sharing** - accessing scientific, legal, medical and commercial data files stored anywhere in the world.
- **Communication**
 - E-mail
 - Chat
 - Bulletin Boards
 - Blogs

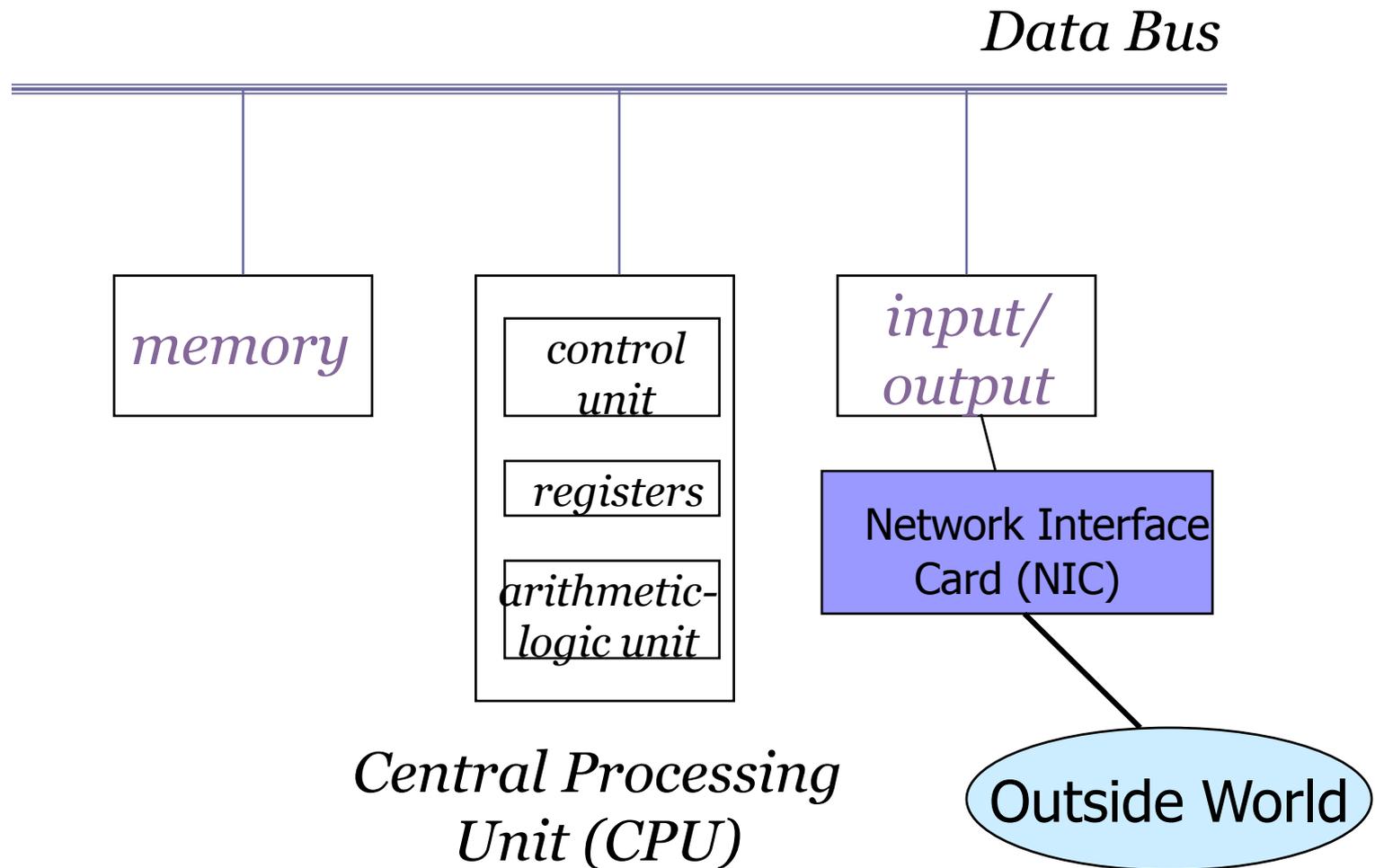
More Network Uses

- **Electronic commerce** (e-commerce) supports the paperless exchange of goods, information and services. (eg. ATMs, electronic tickets, etc.)
- **Entertainment** Digital cable TV, multi-player distributed gaming, on-demand movies
- More??

Basic Concepts

- A **computer network** is a set of independent computers connected by telecommunication links.
- The individual computers are called **nodes, or hosts.**
- The nodes are connected by some method of carrying digitized signals.
 - Wires
 - Light
 - Microwaves
 - Radio Waves

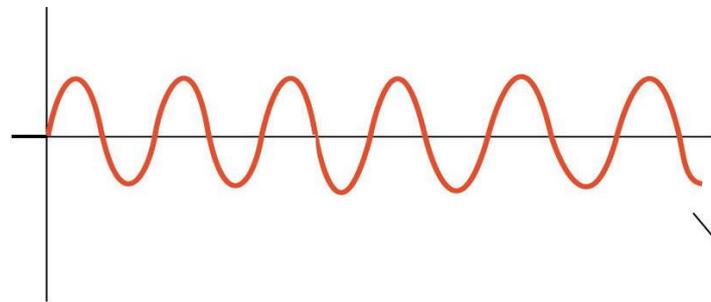
Organization of a von Neumann Machine



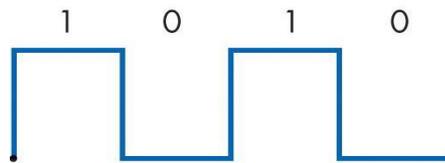
Circuits

- “Switched” means that a **circuit** or path is set up for the duration of a call.
- Telephone (voice) transmission is primarily **analog**, but computer data is **digital**.
- A modem **mod**ulates and **dem**odulates an analog signal (or carrier) to encode digital data.
- **Bandwidth** - capacity of the communication medium

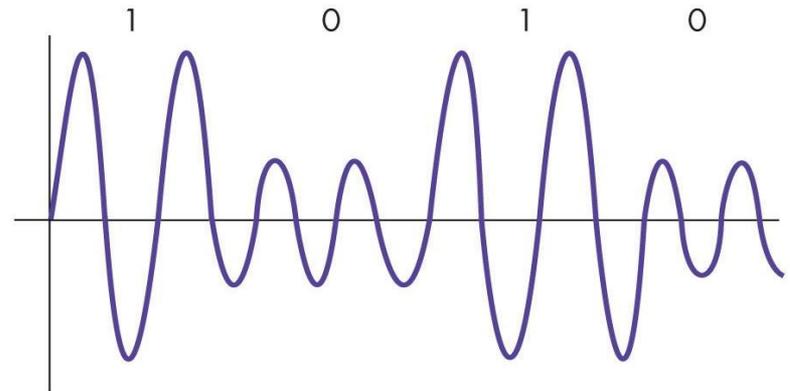
Analog vs. Digital



Analog carrier signal



Input data



Encoded data

Dedicated Communication Links

- **Twisted pair copper wire** (telephone wire)
 - Permanently connected
 - Inexpensive, but limited distance (about 10 Km)
- **Coaxial cable** (like cable TV wire)
 - a little more expensive, but higher maximum transmission rate and less subject to signal interference.
- **Fiber-optic cable** - (glass fiber, transmits light)
 - more expensive, significantly higher speed and fewer errors.

Communication Link Speeds

- “Switched” Phone Lines
 - Maximum of 56 Kbps (need modem)
- Dedicated communication lines
 - Faster data rates than dial-up lines
 - DSL - 300-1500 Kbps (download)
 - Cable Modem – 1-6 Mbps (download)
- Fiber-optic cables
 - 15 Gbps and increasing

Local Area Networks - LANS

- A **LAN** connects computers that are geographically close- (same building, campus).
- Each computer has its own network address.
- A **LAN** is a private network and owned and operated by the company or institution.
- Ethernet (1970's- Xerox PARC) operates at 10, 100, or 1000 Mbps (million bits per second).
 - Shared cable with transceivers and bridges
 - Hubs to which every computer connect

Client-Server Model

- Very common means of distributing information and services.

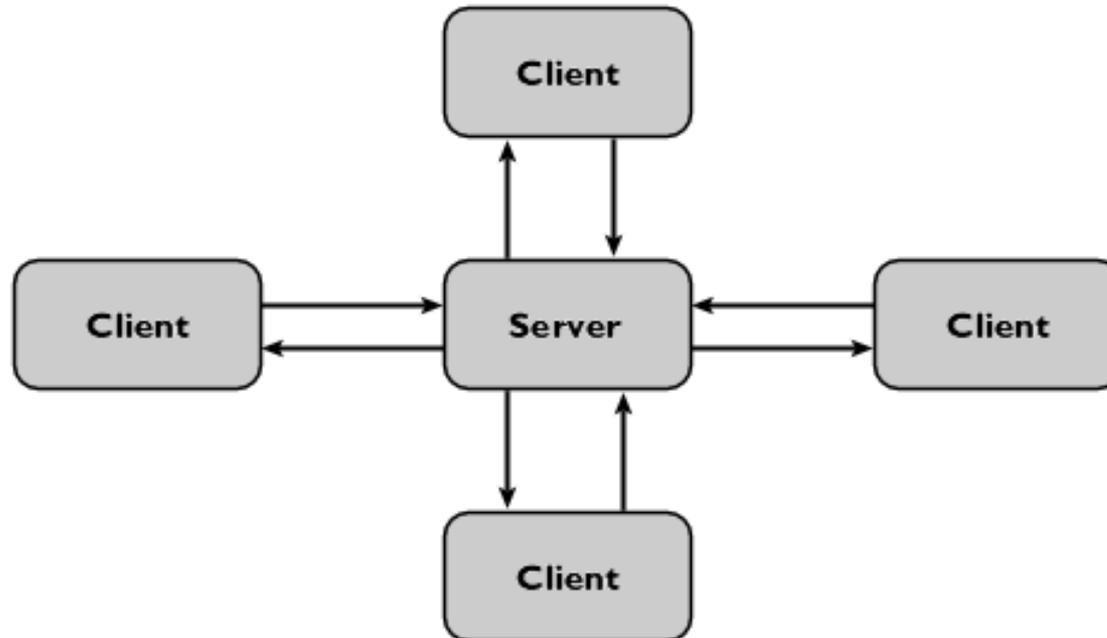
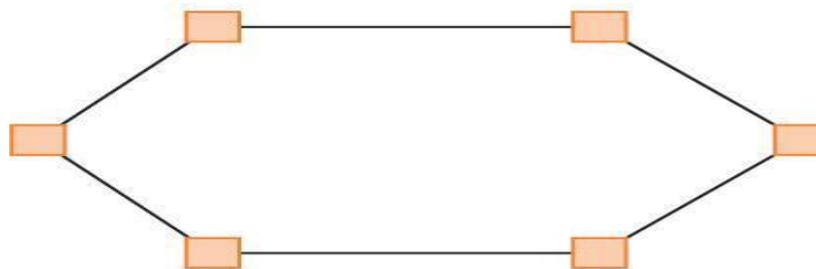


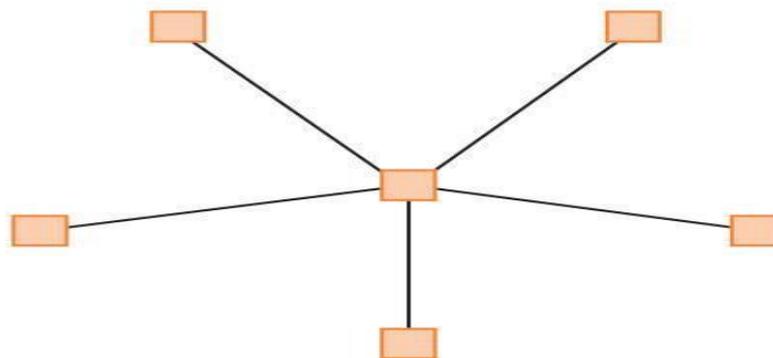
Figure 7.4
Some Common
LAN
Topologies



(a) Bus



(b) Ring



(c) Star

Network Communication

Communication protocols (or rules)

- **Ethernet** uses **contention based** transmission
 - users compete for the same line and **broadcast** a message;
 - if two or more send at the same time there is a collision and everyone must back off and wait a random time before resending;
 - control is distributed and each computer makes its own decision.
- **Token ring** - user must obtain a “token” to send- no collisions, fair but tokens can get lost.

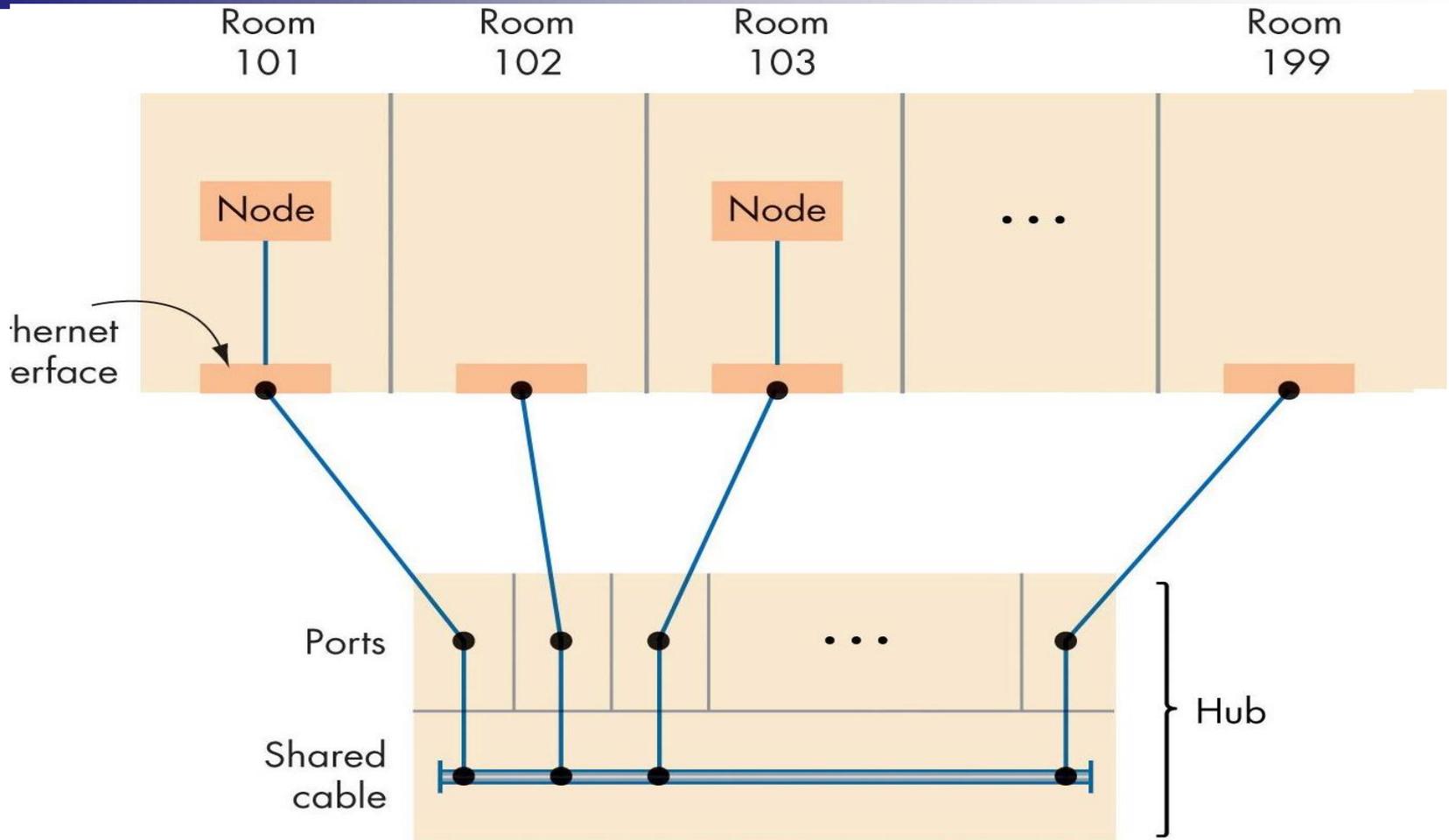


Figure 7.6
An Ethernet LAN Implemented Using a Hub

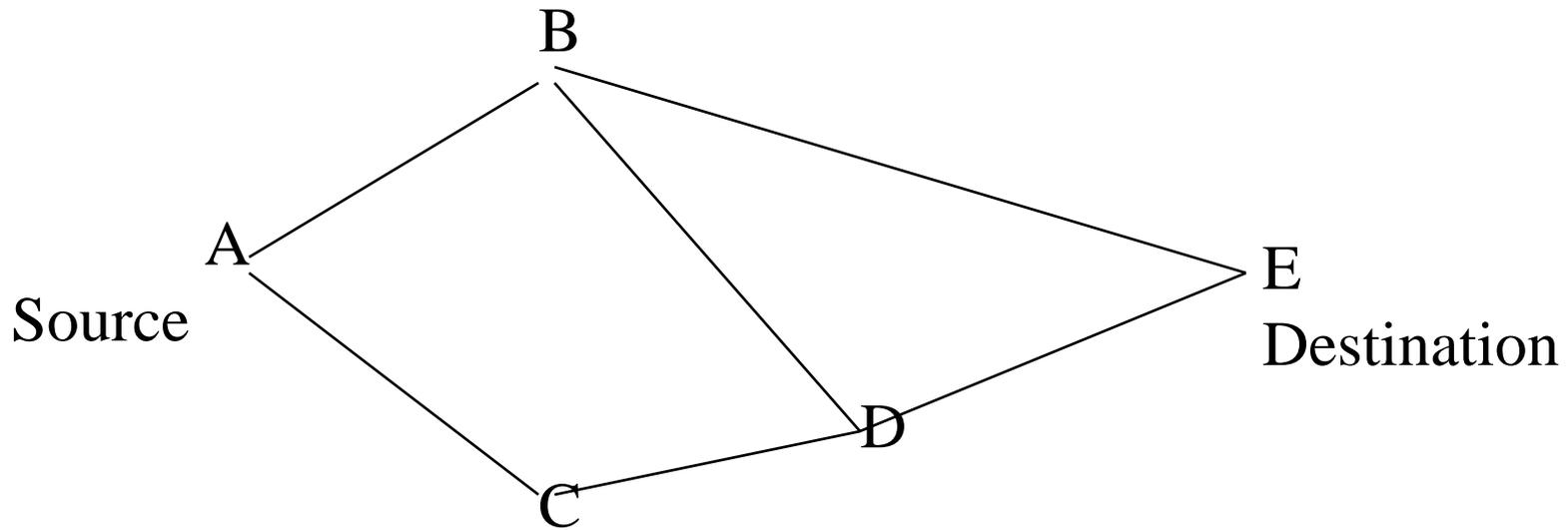
Wide Area Networks- WANs

- WANs extend across town, country or oceans across public areas and use purchased point-to-point lines.
- Uses **store-and-forward packet-switching** technique (unlike LAN which just broadcasts message to all). Unit called a **packet** “hops” from one node to another until it reaches its destination.
- Packet is a fixed size block of information with an address field for its destination.

Packet Transmission

- Large amounts of data must be broken into smaller packets.
- Then it is given its source and destination address.
- It is transmitted to an adjacent node, whose address is appended and an acknowledgment (ACK) is sent (by a router).
- **Routing** algorithms try to determine the shortest path.
- If the ACK does not arrive the packet is resent.

Wide Area Network Example



Possible paths:

A-B-E

A-B-D-E

A-C-D-E

Network Devices

■ Repeater

- Boosts cable signal to extend total distance beyond physical cable limit.

■ Hub

- Centrally located box providing dedicated cable connection to each device on LAN

■ Bridge

- Connects segments of LAN
- Filters messages between LAN segments based on source and destination addresses

Network Devices

■ Router

- More intelligent than bridge
- Creates router-to router hops to foreign network
- protocol specific

■ Gateway

- More intelligent than Router
- Allows networks of different protocols to be connected

Recent Developments

- **Gigabit networks** (speeds greater than 1 billion bits/second (Gbps)).
- **Wireless Communication**- using radio, microwave and infrared signals.
- **Mobile computing** - delivering data to the user, wherever he or she is.
 - **Problems** - line of sight transmission requires transmitters. Wireless media are affected by environment, weather and are not secure.

The Internet

- Development started at MIT in 1962 and later funded by ARPA, the research office of DOD. (Often called ARPANet.)
 - Why the department of defense?
- 1970's rapid expansion in academic and commercial communities.
- Backbone privatized in mid 90's.
 - Allowed commercial enterprises to make money via the internet
 - Did Al Gore invent the internet?
- The internet is not the World Wide Web (WWW)

Internet Addresses

■ Addressing scheme

- 32 bit IP address for each computer (for example 192.207.177.133)
 - Static IP
 - Dynamic Host Configuration Protocol (DHCP)
 - 2^{32} possible addresses. We're running out! IPv6 coming soon.
- **Domain Name Server** -directory of machines within domain
 - Each domain is responsible for providing a name server
 - Contains mnemonic address and corresponding numeric Internet address
 - Maps IP address to name of computer e.g.
viking.cs.utexas.edu = 128.83.143.1
- **Distributed DNS system helps make the network more reliable and robust.**

LAYER	NAME	EXAMPLES
5	Application	HTTP, SMTP, FTP
4	Transport	TCP, UDP
3	Network	IP
2b	Logical Link Control	PPP, Ethernet } Data Link Layer
2a	Medium Access Control	
1	Physical	Modem, DSL, Cable Modem

Figure 7.10
The Five-Layer TCP/IP Internet Protocol Hierarchy

Application Layer

- Applications

- Browsers

- E-mail

- FTP

- IM

- Present information in usable form and use TCP/IP to transmit information to other computers.

Transport Layer (TCP)

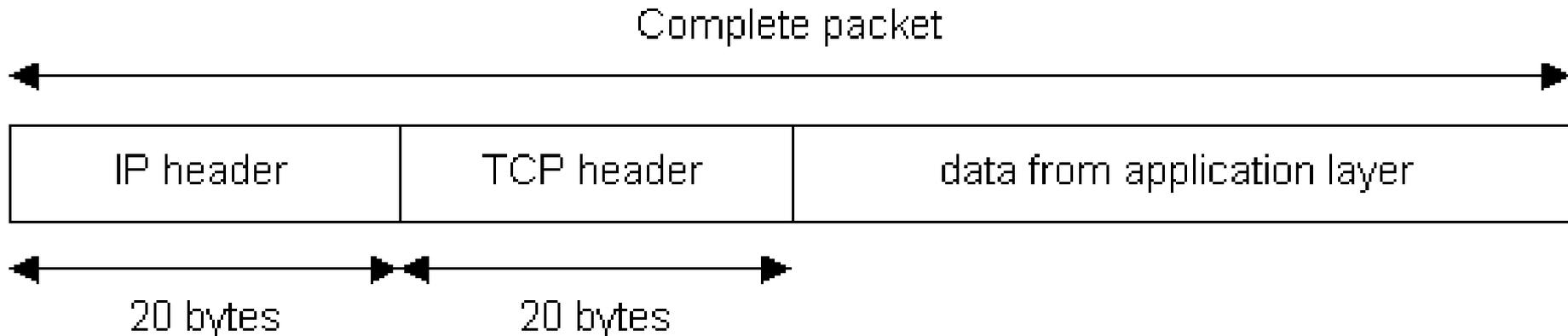
- Transmission Control Protocol
 - TCP is responsible for making sure messages get to the correct applications on the correct computers.
 - Computers have port numbers that the OS “listens” to.
 - Some common ports are:
 - HTTP 80
 - FTP 20/21
 - SMTP 25
 - It is a connection-oriented, reliable service
 - Header is 20 bytes long and contains
 - Source and destination ports (application specific)
 - A sequencing number
 - Checksum
 - Other data

Network Layer (IP)

- Internet Protocol
 - IP sends packets to other IP addresses
 - Does not care about content or connections
 - Does not remember any previous information
 - Header contains
 - Source and destination IP address
 - Checksum
 - Other data

Complete Packet

- Packet contains TCP port information, IP addressing information and application data.
- Imagine sending a novel to a friend by putting each paragraph on a postcard, numbering them, and then sending them in the mail.
 - They would arrive numbered, but out of order.
 - They would arrive at different times.
 - You may have to call and say “Did you mail # 42?”



Low Level Layers

■ Data Link Layer

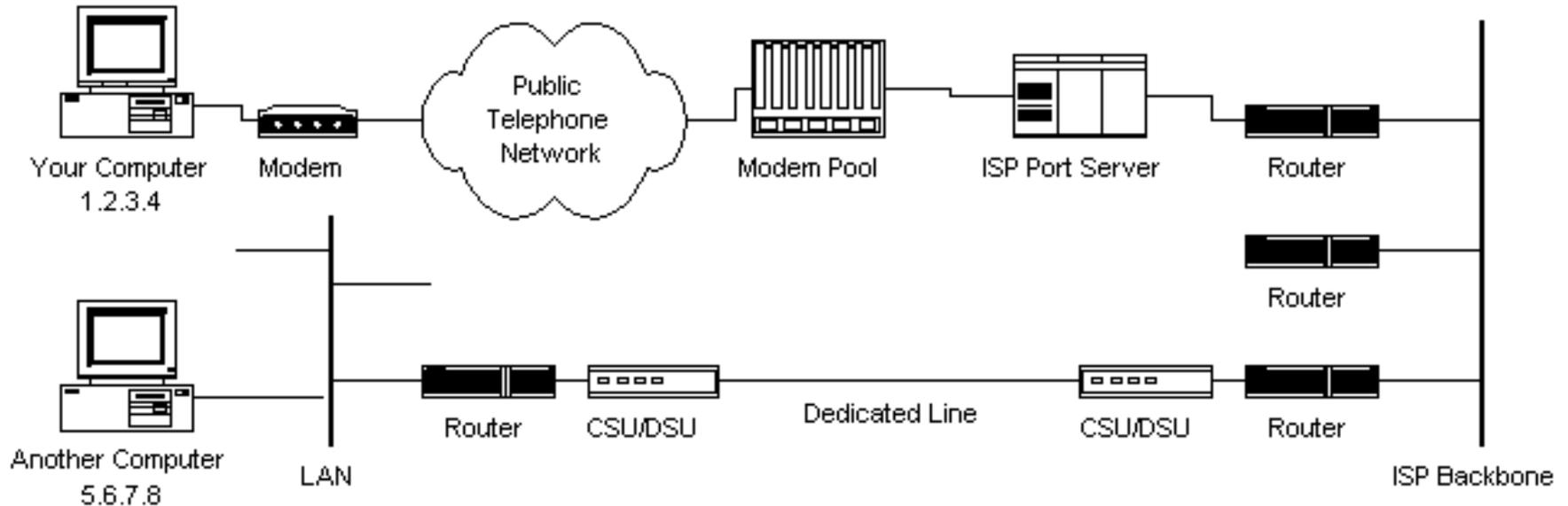
- Creates “error-free” message pipe
- Frames messages
- Arbitrates ownership of a shared line when multiple nodes want to send at the same time

■ Physical Layer

- Protocols govern the exchange of binary digits across physical connection
- Create a “bit pipe” between computers

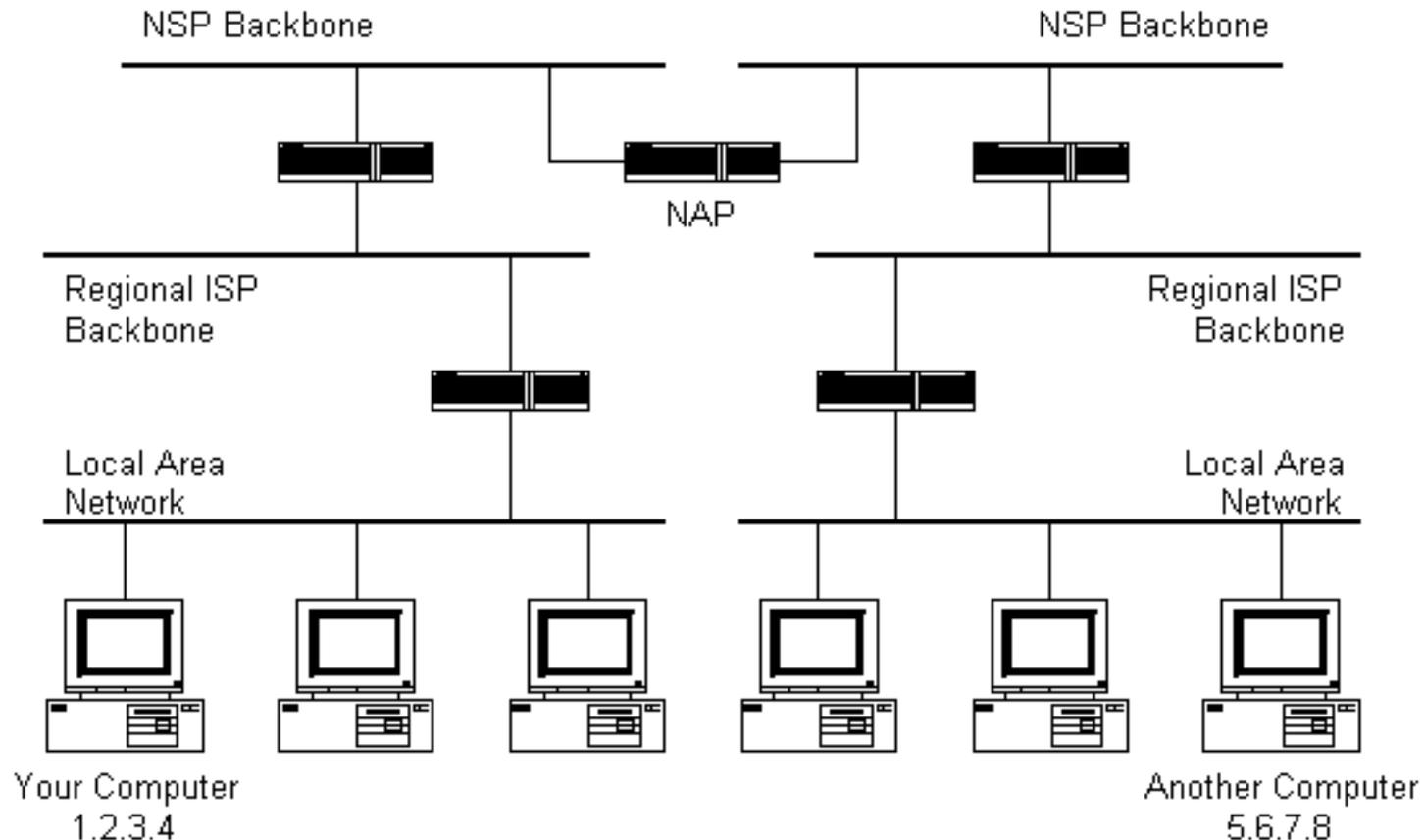
Packet Routing

- Packets are routed locally through routers to the Internet Service Provider (ISP)



The Internet Backbone

- Packets move up a hierarchy of ISPs and then back down the branches



World Wide Web (WWW)

■ Client-Server model

- Client requests a web page from the server by using the Hypertext Transfer Protocol (HTTP) via the TCP and a Universal Resource Locator (URL).
 - <http://www.cnn.com/>
- Usually via a web browser.
- Connectionless protocol.
- Web pages are encoded in Hypertext Markup Language (HTML)

Uniform Resource Locator (URL)

http://www.cs.utexas.edu/users/rpriebe/cs302_032/index.html

- [http://](#) (protocol)
- [www.cs.utexas.edu](#) (name of the computer)
- [/users/rpriebe/cs302_032/](#) (directory path)
- [index.html](#) (name of the file)

■ What does this URL mean?

<ftp://photo1.si.edu/images/gif89a/>

HTML

- A tag-based language that is interpreted by a browser.

```
<html>
```

```
<head>
```

```
<title>Test Page</title>
```

```
</head>
```

```
<body>
```

```
<p>Testing!!</p>
```

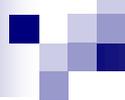
```
</body>
```

```
</html>
```

What happens when you click the link?

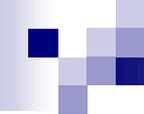
- The browser connects to a Domain Name Server and gets the IP address for the web server
- The browser uses an HTTP request to ask the web server for the page
 - If the server can't find the page you get the 404 error
 - If the server finds the page, the HTML is returned to your browser and interpreted
- The connection is closed
- If the page has additional elements such as graphics or video, a new HTTP connection is made for each element on the page.

Remember that each part of the page may be hundreds of packets!



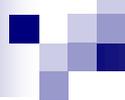
Dynamic Web Pages

- Most web pages are not created “by hand”
- Common to programmatically create web pages
 - Databases
 - Executable programs (server side)
 - Create HTML



“Client-side” programs

- Some programs are downloaded to the client and data is passed to the program
 - Applets
 - Stock tickers
 - Weather programs
 - Sports updates
 - Applications (Web 2.0)
 - Word processors
 - Spreadsheets
 - Databases
 - Many others...



File Transfer Protocol (FTP)

- Simple way to transfer files between computers
- Some common names are SmartFTP or Fetch.
- Anonymous FTP
- FTP via login

E-mail

- Simple Mail Transfer Protocol (SMTP)
 - More complicated than HTTP
 - Maintains connection
 - Checks identity of client
 - Commonly used for sending e-mail
- Post Office Protocol (POP3)
 - Common protocol for internet e-mail clients such as Eudora, Outlook Express, etc.
 - Commonly used for checking e-mail, but not for sending
 - E-mail stored on a mail server and the client either copies the messages from the server or removes them.

Firewall

- A firewall is a mechanism used to protect a trusted network from an untrusted network, usually while still allowing traffic between the two.
- Can be hardware or software
 - Blocks port scans
 - Filters packets
- Especially important for Broadband cable ISPs (RoadRunner). All computers on same LAN.

If you have questions:

<http://computer.howstuffworks.com/firewall.htm>

Home Network

■ Typical Home networks



Back of a router

