



# 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

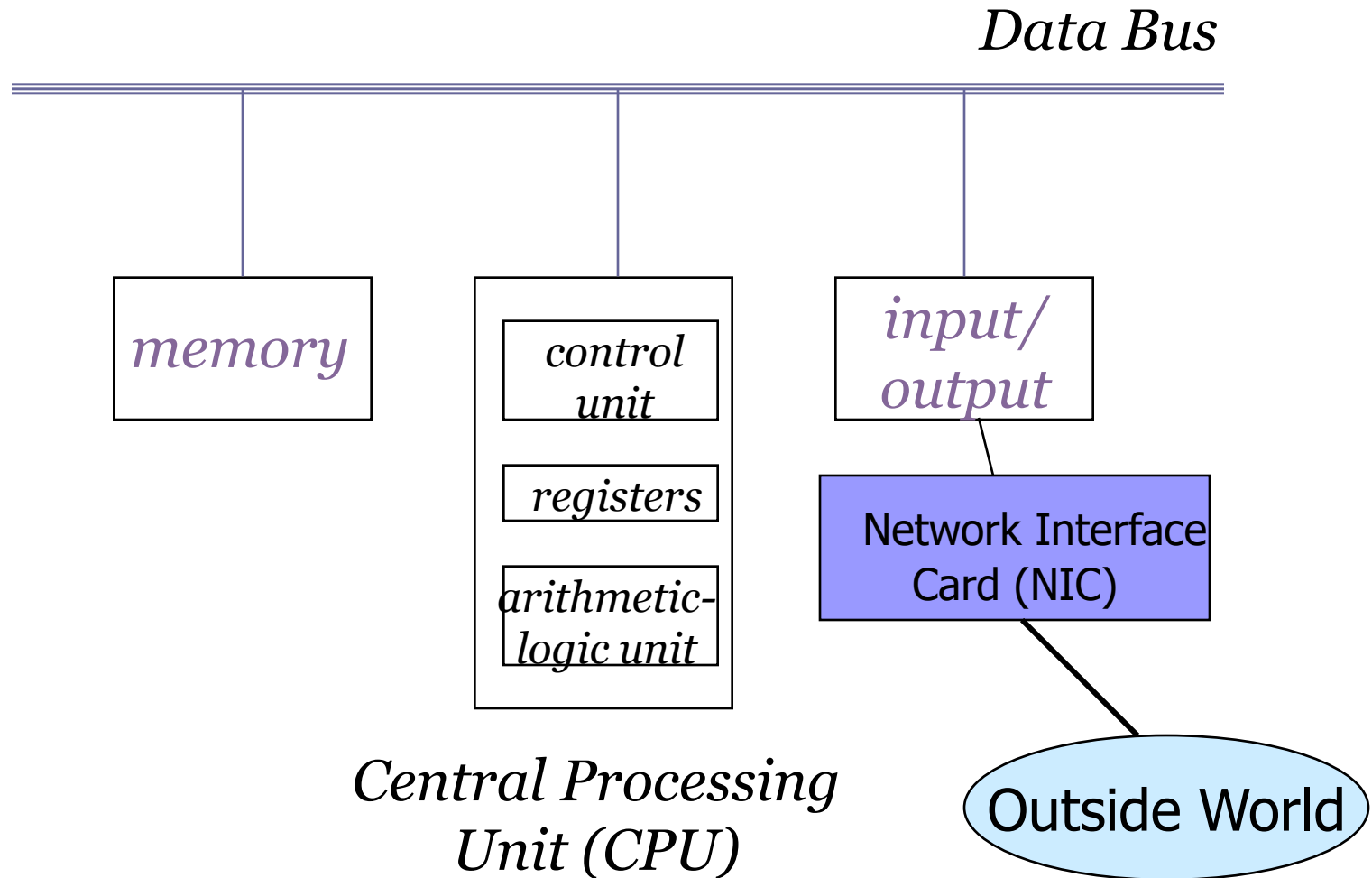
# More Network Uses

- **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

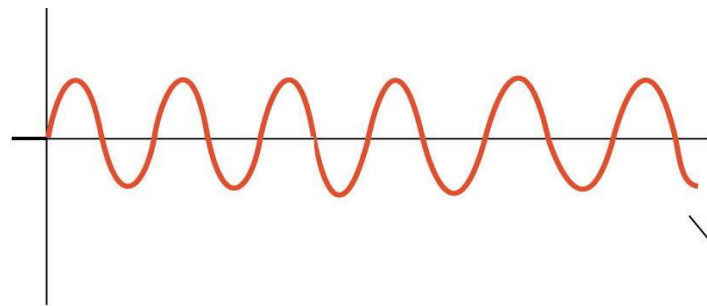
# Organization of a von Neumann Machine



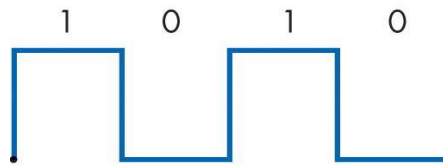
# Circuits

- “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

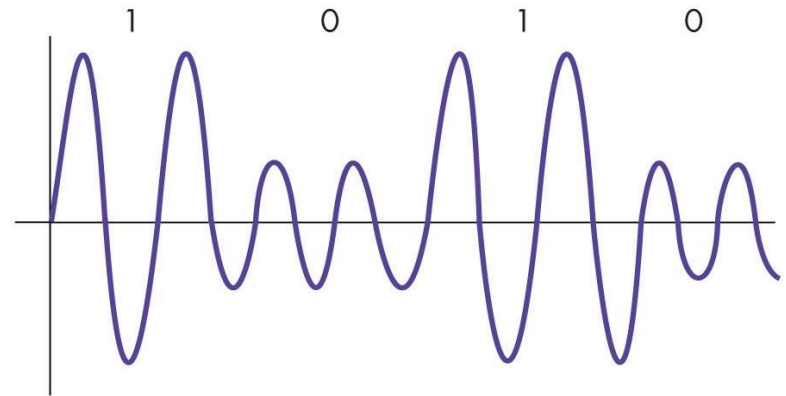
# Analog vs. Digital



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.

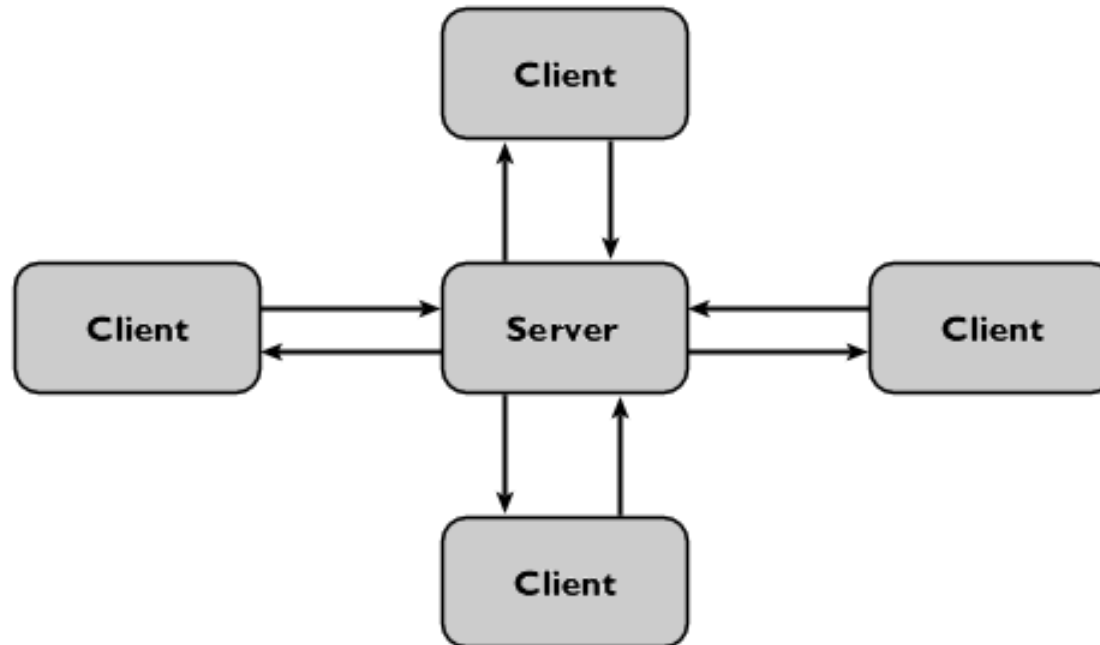
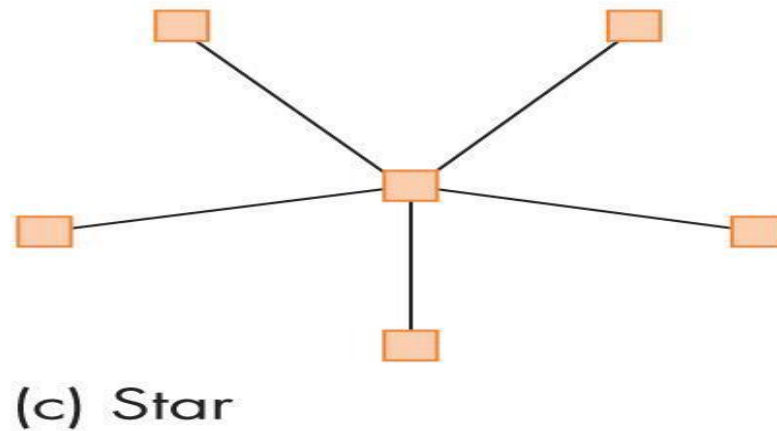
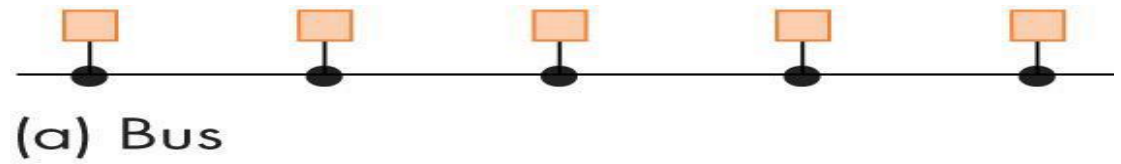


Figure 7.4  
Some Common  
LAN  
Topologies



# 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.

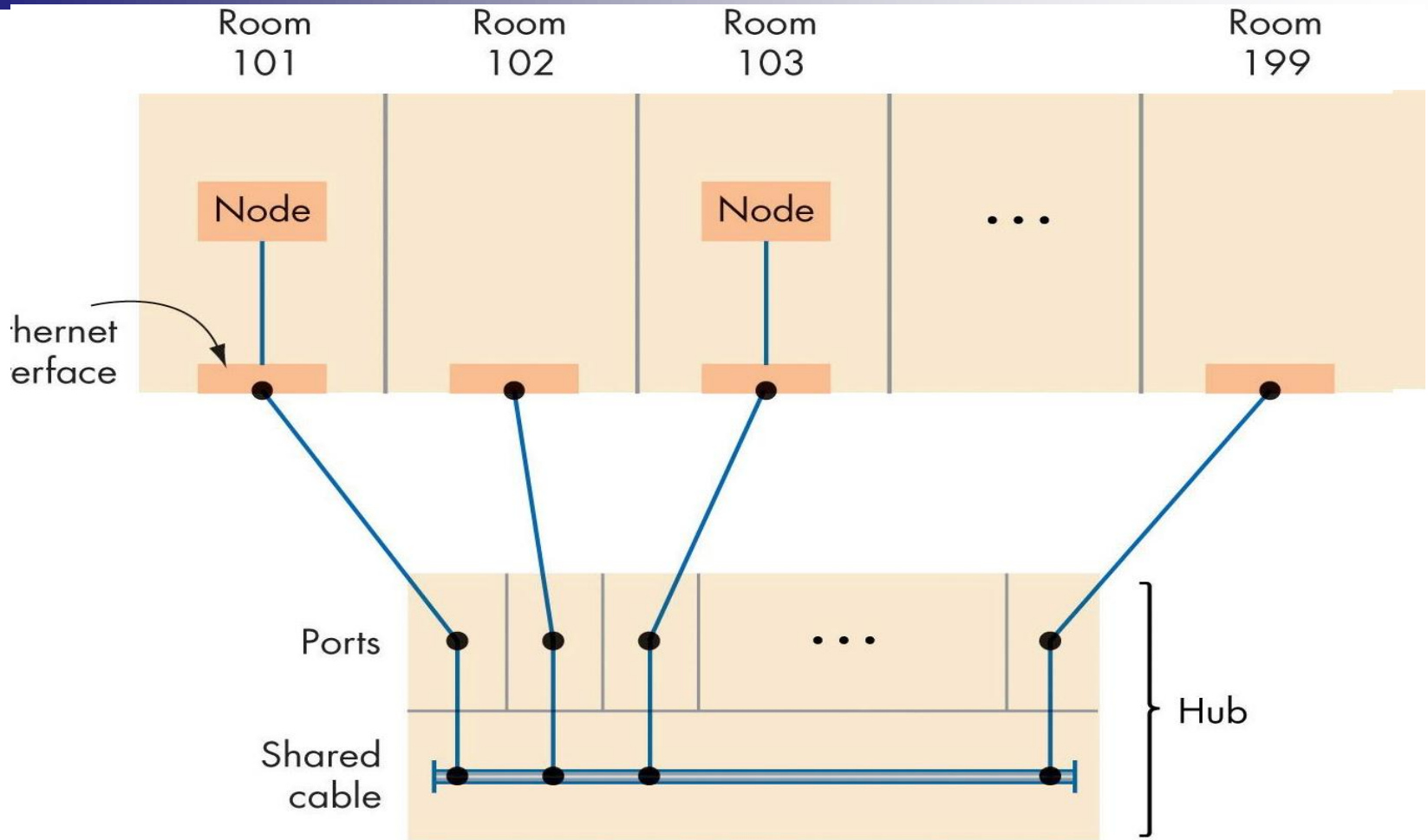


Figure 7.6  
An Ethernet LAN Implemented Using a Hub

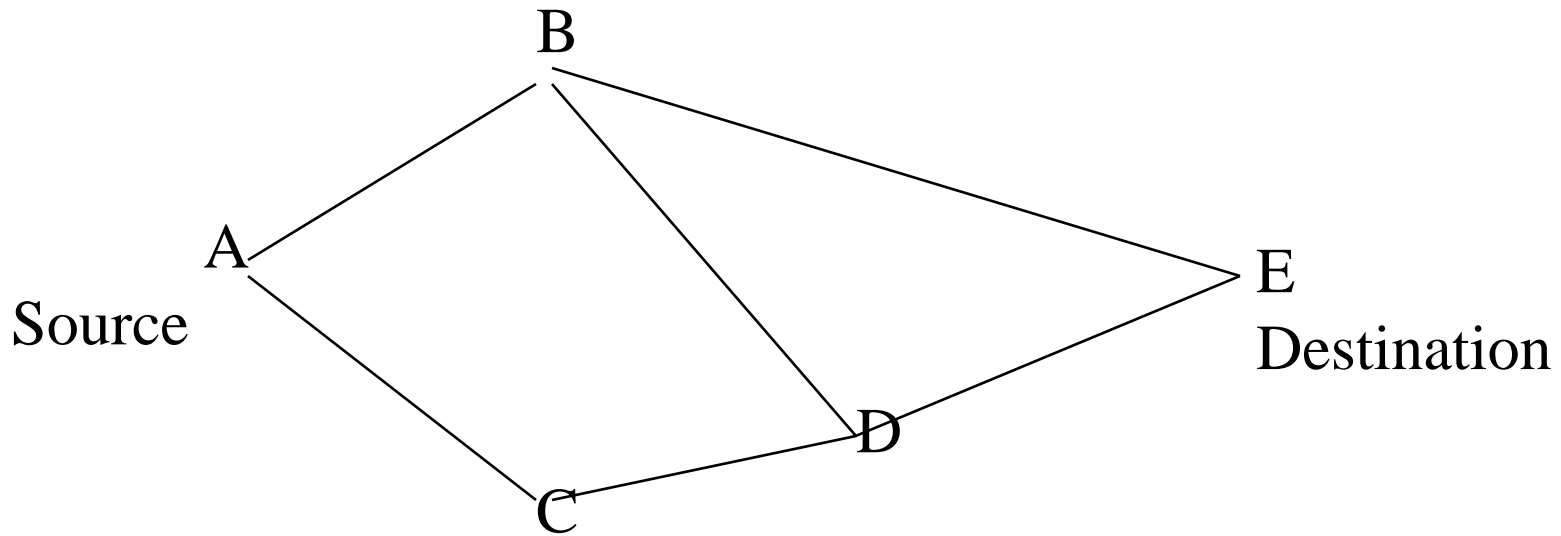
# Wide Area Networks- WANs

- 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

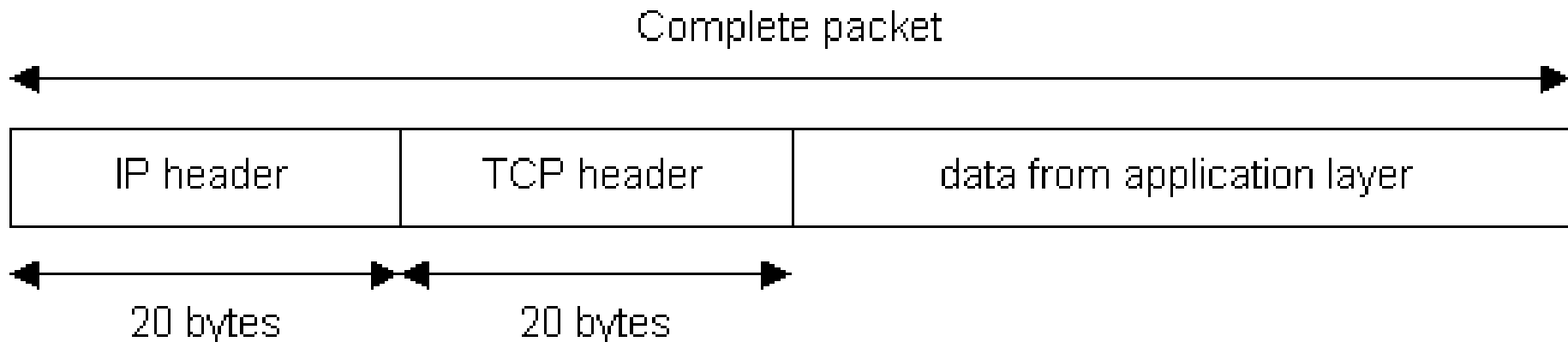
# Network Layer (IP)

- 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

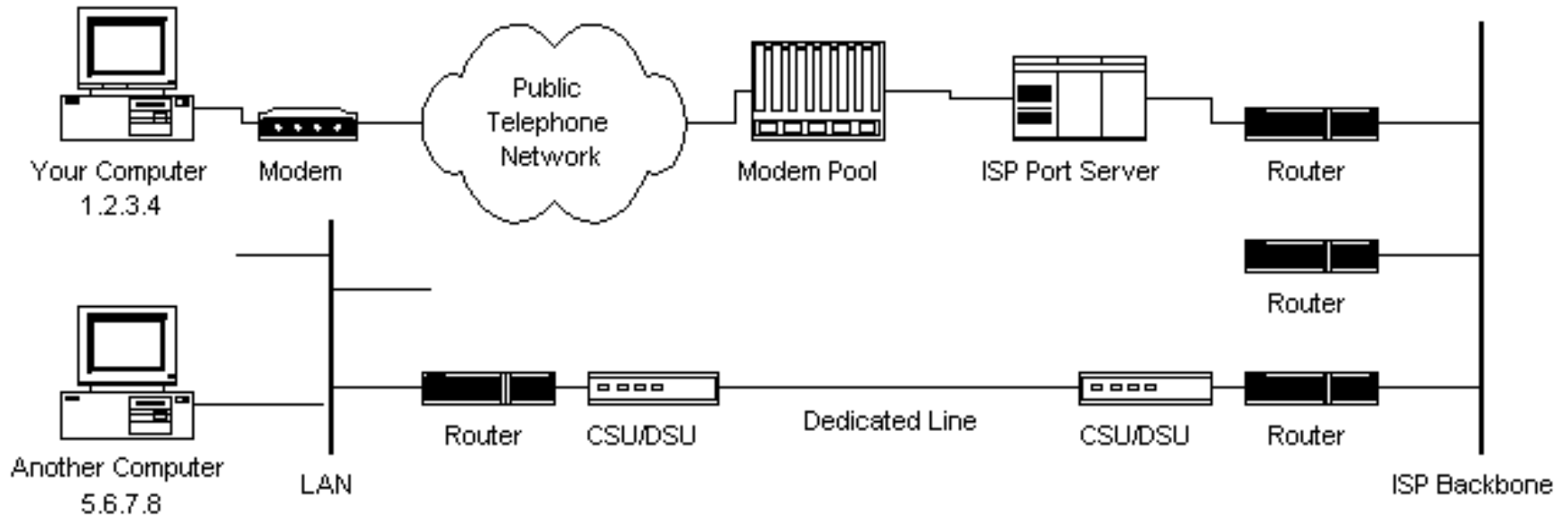
- Creates “error-free” message pipe
- Frames messages
- Arbitrates ownership of a shared line when multiple nodes want to send at the same time

## ■ Physical Layer

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

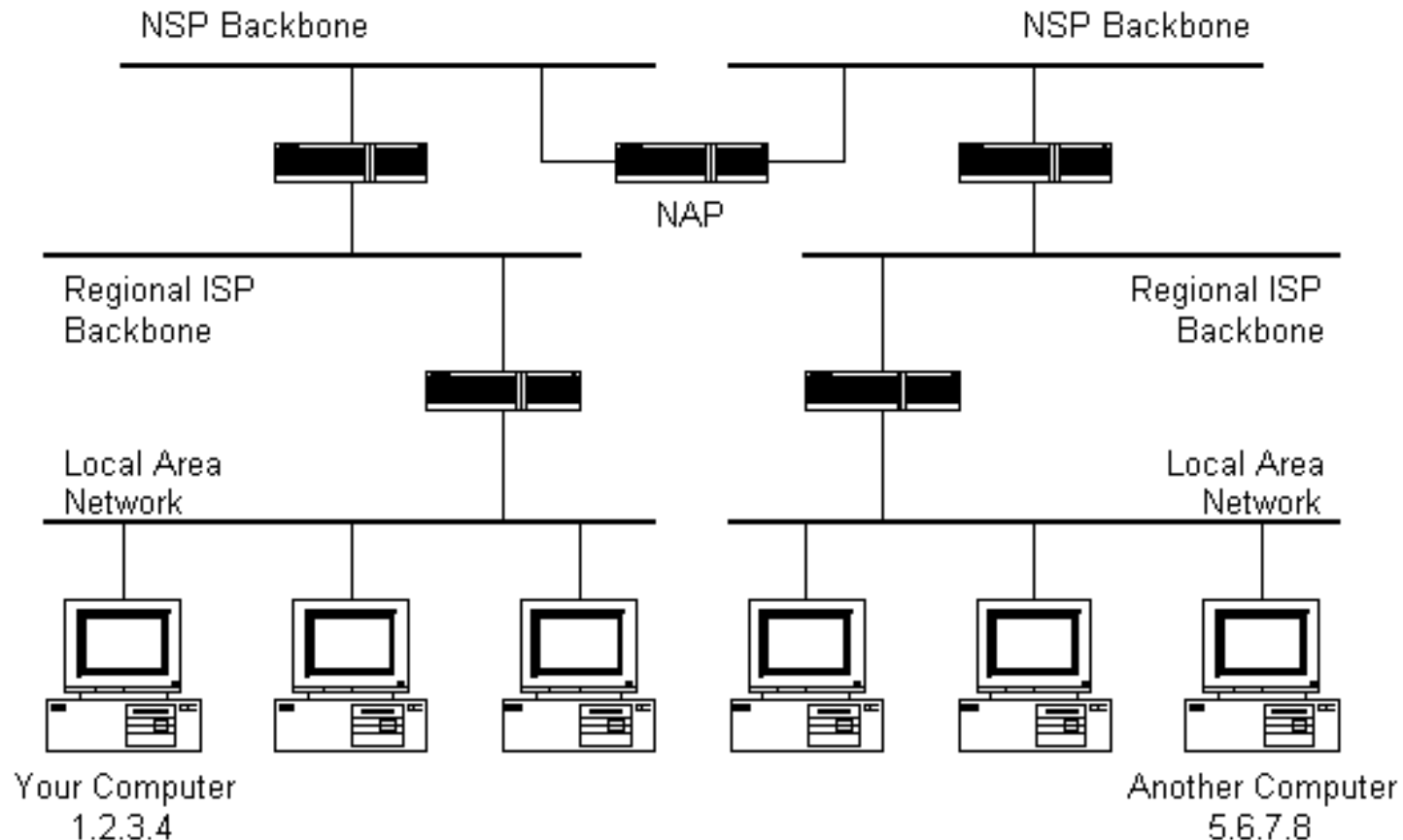
# Packet Routing

- 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://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

