Chapter 7
Networking: Computer Connections
Objectives

- Describe the basic components of a network
- Explain the methods of data transmission, including types of signals, modulation, and choices among transmission modes
- Differentiate among the various kinds of communications links and appreciate the need for protocols
- Describe various network configurations
- List the components, types, and protocols of a local area network
- Appreciate the complexity of networking
- Describe some examples of networking
Networks

- Early data transfers were accomplished by physically “moving the data” around
  - Magnetic tapes, disk packs – “Sneaker Net”
    - “Never underestimate the bandwidth of a station wagon loaded full of mag tapes headed for LA”
      --- anonymous
- Interconnecting computers was becoming necessary to facilitate the information flow
Centralized Data Processing

- Places all hardware, software, and processing in one location
- Very inconvenient and inefficient
  - Input data had to be physically transported to computer
  - Processed material had to be delivered to users
Distributed Data Processing

- Uses computers that are at a distance from central computer
- Local computers had access to central computers
  - Some processing done on local computers, some on central computers
Networking

- Uses communication equipment to connect two or more computers and their resources
  - Can be PC based
  - Distributed data processing systems are networks
- Allows connected users to share data and resources
- LAN – Local Area Network
  - shares among users in close proximity
- WAN – Wide Area Network
  - shares among users who are geographically distant
Putting Together a Network

- Basic Components
  - Sending device
  - Communications link
  - Receiving device
Digital Transmission

- Sends data as distinct pulses, either on or off
  - Similar to how data travels through computer
Analog Transmission

- Continuous electrical signal in the form of a wave
  - Called carrier wave

- Many communications media already in place for analog (voice) transmission
  - Phone lines are most common

- Digital signal from computer must be converted to analog form to be transmitted over analog lines
Converting Digital to Analog

- Carrier wave can be altered
  - Amplitude (height) of wave
  - Frequency (number of times a wave repeats during a cycle) of wave
- Conversion from digital to analog called modulation
- Conversion from analog to digital called demodulation
Modem

- Short for modulator/demodulator
- Converts digital signal to analog and vice versa
Types of Modems

- External modem separate from computer
- Internal modem inserted into computer
  - Standard on most computers today
- PC Card modem slides into slot on laptop
  - Roughly credit card size
- Cable connects modem to standard phone jack
Modem Data Speeds

- Measured in bits per second (bps)
  - Early modems transmitted at 300 bps
  - Fastest current modems transmit at 56,000 bps
- Federal Communications Commission (FCC) restrictions prohibit actual speeds faster than 53,000 bps
- Actual speed depends on line conditions and other variables
Integrated Systems Digital Network (ISDN)

- Special type of telephone circuit
  - Can move data at 128,000 bps
  - Includes two phone lines, so you can talk on the phone while online

- Drawbacks
  - Expensive, especially at installation
  - Not available in all areas
Digital Subscriber Line (DSL)

- Uses advanced electronics to send data over telephone line at very high speeds
  - Always on - no need to dial a connection
  - Can use phone while online

- Drawbacks
  - You must be within three miles of telephone company’s switching office
    - That office must have DSL equipment
Cable Modems

- Uses coaxial cable already in place for your TV
  - Very fast transmission speed, especially for downloading
  - Always on: no need to dial a connection

- Drawbacks
  - All users share a cable segment’s capacity
    - As more users in neighborhood go online, speed decreases
  - No security for individual users or data
    - Purchase a firewall program for security
Cellular Modems

- Transmit data over the cellular telephone system
  - Roughly half the speed of a regular telephone network
Sending data to remote location only works if receiving device is ready to accept it

Two approaches to keeping devices in step:
- Asynchronous transmission
- Synchronous transmission
Asynchronous Transmission

- Also called start/stop transmission
  - Start bit transmitted at the beginning of each group of bits
  - Stop bit sent at end of each group
  - Each group typically consists of one character
- Receiving device gets start signal and sets up mechanism to accept the group
- Used for low-speed communications
Synchronous Transmission

- Large block of characters transmitted
- Internal clocks of devices synchronized
- Error-check bits make sure all characters received
- Much faster, but equipment is more expensive
Simplex, Half-Duplex, and Full-Duplex Transmission

- **Simplex transmission** sends data in one direction only
  - Example: television broadcasting

- **Half-duplex transmission** sends data in both directions, but only one way at a time
  - Example: bank teller sends data about a deposit; after data received, a confirmation returns

- **Full-duplex transmission** allows transmission in both directions at same time
  - Example: a conversation
  - Typically used for high-speed data communication
Communications Media

- Physical means of data transmission
- Bandwidth is measure of the capacity of the communications link
Types of Communications Media

- Wire pairs
- Coaxial cables
- Fiber optics
- Microwave transmission
- Satellite transmission
- Wireless transmission
Wire Pairs

- Also known as twisted pair
  - Two wires twisted around each other to reduce electrical interference
- Inexpensive
- Already in place (for telephone systems)
- Susceptible to electrical interference and noise
  - Noise - anything that causes signal distortion
Coaxial Cable

- A center conductor wire surrounded by layer of insulation and metallic sheath
- Commonly used to connect to cable TV
- Higher bandwidth and less susceptibility to noise than twisted pair
Fiber Optics

- Use light instead of electricity to send data
- Much higher bandwidth than coaxial cable
- Immune to electrical interference
- Materials cheaper than coaxial, but installation costs high
Microwave Transmission

- Uses line-of-sight transmission of data signals
  - Sending microwave must “see” receiver
- Requires relay stations approximately every 30 miles
  - Waves are straight, earth is curved
- Offers high speed and cost-effectiveness
- Susceptible to weather conditions
Satellite Transmission

- A form of microwave transmission
  - Satellite acts as relay station
- Components
  - Earth station sends and receives signal to satellite
  - Transponder receives and amplifies signal, changes frequency, and retransmits data
- Useful when signal must travel thousands of miles
Wireless Transmission

- Transmits data over relatively short distances without wires

Examples
- IrDA - uses infrared line-of-sight
- Bluetooth - uses radio waves to connect mobile devices
- 802.11 standards - govern wireless transmission
Setting Standards

- Protocol - a set of rules for the exchange of data between a terminal and a computer or two computers
  - Agreement on how data is to be sent and receipt acknowledged
  - Needed to allow computers from different vendors to communicate
  - Transmission Control Protocol/Internet Protocol (TCP/IP) permits any computer to communicate with the Internet
Network Topology

- The physical layout of a network
- Node - each computer, printer, or server on network
- Three common topologies
  - Star
  - Ring
  - Bus
Star Topology

- Central (hub) computer manages network
- All messages routed through hub
  - Helps prevent collisions among messages
- Connection failure between hub and any node will not affect overall system
  - If hub is down, the network fails
Ring Topology

- Links all nodes in a circular chain
- Data messages travel around ring in a single direction
  - Each node checks message to see whether that node is addressee
  - If not, message passed to next node
- No danger of data collision
- If one node fails, ring is broken and network fails
Bus Topology

- All nodes connected to single line (bus)
- Computers send messages to other computers on network
  - If messages collide with other messages, sending node resends message
- Nodes can be added/removed from network without affecting network
- If a node fails, network does not fail
Wide Area Network (WAN)

- Can span the world or link computers across town
  - Metropolitan Area Network (MAN) - networks that cover a single city

- Components
  - Communications services
  - WAN hardware
  - WAN software
Communications Services

- Provided by common carriers
  - Companies licensed by FCC to provide these services
- Two general categories
  - Switched
  - Dedicated
Switched Service

- Also called a dial-up connection
  - Establishes a temporary connection between two points when call is placed
  - When call is ended, connection is broken
- Most common is public telephone system
Dedicated Service

- Provides permanent connection between two or more locations
  - Companies can build their own (microwave, fiber, etc.)
  - Can also lease circuits from common carrier
    - Called leased lines
  - Most common leased lines
    - T1 and T3 high-capacity digital lines
    - DSL or ISDN lines
WAN Hardware

- Normally controlled by one or more host processors (typically mainframe computers)
- Host connectors connect to WAN through front-end processor
  - Relieves host computer of some communications tasks, freeing it for processing
- Multiplexer combines data from several slow-speed devices into a single data stream for transmission
WAN Topology

Wide Area Backbone

← A Happy Router
WAN Software

- Terminal emulation software
  - allows PC to emulate mainframe terminal

- File transfer (FTP) software
  - Allows users to upload/download files
  - Download - to retrieve a file from another computer
  - Upload - to send a file to another computer
Local Area Network (LAN)

- A collection of computers that share hardware, software, and data
  - Typically personal computers
  - Typically within an office or building

- LANs have changed the economies of computing
  - LANs allow the sharing of resources
    - Use of inexpensive computers to access expensive resources
    - Printers, disks…
    - Remote printing is common

- LANs came along just in time..
  - Internet design assumed many LANs would be interconnected via the Internet
LAN Components

- Network cable
- Network interface card (NIC)
- Router
- Gateway
Network Cable

- Provides a way to connect to network
  - Low-cost LANs connected with twisted pair wire
  - Many connected by coaxial or fiber optic cable
  - Wireless access point connects to wired network
    - Provides wireless connection to network
Network Interface Card

- Connects each computer to wiring in the network
  - Handles sending, receiving, and error checking of transmitted data
- Can be a circuit board or PC card
- Wireless NIC allows user to connect through wireless access point
Routers

- Bridge allows connection of similar networks (those using the same protocol)
- Router directs communications traffic when several networks connected together
  - If network traffic clogged, router can redirect traffic to another route
- IP switch used in place of router when networks use the Internet protocol
  - Less expensive and faster than routers
Gateway

- Lets a node communicate with a computer on another dissimilar network
  - Primary function is converting protocol among networks
Client/Server Network

- Server computer controls network
  - Often has several hard drives, fastest printer
- Client computer requests services from server
  - Thin client has little or no storage
- Processing approaches
  - Client/server
  - File server
Client/Server

- Client requests data from server
- Server passes only the requested data
  - Client may perform some processing, but most data processed on server
File Server

- Client requests data from server
- Server sends entire file
  - Client performs all data entry and processing
  - File retransmitted to server
Peer-to-Peer Networks

- All computers have equal status
- Users share each other’s files, printers, etc. as needed
- Common in small offices
- Networks tend to be slow
LAN Protocols: Ethernet

- Dominant network protocol
- Uses either bus or star topology
- Node “listens” to see when the network is available
  - If two computers transmit at same time, collision occurs
  - Network detects the collision
  - Each computer waits random amount of time and retransmits
LAN Protocols: Token Ring

- Uses ring topology
- Token (electrical signal) controls which node can send messages
  - Token circulates among nodes
  - A computer waits for an empty token, attaches message, and transmits
- Only one token, so only one device can access network at a time
Network Design

- Transmission speed (i.e., data rate)
- Medium (wired, wireless....)
- Topology – Physical layout of components
- Protocol – Rules governing communication
- Distance
  - LAN
  - WAN
- Technology
  - Peer-to-peer
  - File server
  - Client/server
Mixed & Matched….

Example – East and West coast:

- Request made
  - Twisted pair in the phone lines on the East Coast
  - Microwave and satellite transmission across the country
  - Twisted pair in the phone lines on the West coast

- Data transferred
  - Twisted pair in the phone lines on the West Coast
  - Microwave and satellite transmission across the country
  - Twisted pair in the phone lines on the East coast
Network Uses

- Electronic mail (e-mail)
- Facsimile (fax) technology
- Groupware
- Teleconferencing
- Electronic data interchange
- Electronic fund transfers
- Computer commuting
- The Internet
Electronic Mail

- Sends message from one computer to another
  - Stored until recipient “opens” mail
  - Does not interrupt the way a ringing phone does
- Does not require both participants to be present at time of transmission
Facsimile

- Uses computer technology and communications links to send documents almost anywhere
  - Can send drawings, graphics, text
  - Document placed in fax machine and digitized
  - Built-in modem converts digital signal to analog and transmits
  - Receiving fax reassembles document and prints it
- Fax modem performs same functions on PC
Groupware

- Software that allows groups of people to work on files or projects together
  - Data is stored in database on disk
  - Communications lines required to let remote employees work together
Teleconferencing

- Brings people and ideas together
  - Videoconferencing uses video cameras, screens, computers, and communications to allow remote groups of people to have meetings
  - Much less expensive than travel
Electronic Data Interchange

- Allows businesses to transmit standard business documents electronically
  - Invoices and purchase orders are examples of standard business documents
  - Uses XML as standard for defining data
- Eliminates the need to fill out paper forms on one end and key them into a computer on the other end
  - Reduces paperwork and personnel costs
Electronic Fund Transfers

- Pay for goods and services by having funds transferred among various accounts
  - Automated teller machine is manifestation of EFT
  - Direct deposit of paychecks, government benefits checks, etc. is high-volume EFT use
Telecommuting

- Use computers and communications to work from home
  - Can link directly to company’s networks or download work and upload it when finished
  - Most telecommuters work in the office at least a couple of days per week
The Internet

- A global network of hundreds of thousands of computers
- Widely considered to be the defining technology of the beginning of this century
Interconnecting networks was a revolutionary idea....

- Simply connect to your closest neighbor and you are in!
- Issues now arise
  - Privacy
  - Politics
  - Borders