# Technology Guide 4

## Telecommunications

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Turban, McLean, Wetherbe
Lecture Slides by A. Lekacos,
Stony Brook University
John Wiley & Sons, Inc.

# Telecommunications

Telecommunications generally refers to all types of long-distance communication that uses common carriers, including telephone, television, and radio. Data communications is the electronic collection, exchange, and processing of data or information, including text, pictures, and voice, that is digitally coded and intelligible to a variety of electronic devices.

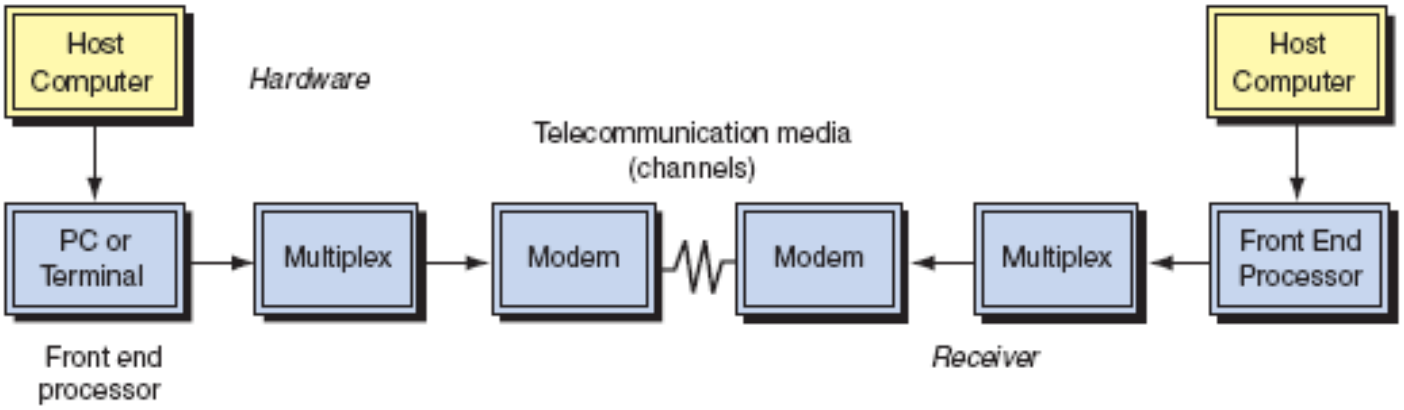
# Telecommunications System

A telecommunications system is a collection of compatible hardware and software arranged to communicate information from one location to another.

- The major components are:
  - **Hardware**—all types of computers (e.g., desktop, server, mainframe) and communications processors (such as a modems or small computers dedicated solely to communications).
  - **Communications media**—the physical media through which **electronic signals** are transferred; includes both wireline and wireless media.
  - **Communications networks—**the linkages among computers and communi-cations devices.
  - **Communications processors—**devices that perform specialized data commu-nication functions; includes front-end processors, controllers, multiplexors, and modems.

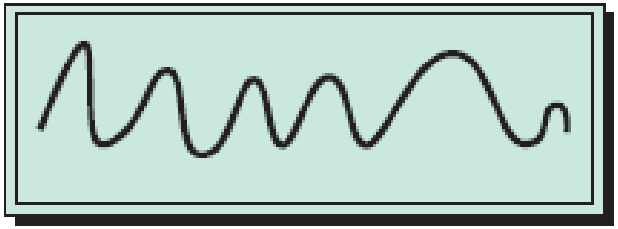
# Telecommunications System Continued

- **Communications software—**software that controls the telecommunications system and the entire transmission process.
- **Data communications providers—**regulated utilities or private firms that provide data communications services.
- **Communications protocols—**the rules for transferring information across the system.
- **Communications applications—**electronic data interchange (EDI), telecon-ferencing, videoconferencing, e-mail, facsimile, electronic funds transfer, and others.

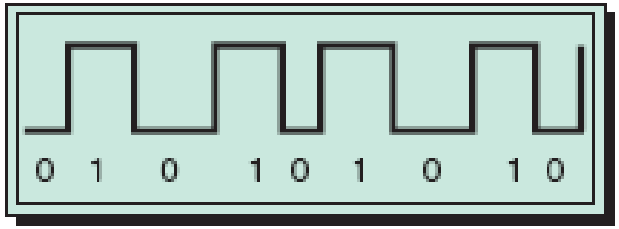


# Electronic Signals

- Telecommunications media can carry two basic types of signals:
  - Analog signals are continuous waves that "carry" infor-mation by altering the *amplitude* and *frequency* of the waves.
  - Digital signals are discrete on-off pulses that convey information in terms of 1's and 0's, just like the central processing unit in computers.



Analog data transmission
(wave signals)

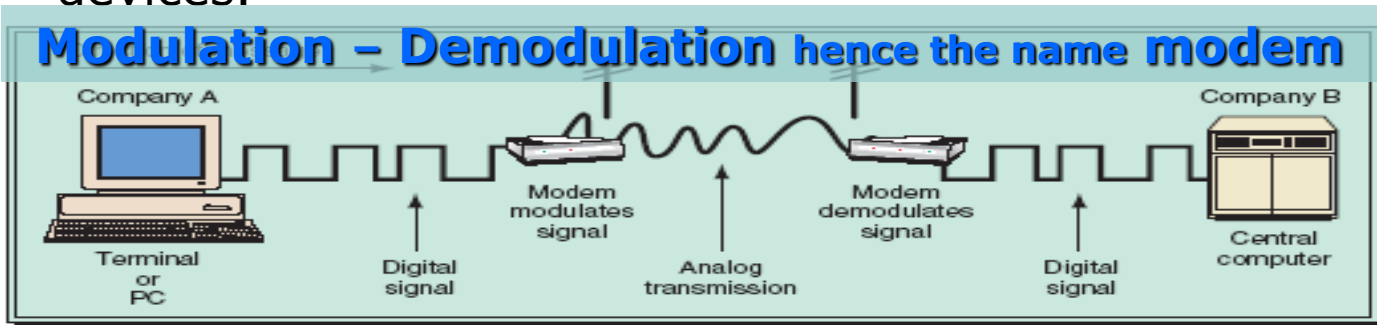



Digital data transmission
(pulse signals)

# Communications Processors

Communications processors are hardware devices that support data transmission and reception across a telecommunications system. These devices include modems, multiplexers, front-end processors, and concentrators.

- A modem is a communications device that converts a computer's digital signals to analog signals before they are transmitted over standard telephone lines.
- A multiplexer is an electronic device that allows a single communications channel to carry data transmissions simultaneously from many sources.
- A front-end processor, is a specialized computer that manages all routing communications with peripheral devices.



# Communications Media Comparisons

For data to be communicated from one location to another, a physical pathway must be used. These pathways are called communications media (channels) and can be either physical or wireless. The physical transmission use wire, cable, etc.; wireless transmission media send communications signals through the air.

**TABLE T-4.1 Advantages and Disadvantages of Communications Channels**

| Channel | Advantages | Disadvantages |
|---|---|---|
| **Twisted-pair** | Inexpensive<br>Widely available<br>Easy to work with<br>Unobtrusive | Slow (low bandwidth)<br>Subject to interference<br>Easily tapped (low security) |
| **Coaxial cable** | Higher bandwidth than twisted pair<br>Less susceptible to electromagnetic interference | Relatively expensive and inflexible<br>Easily tapped (low-to-medium security)<br>Somewhat difficult to work with |
| **Fiber-optic cable** | Very high bandwidth<br>Relatively inexpensive<br>Difficult to tap (good security) | Difficult to work with (difficult to splice) |
| **Microwave** | High bandwidth<br>Relatively inexpensive | Must have unobstructed line of sight<br>Susceptible to environmental interference |
| **Satellite** | High bandwidth<br>Large coverage area | Expensive<br>Must have unobstructed line of sight<br>Signals experience propagation delay<br>Must use encryption for security |
| **Radio** | High bandwidth<br>No wires needed<br>Signals pass through walls<br>Inexpensive and easy to install | Create electrical interference problems<br>Susceptible to snooping unless encrypted |
| **Cellular Radio** | Low to medium bandwidth<br>Signals pass through walls | Require construction of towers<br>Susceptible to snooping unless encrypted |
| **Infrared** | Low to medium bandwidth | Must have unobstructed line of sight<br>Used only for short distances |

# Communications Media (Channels)

**TABLE T-4.2 Comparisons among Various Communications Media**

| Technology | Capacity (Mbps) | Advantage | Limitations |
|---|---|---|---|
| Fiber to Home | Several hundred, up to 1000 | Highest speed | cost |
| DSL | Downstream: 6–8; upstream: up to 1.5 | Uses existing phone lines | Speed decreases with distance, no service past 18000 feet |
| Wireless (terrestrial) | Comparable to DSL | No cables required | Multipath interference, weather and terrain problems, limited distance |
| Wireless (satellite) | To be defined | No cable, no antennas, best suited to broadcasts | Limited data rates likely |
| Cable | Downstream: typical ~1; upstream: 0.1–0.5 | Uses existing coaxial cable | Data rate drops with number of users, poor security, requires major upgrade |

# Satellite Communications Systems

A satellite is a space station that receives microwave signals from an earth-based station, amplifies the signals, and broadcasts the signals back over a wide area to any number of earth-based stations. Transmission to a satellite is an uplink, whereas downlink is a transmission from a satellite to an earth-based station.

**TABLE T-4.3 Three Basic Types of Telecommunications Satellites**

| Type | Considerations | Orbit | Number |
|---|---|---|---|
| GEO | • Stellites remain stationary relative to point on Earth<br>• Few satellites needed for global coverage<br>• Transmission delay (approximately .25 second)<br>• Most expensive to build and launch<br>• Longest orbital life (12+ years) | 22,300 miles | 8 |
| MEO | • Satellites move relative to point on Earth<br>• Moderate number needed for global coverage<br>• Require medium-powered transmitters<br>• Negligible transmission delay<br>• Less expensive to build and launch<br>• Moderate orbital life (6–12 years) | 6,434 miles | 10–12 |
| LEO | • Satellites move rapidly relative to point on Earth<br>• Large number needed for global coverage<br>• Require only low-power transmitters<br>• Negligible transmission delay<br>• Least expensive to build and launch<br>• Shortest orbital life (as low as 5 years) | 400–700 miles | many |

# “Newer” Wireless Technologies

Wireless Application Protocol (WAP) is a technology that enables wireless transmissions. Because of the requirements of faster speed and strict security requirements that existing WAP cannot fulfill, newer technologies are being created.

- Bluetooth
- Fiber optics without the fiber
- Ultrawideband (UWB)
- Software-Defined Radio
- Wireless Personal Area Network
- Adaptive Radio
- Mesh Networks
- HomePlug

**Wireless Network Standards**

| 802.11 standard | Functions |
|---|---|
| 802.11a | 54-mbps top speed; incompatible with 802.11b |
| 802.11b | 11-mbps top speed; popular in home and small-business networks |
| 802.11e | Enhances audio and video transmission on 802.11a, b or g |
| 802.11g | New standard with 54-mbps top speed; compatible with 802.11b |
| 802.11i | Adds enhanced 128-bit encryption to 802.11a, b or g |

# Characteristics of Communications Media

Communications media have several characteristics that determine their efficiency and capabilities. These characteristics include the speed, direction, mode, and accuracy of transmission.

- Transmission speed
  - Bandwidth refers to the range of frequencies that can be sent over a communications channel. Frequencies are measured in the num-ber of cycles per second (or *Hertz*, abbreviated Hz).
  - A baud is a detectable change in a signal. The amount of data that can be transmitted through a channel is known as its baud rate, measured in bits per second (bps).
- Channel capacity is usually divided into three bandwidths:
  - Narrowband
  - Voice-band
  - Broadband channels

# Transmission Rates

**TABLE T-4.5 Transmission Rates in Different Media**

| Medium | Capacity |
|---|---|
| Twisted pair | Up to 128 Mbps |
| Coaxial cable | Up to 200 Mbps |
| Fiber-optic cable | 100 Mbps to 2 Gbps |
| Broadcast radio | Up to 2 Mbps |
| Microwave | 45 Mbps |
| Satellite | 50 Mbps |
| Cellular radio, 2 G cell phone | 9600 bps to 14.4 Kbps |
| Cell phone, 3 G | Up to 2 Mbps |
| Cell phone, 2.5 G | GPRS, up to 115 Kbps |
| | EDGE, up to 384 Kbps |
| Infrared | 1 to 4 Mbps |

# Transmission Direction and Mode

Data transmissions can be described in terms of their direction and their timing. Direction of data transmission can be a simplex, half-duplex or full-duplex. Timing of data transmissions can be either asynchronous or synchronous.

- Simplex data transmission uses one circuit in one direction only.
- Half-duplex data transmission uses only one circuit, but it is used in both directions.
- Full-duplex data transmission uses two circuits simultaneously for communications one for each direction.
- Asynchronous transmission, only one character is transmitted or received at a time.
- Synchronous transmission, a group of characters is sent over a communications link in a continuous bit stream while data transfer is controlled by a timing signal initiated by the sending device.

# Telecommunications Carriers

Telecommunications carriers are companies that provide the communications technology (e.g., telephone lines, satellites, and communications software) and services needed for data communications.

- Switched lines are telephone lines, provided by common carriers, that a person can access from his or her computer to transmit data to another computer; the transmission is routed or switched through paths to its destination.
- Dedicated lines, also called leased lines, provide a constant connection between two devices and require no switching or dialing. These lines are continuously available for transmission.

# Network Protocols

Protocol is a set of rules and procedures governing transmission and communications across a network. Its principal functions are line access, collision avoidance, identification of each device in the communication path, to secure the attention of the other device, to verify correct receipt of the transmitted message, to verify that a message requires retransmission and to perform recovery when errors occur.

- Token-passing approach, a small data packet, called a *token*, is sent around the network.
- Contention, which is part of the Ethernet protocol, a device that wants to send a message checks the communications medium to see if it is in use.
- Transmission Control Protocol/Internet Protocol (TCP/IP) is a protocol for sending information across sometimes-unreliable networks with the assurance that it will arrive in uncorrupted form. It is the standard protocol of the Internet and intranets
- Voice-over IP (VoIP) systems, analog voice signals are digitized and transmitted as a stream of packets over a digital IP data network

# Communications Standards

The protocols required to achieve communication on behalf of an application are actually multiple protocols existing at different levels or layers. Each layer defines a set of functions that are provided as services to upper layers and each layer relies on services provided by lower layers. At each layer, one or more protocols define how the software programs interact to accomplish the functions for that layer.

The most widely known is the Open Systems Interconnection (OSI) Reference Model developed by the ISO.

- Layer 1: Physical layer. Concerned with transmitting raw bits over a com-munications channel; provides a physical connection for the transmission of data among network entities and creates the means by which to activate and deactivate a physical connection.

# Communications Standards Continued

Open Systems Interconnection (OSI) Reference Model

- Layer 2: Data link layer. Provides a reliable means of transmitting data across a physical link; breaks up the input data into data frames sequentially and processes the acknowledgment frames sent back by the receiver.
- Layer 3: Network layer. Routes information from one network computer to another; computers may be physically located within the same network or within another network that is interconnected in some fashion; accepts mes-sages from source host and sees to it they are directed toward the destination.
- Layer 4: Transport layer. Provides a network-independent transport service to the session layer; accepts data from session layer, splits it up into smaller units as required, passes these to the network layer, and ensures all pieces arrive correctly at the other end.

# Communications Standards Continued

Open Systems Interconnection (OSI) Reference Model

- Layer 5: Session layer. User's interface into network; where user must negotiate to establish connection with process on another machine; once connection is established the session layer can manage the dialogue in an orderly manner.
- Layer 6: Presentation layer. Here messages are translated from and to the format used in the network to and from a format used at the application layer.
- Layer 7: Application layer. Includes activities related to users, such as sup-porting file transfer, handling messages, and providing security

# Transmission Standards

A number of network bandwidth boosters address the need for greater bandwidth on networks for advanced computing applications.

- Fiber distributed data interface (FDDI) like token-ring networks, passes data around a ring
- Asynchronous transfer mode (ATM) networks are based on switched technologies, allowing for almost unlimited bandwidth on demand.
- Switched hub technologies are often used to boost local area networks. A switched hub can turn many small LANs into one big LAN.
- Synchronous optical network (SONET) is an interface standard for transporting digital signals over fiber-optic links.

# Transmission Standards Continued

- T-carrier system is a digital transmission system that defines circuits that operate at different rates, all of which are multiples of the basic 64 Kbps used to transport a single voice call. These circuits include T1 (1.544 Mbps, equivalent to 24 channels); T2 (6.312 Mbps, equivalent to 96 channels); T3 (44.736 Mbps, equivalent to 672 channels); and T4 (274.176 Mbps, equivalent to 4,032 channels).
- Integrated services digital network (ISDN) is a high-speed data transmission technology that allows users to simultaneously transfer voice, video, image, and data at high speed over standard copper telephone lines, using multiplexing.
- A Digital Subscriber Line (DSL) provides high-speed, digital data transmission from homes and businesses over existing telephone lines.

# Transmission Standards Continued

- Infinite Bandwidth (InfiniBand) is a new standard designed to dramatically increase the velocity of information by overhauling a key bottleneck–today's general-purpose, shared bus inside the computer. That shared bus, named the Peripheral Component Interconnect (**PCI**) bus can carry one message at a time past many points. The new standard, called a **switched fabric network**, will able to juggle hundreds or thousands of messages at a time both inside and outside the computer, moving them precisely from origin to destination.
- Circuit switching is an end-to-end circuit that must be set up before the call can begin.

# Software Standards

Computers and computing devices from different vendors require an open system to "talk" to each other. Three types of software standards are necessary for an open system:

- Operating systems. A network operating system (NOS) is the system software that controls the hardware devices, software, and communications media and channels across a network.
- Graphical User Interface standard. X Windows is the standard for GUI. It runs on all types of computers.
- Software application standards. Because of the large number of applications standards are not widespread. The unified standards cover DBMSs, user interfaces, programming languages, electronic data interchange and so on.

# Interfaces

An interface is a physical connection between two communications devices. One important concept of interfacing concerns the types of data transfer— parallel or serial.

- Parallel data transfer, most often used for local communication, employs a communications interface with a series of dedicated wires, each serving one purpose. In parallel communication, both data and control signals are transmitted simultaneously.
- Serial data transfer, most often used for long-distance communications, is bit by bit rather than many bits in parallel. Most data communications devices transmit in serial fashion. While much slower than parallel data transfer, serial transfer is simpler and requires much less on the part of the receiving system.

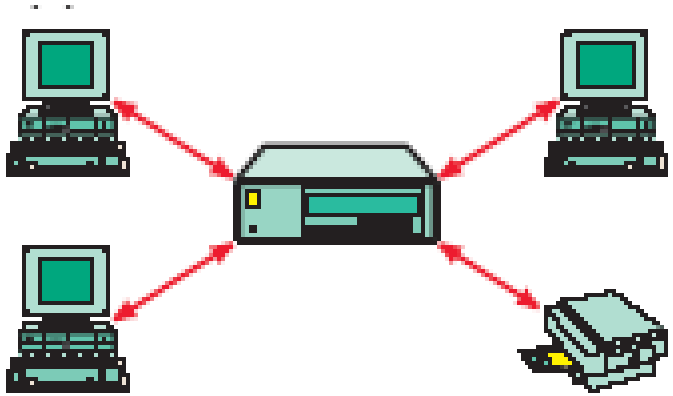
# Network Topology

The topology of a network is the physical layout and connectivity of a network. Specific protocols or rules of communications, are often used on specific topologies. Note: *topology* refers to the ways the channels connect the nodes, whereas *protocol* refers to the rules by which data communications take place over these channels. Neither concept should be confused with the *physical cabling* of the network.

- There are five basic network topologies:
  - Star
  - Bus
  - Ring
  - Hierarchical
  - Hybrid

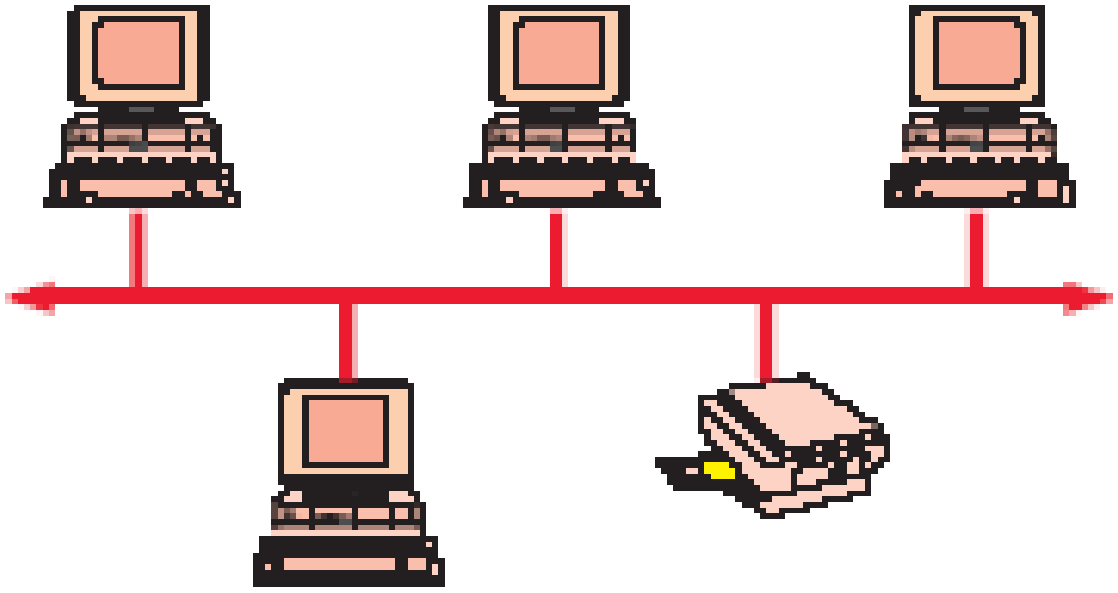
# Network Topology - Star

A star network has a central node that connects to each of the other nodes by a single, point-to-point link. Any communication between one node and another in a star topology must pass through the central node.



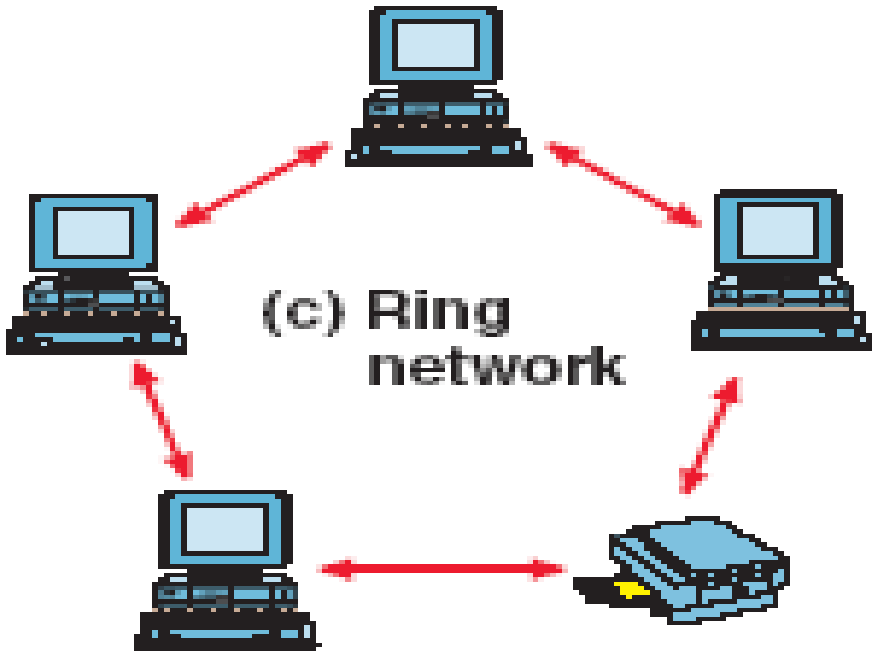
# Network Topology - Bus

In a bus topology, nodes are arranged along a single length of twisted pair wire, coaxial cable, or fiber-optic cable that can be extended at the ends.



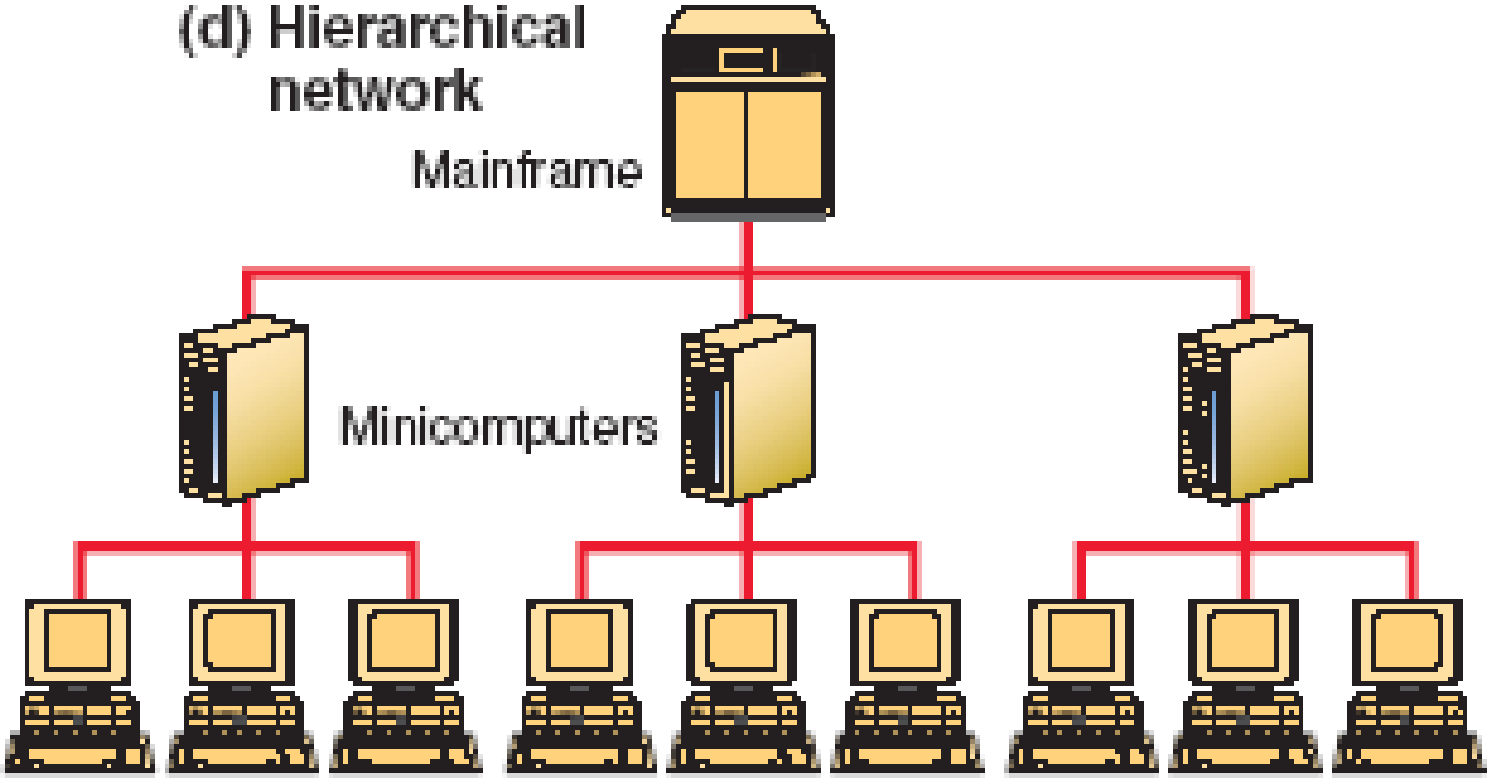
# Network Topology - Ring

In a ring topology, nodes are arranged along the transmission path so that a signal passes through each station one at a time before returning to its originating node.



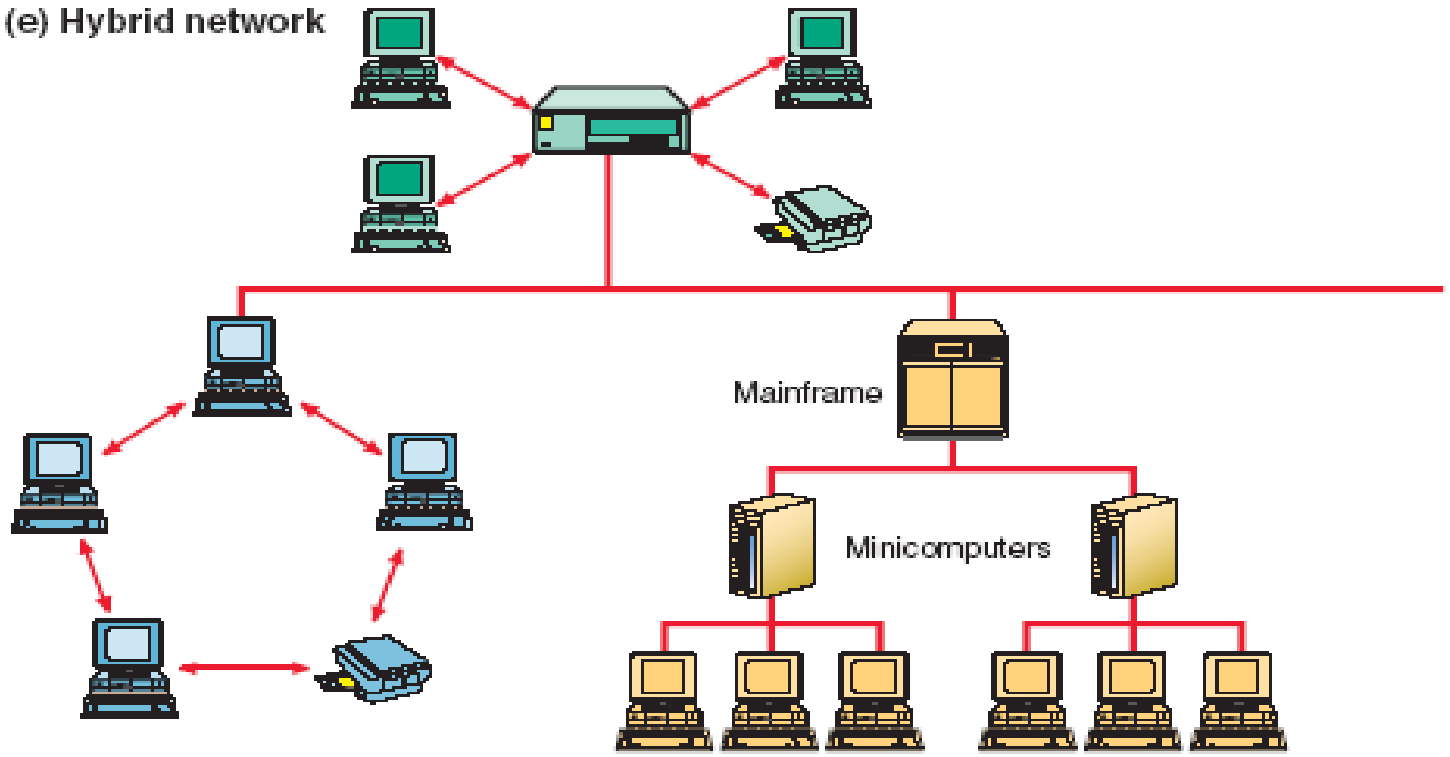
# Network Topology - Hierarchical

Hierarchical topologies typically connect desktops to minicomputers to a mainframe.



# Network Topology - Hybrid

Networks that combine more than one type (such as a ring segment connected to a star segment) are considered hybrid topologies.



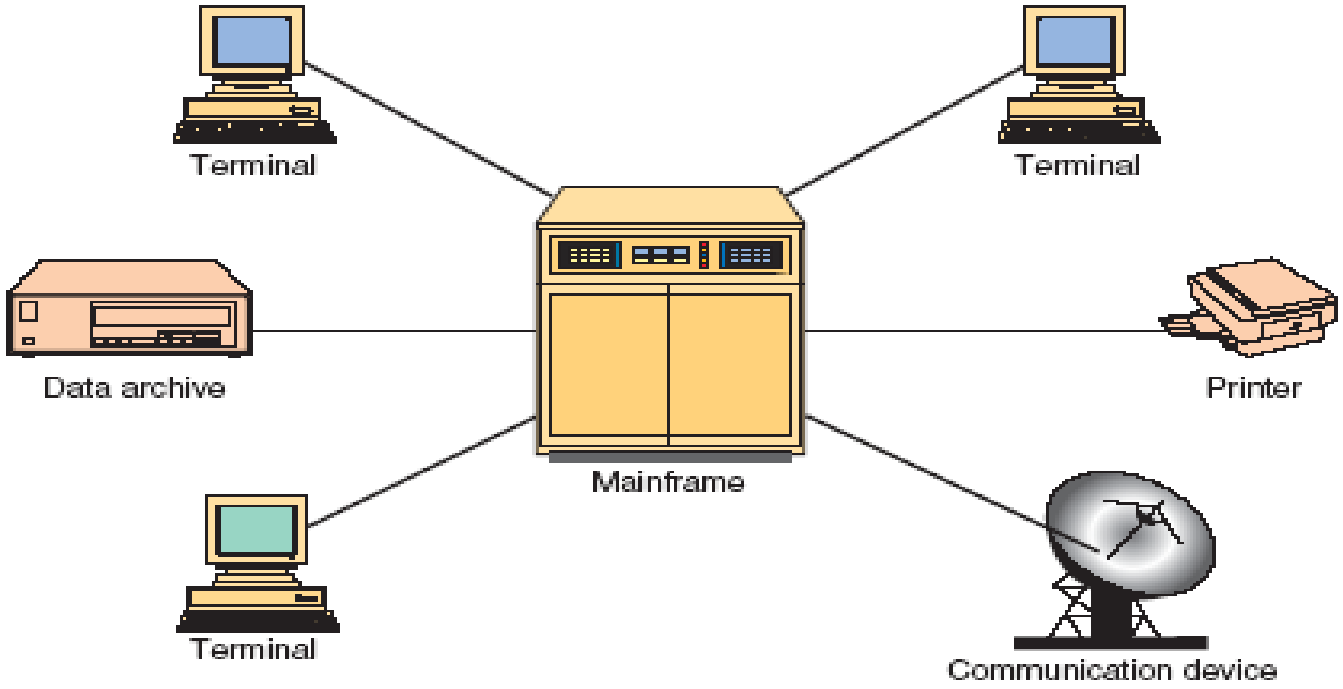
# Network Size

There are two general network sizes: local area networks and wide area networks. A "metropolitan" area network falls between the two in size.

- A local area network (LAN) connects two or more communicating devices within a short distance (2,000 feet), so that every user device on the network has the potential to communicate with any other device. LANs are usually intraorganizational, privately owned, internally administered.
- Wide area networks (WANs) are long-haul, broadband, generally public-access networks covering wide geographic areas that cross rights-of-way where communications media are provided by common carriers. WANs include *regional networks* such as telephone companies or *international networks* such as global communications service providers.
- A metropolitan area network (MAN) is a data network designed usually for a town or a city. The fiber optic and associated equipment that make up the MAN can be connected to the national communications backbone.

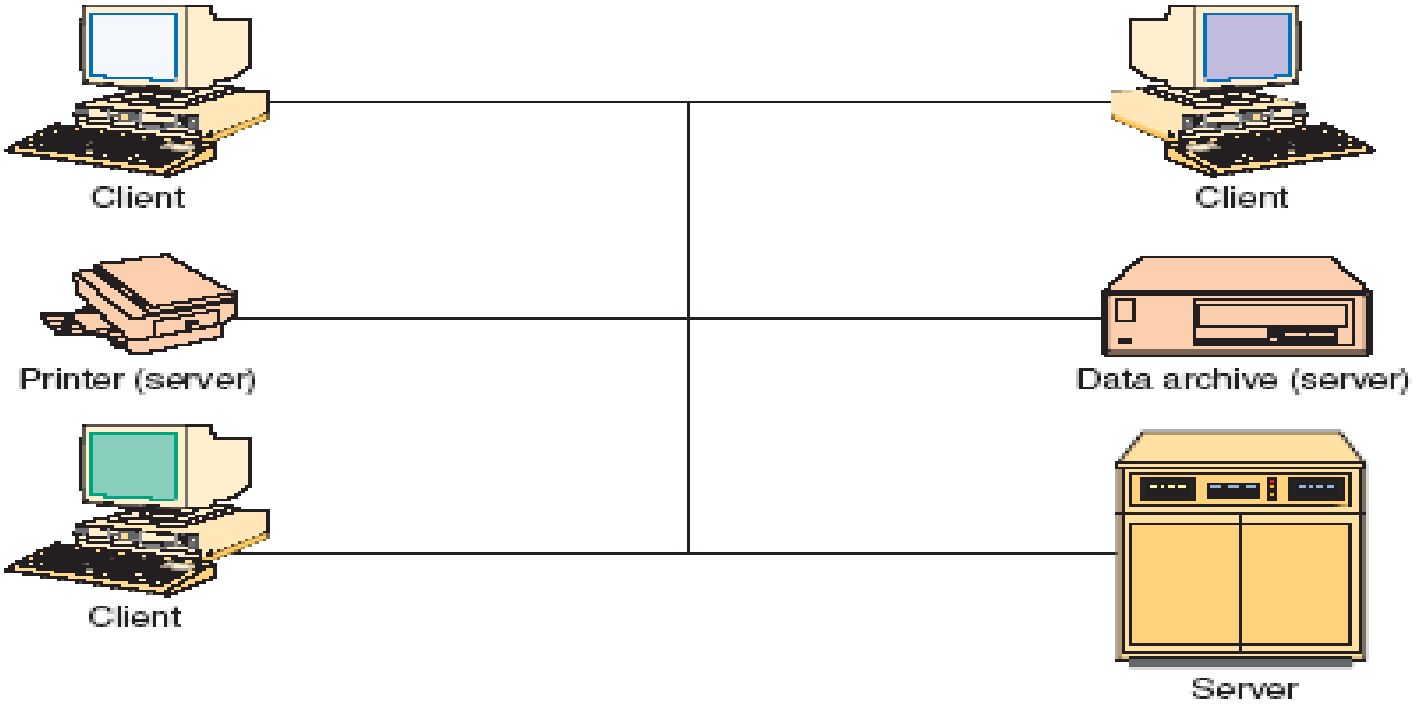
# Network Architecture - Centralized

Centralized computer systems are centered around a large computer, known as the *host*, that provides computational power and internal storage. Several devices that lack self-contained computer processors, such as dumb terminals and printers, are connected to the host. Information is entered, distributed, stored, or communicated through these devices.



# Network Architecture - Client/Server

The basic structure of client/server architecture is a client device and a server device that are distinguishable, but interact with each other. This architecture divides processing between "clients" and "servers". Both are on the network, but each processor is assigned functions it is best suited to perform.



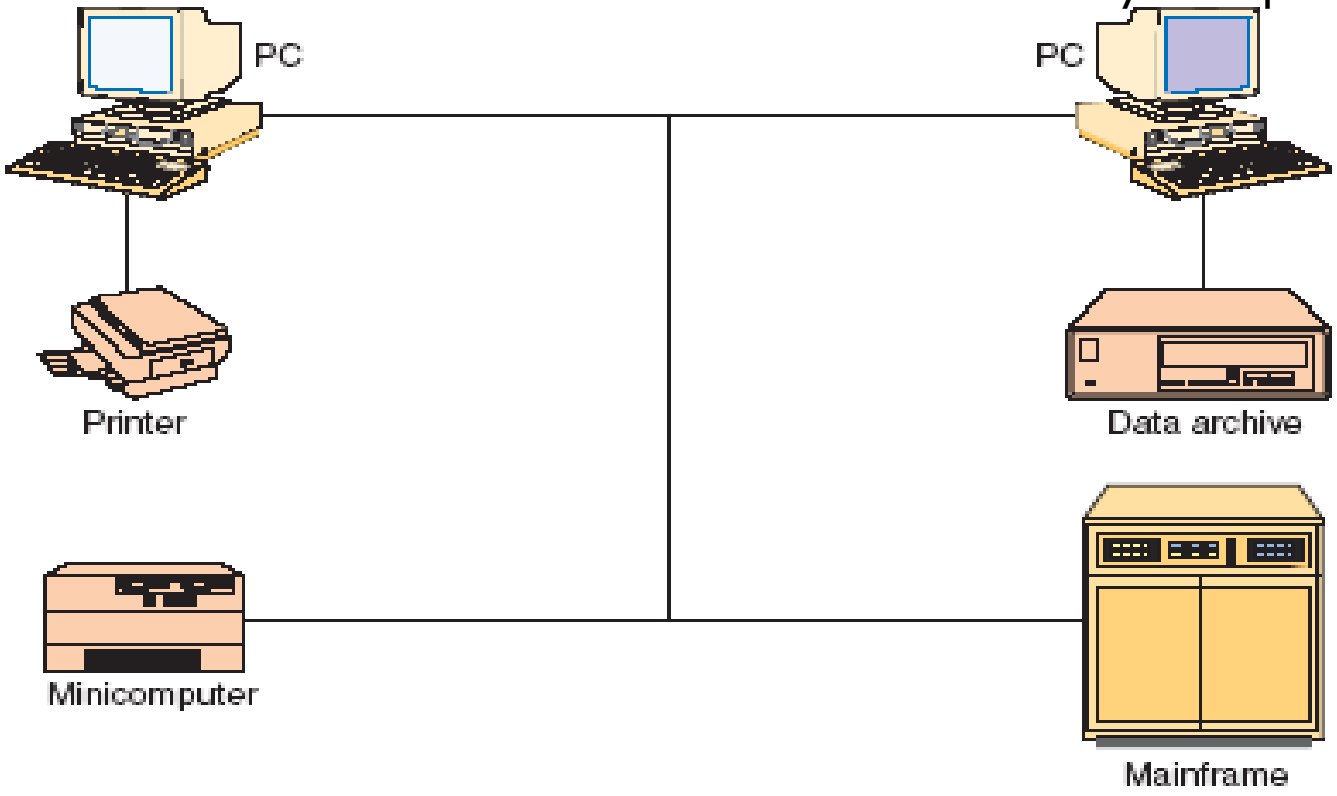
# Network Architecture - Client/Server

There are five models of client/server implementation, depending on the partitioning of the three components between the server and the client.

1. Distributed presentation in which all three components are on the server, but the presentation logic is distributed between the client and the server.
2. Remote presentation in which applications logic and database management are on the server, and the presentation logic is located on the client.
3. Distributed function in which data management is on the server and presentation logic is on the client, with application logic distributed between the two.
4. Remote data management in which database management is on the server, with the other two components on the client.
5. Distributed data management in which all three components are on the client, with database management distributed between the client and the server.

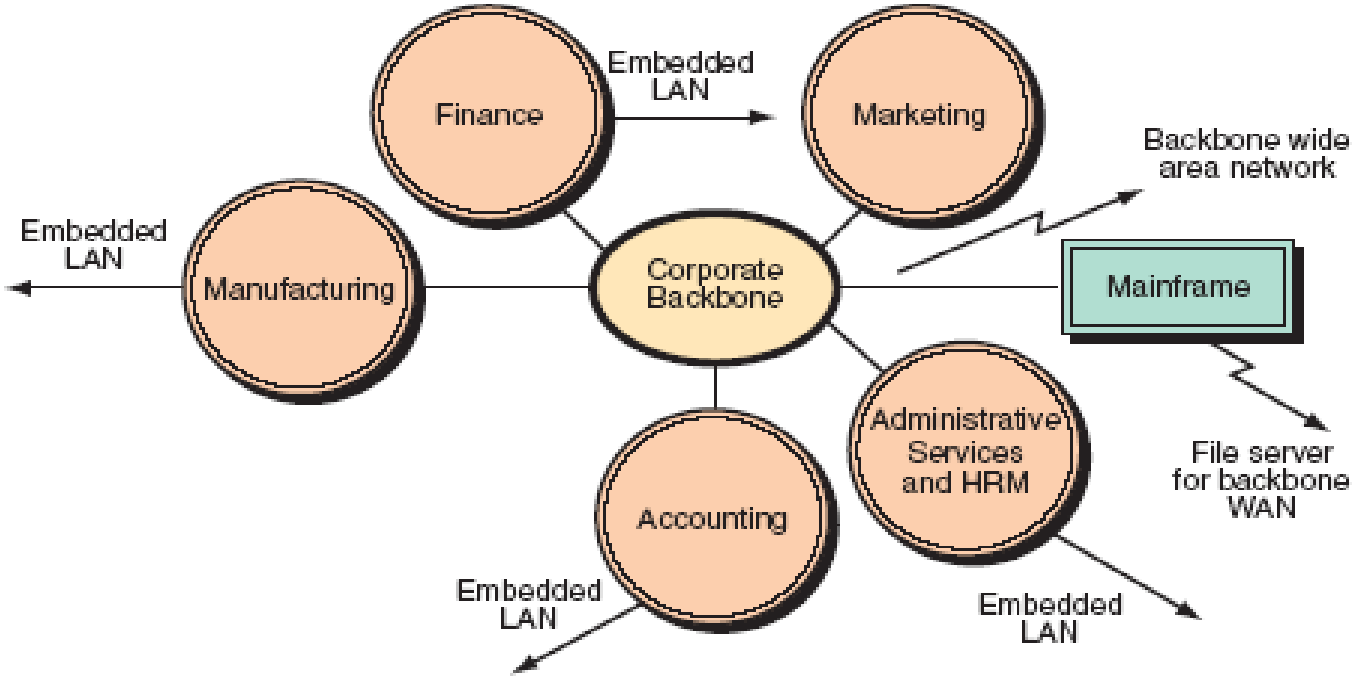
# Network Architecture - Peer-to-Peer

A peer-to-peer network architecture allows two or more computers to pool their resources together. Individual resources like disk drives, CD-ROM drives, and printers are transformed into shared, collective resources that are accessible from every computer.



# Systems and Enterprise Networking

Open systems are those that allow any computing device to be seamlessly connected to and to interact with any other computing device, regardless of size, operating system, or application. Open systems can provide flexibility in implementing IT solutions, optimization of computing effectiveness, and the ability to provide new levels of integrated functionality to meet user demands.



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