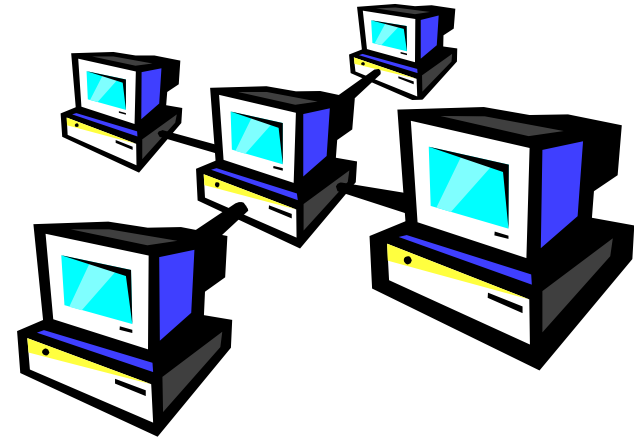


Computer Networks (IN 2510)



Dr. C. Amalraj

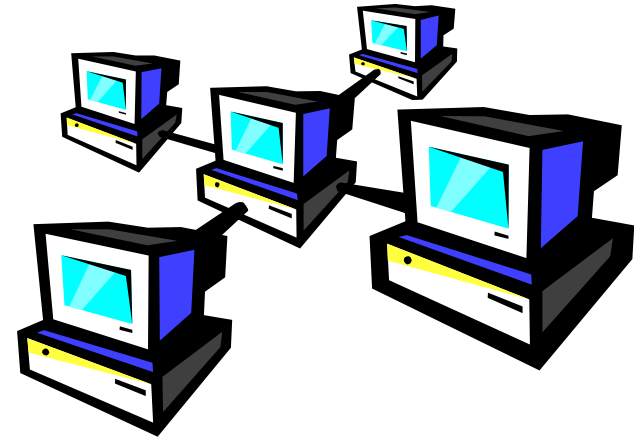
01/12/2020

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Lecture 2:

Networking Fundamentals



Outline

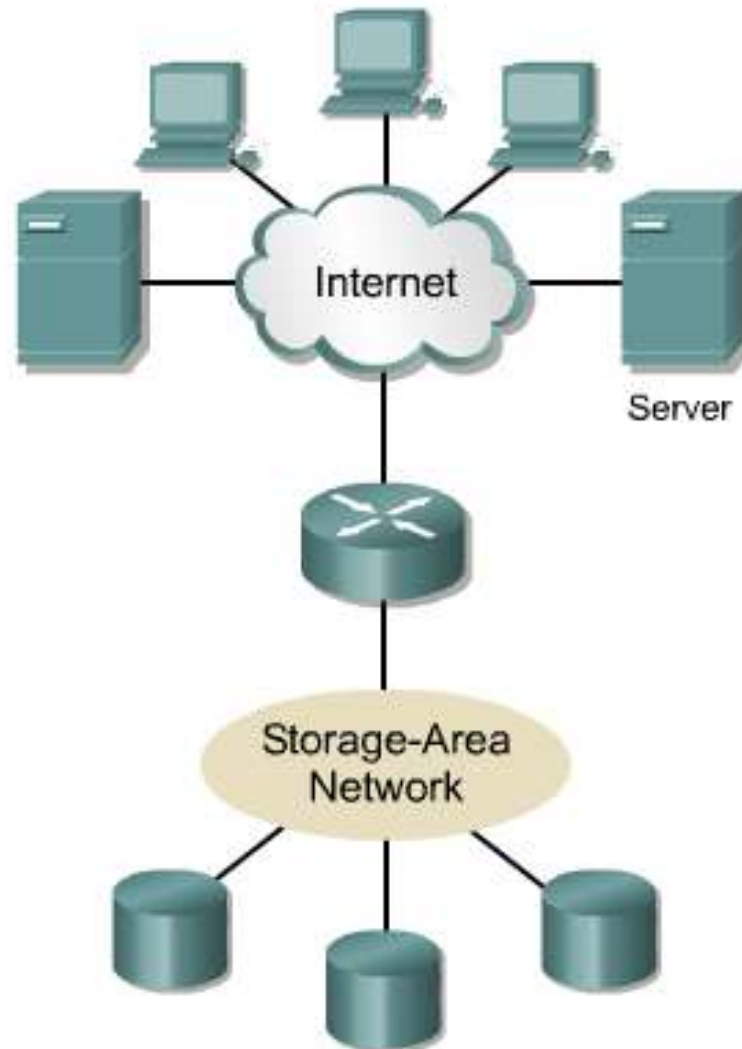
Storage-Area Networks

Controller Area Network

Communication Media

Network Hardware Components

Storage-Area Networks (SANs)



Storage-Area Networks (SANs)

- ❖ A **Storage Area Network** (SAN) is a high-speed special-purpose network (or subnetwork) that interconnects different kinds of data storage devices with associated data servers.
- ❖ Storage is accessed at **block level** not at **file level**
- ❖ SANs are primarily used to enhance storage devices, such as disk arrays, tape libraries, and optical jukeboxes, accessible to servers so that the devices appear like locally attached devices to the operating system.

Benefits Storage-Area Networks

- ❖ Simplifies storage administration
 - Reduce cost
- ❖ Adds flexibility
 - **reason:** cables and storage devices do not have to be physically moved to shift storage from one server to another
- ❖ High Scalability
- ❖ Improved Availability
- ❖ Improved data protection
- ❖ Improved data backup efficiency (disaster recovery)
- ❖ Improved capacity usage
- ❖ Enable storage virtualization

Controller Area Network (CAN)

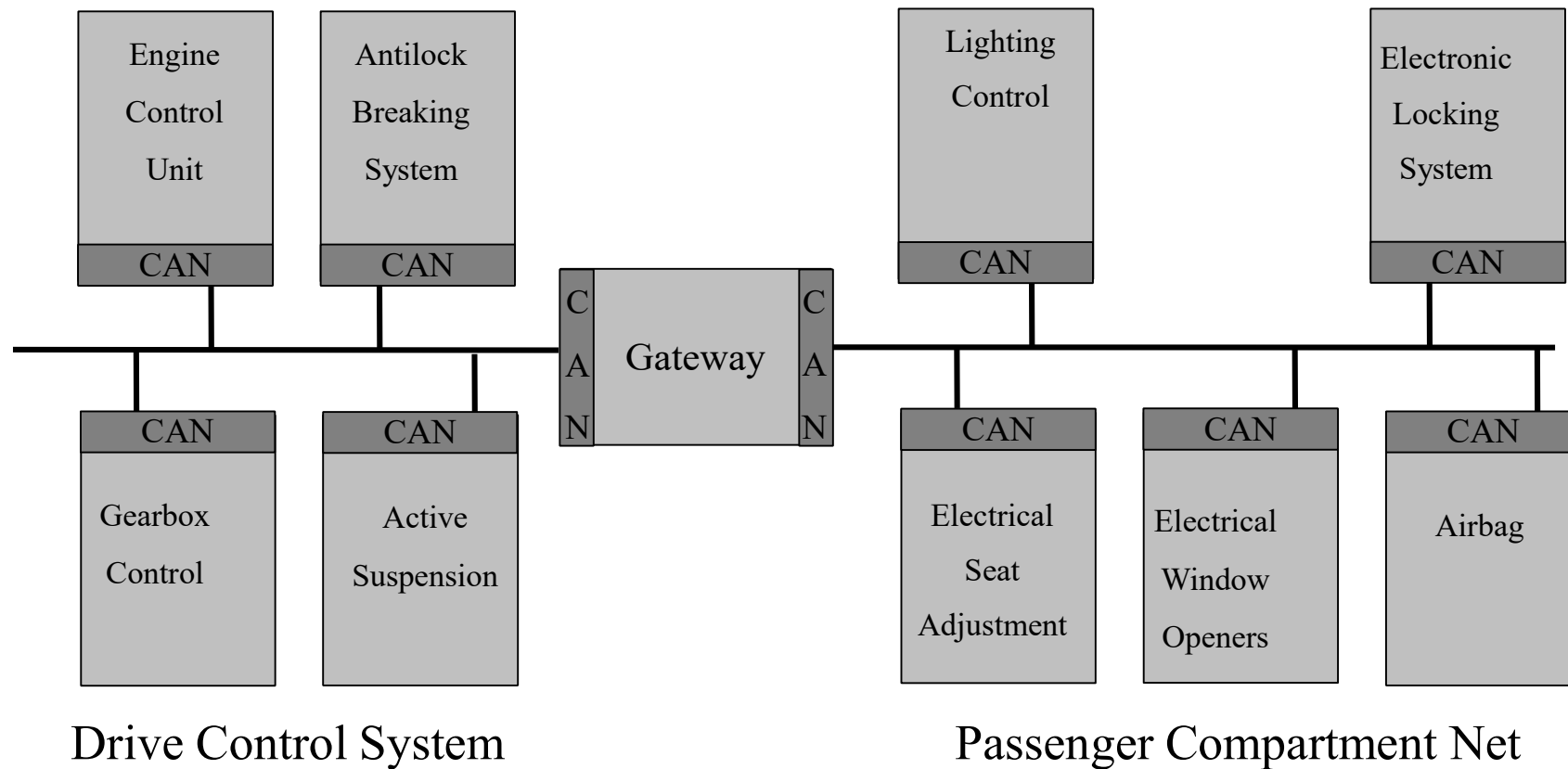
Controller Area Network is a serial bus network of microcontrollers that connects devices, sensors and actuators in a system or sub-system for real-time control applications.

❖ It is a dedicated development of the automotive electronic industry

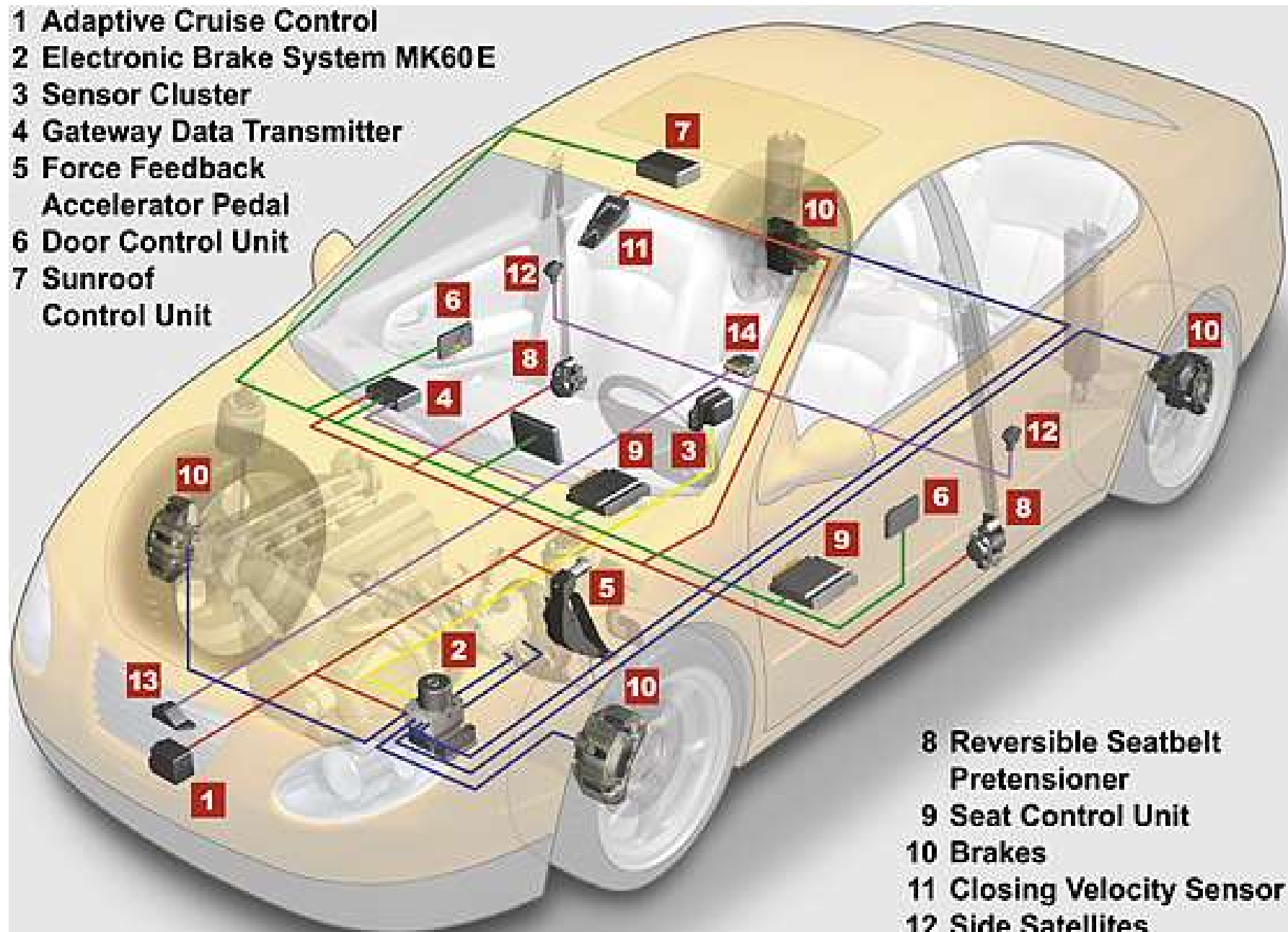
Controller Area Network (CAN)

- ❖ CAN is a **peer-to-peer** network. This means that there is no master that controls when individual nodes have access to read and write data on the CAN bus.
- ❖ When a CAN node is ready to transmit data, it checks to see if the bus is busy and then simply writes a CAN **frame** (protocol data unit) onto the network.
- ❖ CAN is ideally suited in applications requiring a large number of short messages with high reliability.

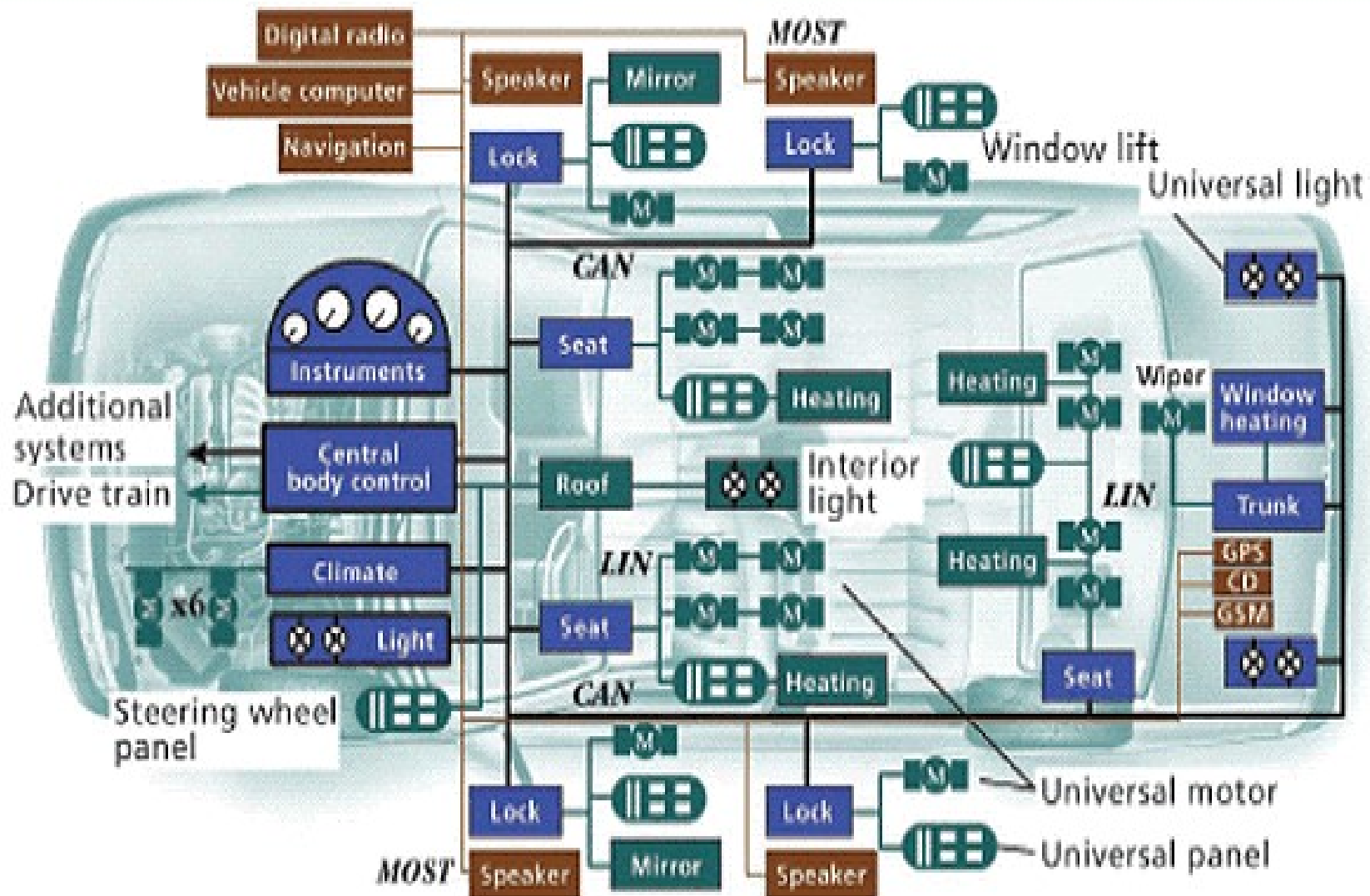
Controller Area Network (CAN)



- 1 Adaptive Cruise Control
- 2 Electronic Brake System MK60E
- 3 Sensor Cluster
- 4 Gateway Data Transmitter
- 5 Force Feedback Accelerator Pedal
- 6 Door Control Unit
- 7 Sunroof Control Unit



- 8 Reversible Seatbelt Pretensioner
- 9 Seat Control Unit
- 10 Brakes
- 11 Closing Velocity Sensor
- 12 Side Satellites
- 13 Upfront Sensor
- 14 Airbag Control Unit



CAN Controller area network
 GPS Global Positioning System
 GSM Global System for Mobile Communications
 LIN Local interconnect network
 MOST Media-oriented systems transport

PEI Technologies

Why is it important to know about CAN ?

- ❖ among the car network systems it is the market leader
- ❖ it is the in car backbone network of BMW, Volkswagen , Daimler-Chrysler , Porsche and more manufacturers
- ❖ CAN covers some unique internal features you can't find elsewhere..
- ❖ there is an increasing number of CAN-applications also outside the automotive industry

CAN Applications

- ❖ CAN was first created for automotive use, so its most common application is **in-vehicle electronic networking**
- ❖ Railway applications
- ❖ Medical equipment manufacturers use CAN as an embedded network in medical devices
- ❖ Hospitals control operating room components such as lights, tables, cameras, X-ray machines, and patient beds with CAN-based systems
- ❖ Lifts and escalators use embedded CAN networks, and hospitals use the CANopen protocol to link lift devices, such as panels, controllers, doors, and light barriers, to each other and control them.
- ❖ CANopen is also used in nonindustrial applications such as laboratory equipment, sports cameras, telescopes, automatic doors, and even coffee machines.

CAN Benefits

- ❖ Low-Cost, Lightweight Network
- ❖ Broadcast Communication
 - Each of the devices on the network has a CAN controller chip and is therefore intelligent. Each device can decide if a message is relevant or if it should be filtered. This structure allows modifications to CAN networks with minimal impact.
- ❖ Priority
 - Every message has a priority, so if two nodes try to send messages simultaneously, the one with the higher priority gets transmitted and the one with the lower priority gets postponed.
- ❖ Error Capabilities

CAN Limitations

- ❖ Unfair access - node with a high priority can "hog" the network.
- ❖ High latency for low priority nodes.

Types of Networks

- ❖ **Intranet** – An intranet is a private LAN designed for use by everyone within an organization.
 - protected from unauthorized external access by means of a network **gateway** and **firewall**
 - may be created simply by using private IP address ranges, such as 192.168.0.0/16
- ❖ **Extranet** – a network that connects people within your company with people who are outside your company -- all within a secure, password-protected network that can be accessed from anywhere.

Communications Media

❖ *Communications Channel*

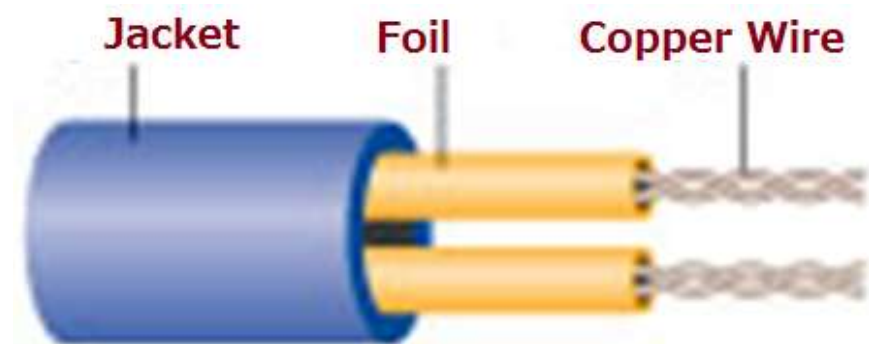
- To transfer data from one computer to another requires some type of link through which the data can be transmitted. This link is known as the *communications channel*.
- To send data through the channel requires some type of *transmission media*, which may be either physical or wireless.

Physical Media

- ❖ *Twisted-pair cable* – consists of two independently insulated wires twisted around each other (least expensive type of cable—the kind that is used in many telephone systems)
- ❖ *Coaxial cable* – consists of an insulated center wire grounded by a shield of braided wire (the primary type of cabling used by the cable television industry; it is more expensive than twisted pair)
- ❖ *Fiber-optic cable* – contains hundreds of clear fiberglass or plastic fibers (threads) (made from thin, flexible glass tubing; bandwidth is greater, so it can carry more data; it is lighter than metal wires and is less susceptible to interference; it is fragile and expensive)
- ❖ *ISDN line* – a special digital telephone line that transmits and receives information at very high speeds

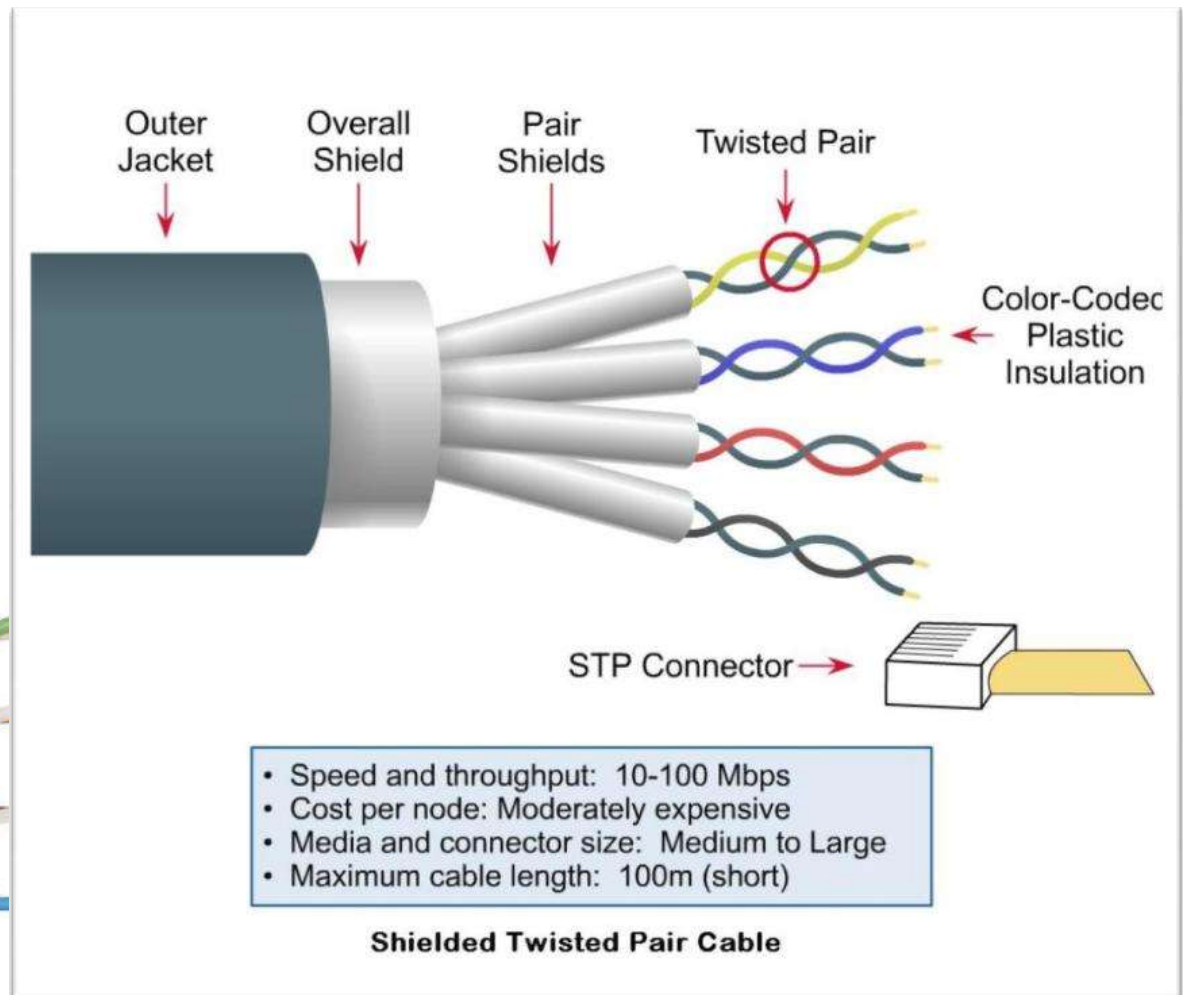
Twisted Pair (Wire Pair)

- ❖ Inexpensive
- ❖ Good performance in short distances
- ❖ Easy to install
- ❖ Susceptible to electrical interference (noise)
- ❖ Physical characteristics
 - Requires two conductors
 - Twisted around each other to reduce electrical interference
 - Plastic sheath
- ❖ Two Types
 - Unshielded Twisted Pair (UTP)
 - Shielded Twisted Pair (STP)



Shielded Twisted Pair

- ❖ Shielded twisted pair
 - Metallic protective sheath
 - Reduces noise
 - Increases speed



Categories of UTP: CAT 5

- ❑ 100 MHz Bandwidth
- ❑ 24.0 dB Attenuation
- ❑ 100 ohms Impedance
- ❑ Used for high-speed data transmission
- ❑ Used in 10BaseT (10 Mbps) Ethernet & Fast Ethernet (100 Mbps)

Categories of UTP: CAT 5e

- ❑ 150 MHz Bandwidth
- ❑ 24.0 dB Attenuation
- ❑ 100 ohms Impedance
- ❑ Transmits high-speed data
- ❑ Used in Fast Ethernet (100 Mbps), Gigabit Ethernet (1000 Mbps) & 155 Mbps ATM

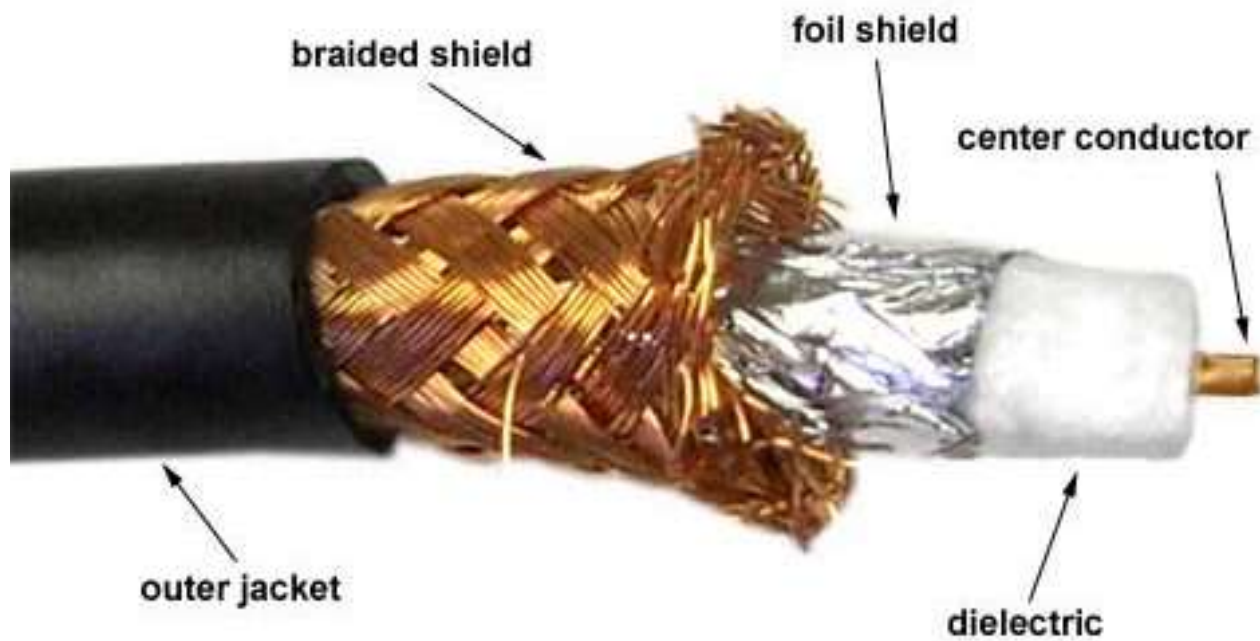
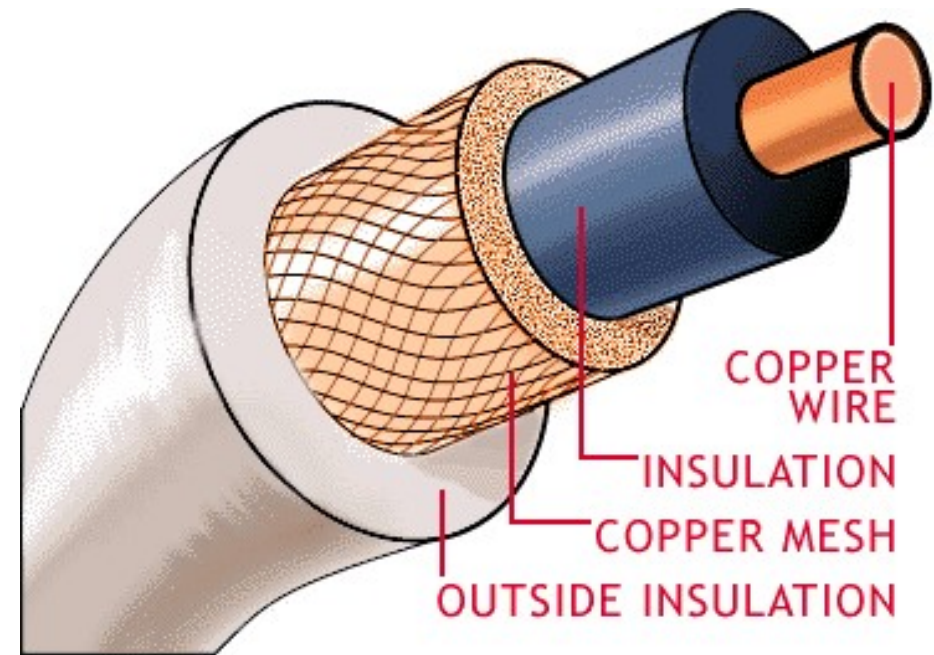
Categories of UTP: CAT 6

- ❑ 250 MHz Bandwidth
- ❑ 19.8 dB Attenuation
- ❑ 100 ohms Impedance
- ❑ Transmits high-speed data
- ❑ Used in Gigabit Ethernet (1000 Mbps) & 10 Gig Ethernet (10000 Mbps)

Categories of UTP: CAT 6a

	Cat6	Cat6a
Speed	10 Gbps over 33-55 meters (110-165 feet) of cable	10 Gbps over 100 meters (330 feet) of cable
Frequency	Up to 250 MHz	Up to 500 MHz
Maximum cable length	100 meters for slower network speeds (up to 1,000 Mbps) and higher network speeds over short distances. For Gigabit Ethernet, 55 meters max, with 33 meters in high crosstalk conditions.	100 meters across all systems and conditions for Gigabit Ethernet.

Coaxial Cable



Coaxial Cable

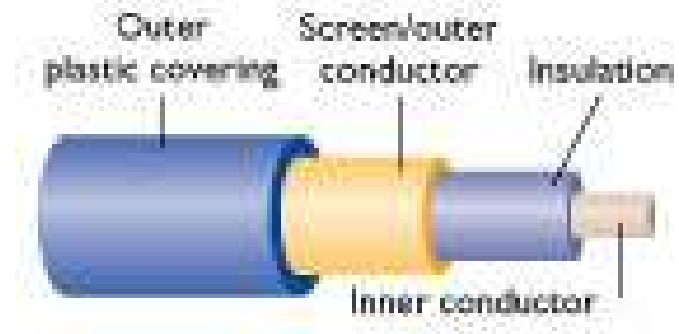
- ❖ At one time, coaxial cable was the most widely used network cabling
- ❖ Coaxial was relatively inexpensive, and it was light, flexible, and easy to work with
- ❖ It was so popular that it became a safe, easily supported installation
- ❖ Coaxial cable is very durable
- ❖ Coaxial cable can support greater cable lengths between network devices than twisted pair cable

Coaxial Cable

In its simplest form, coaxial consists of a core made of solid copper surrounded by insulation, a braided metal shielding, and an outer cover. One layer of foil insulation and one layer of braided metal shielding is referred to as dual shielded. However, quad shielding is available for environments that are subject to higher interference. Quad shielding consists of two layers of foil insulation and two layers of braided metal shielding.

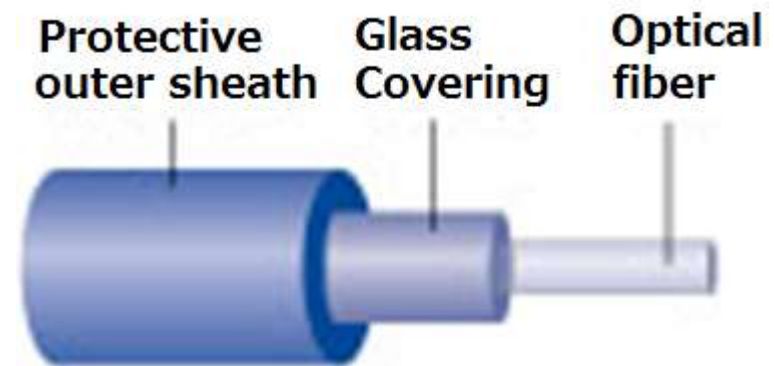
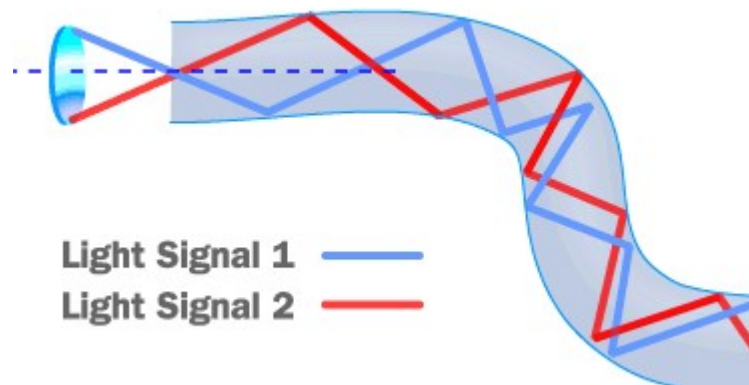
Coaxial Cable

- ❖ Higher bandwidth
- ❖ Less susceptible to noise
- ❖ Used in cable TC systems
- ❖ Physical characteristics
 - Center conductor wire
 - Surrounded by a layer of insulation
 - Surrounded by a braided outer conductor
 - Encased in a protective sheath



Fiber-Optic Cables

- ❖ Physical characterizes
 - Glass or plastic fibers
 - Very thin (thinner than human hair)
 - Material is light
- ❖ Fiber-optic cable is good for very high-speed, high-capacity data transmission because of the lack of attenuation and the purity of the signal



Fiber-Optic Cables

- ❖ optical fibers carry digital data signals in the form of modulated pulses of light
- ❖ Higher bandwidth
- ❖ relatively safe way to send data
 - because no electrical impulses are carried over the fiber-optic cable
 - fiber-optic cable cannot be tapped and the data stolen, which is possible with any copper-based cable carrying data in the form of electronic signals

Single and Multimode Fiber

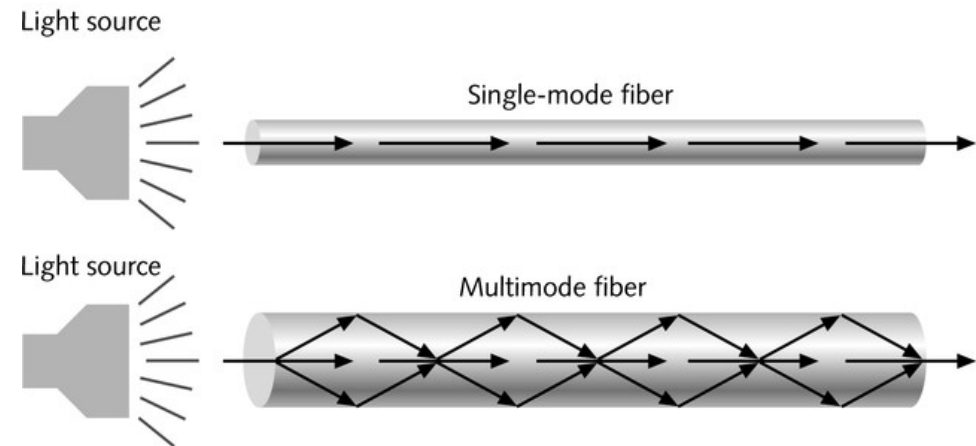
Single-mode fiber

- Carries light pulses along single path

- Uses Laser Light Source

Multimode fiber

- Many pulses of light generated by LED travel at different angles

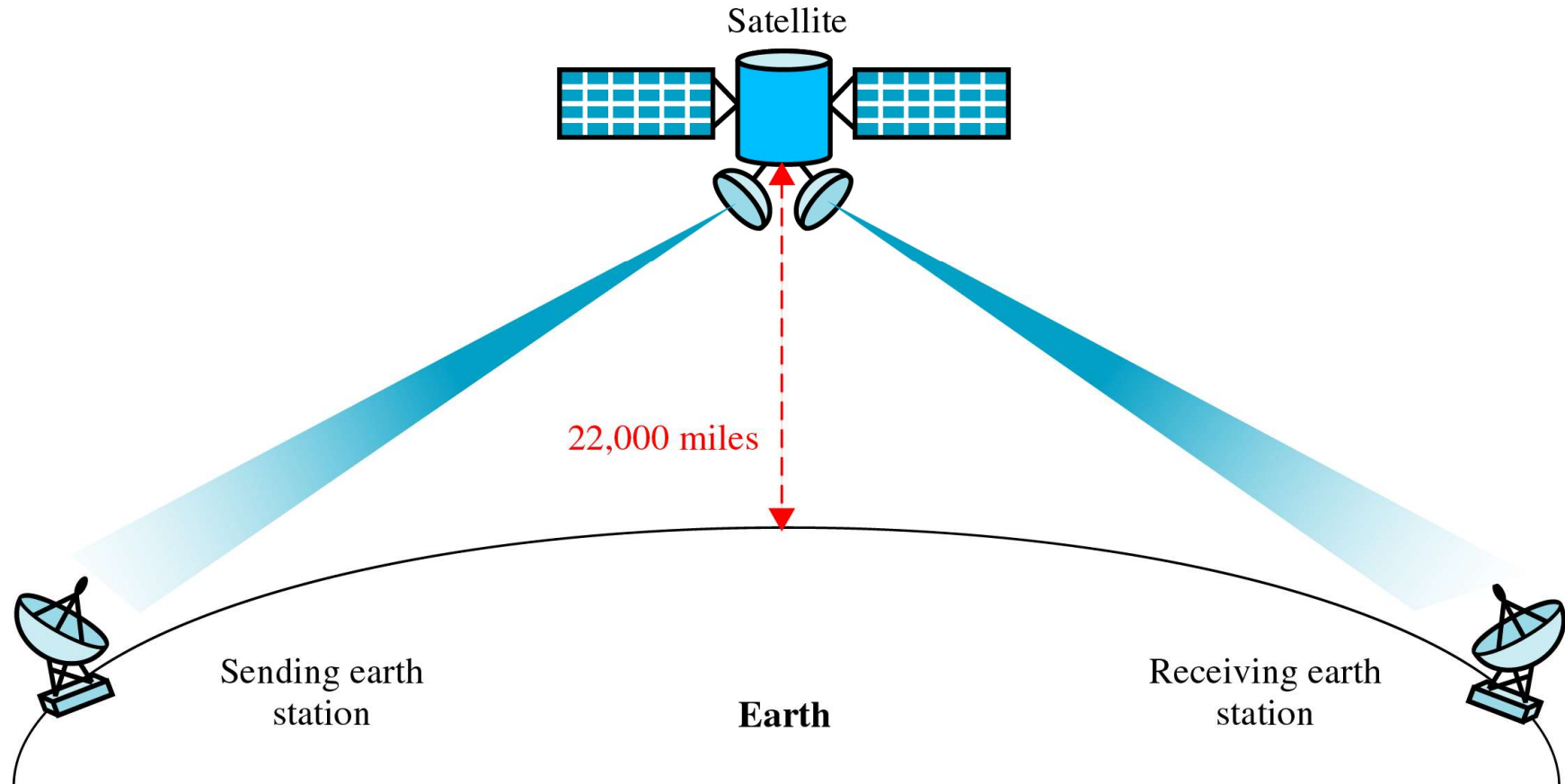


Wireless Media

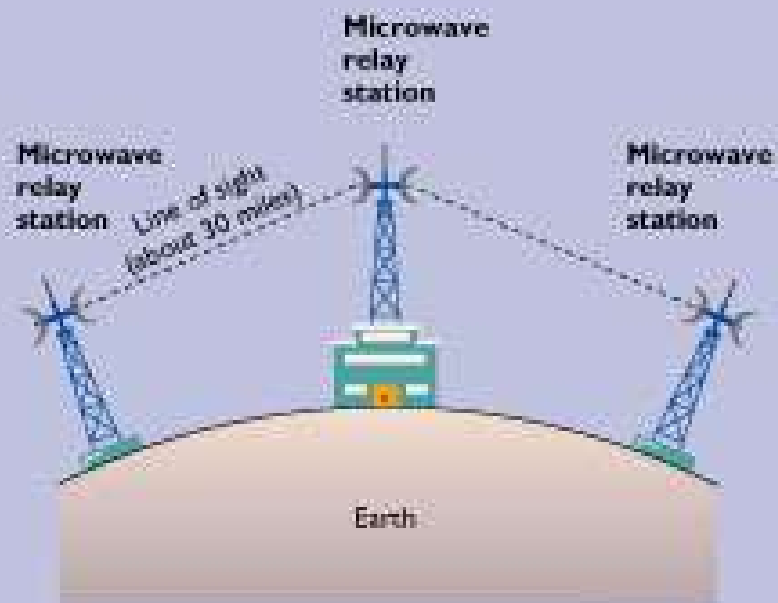
- ❖ *Microwave system* – transmits data via high-frequency radio signals through the atmosphere
- ❖ *Satellite system* – receive transmitted signals, amplify them, and then transmit the signals to the appropriate locations
- ❖ *Cellular technology* – uses antennae resembling telephone towers to pick up radio signals within a specific area (cell)
- ❖ *Infrared technology* – transmits data as infrared light waves from one device to another, providing wireless links between PCs and peripherals

Note: *The type selected* is determined by the type of network, the size of the network, and the cost.

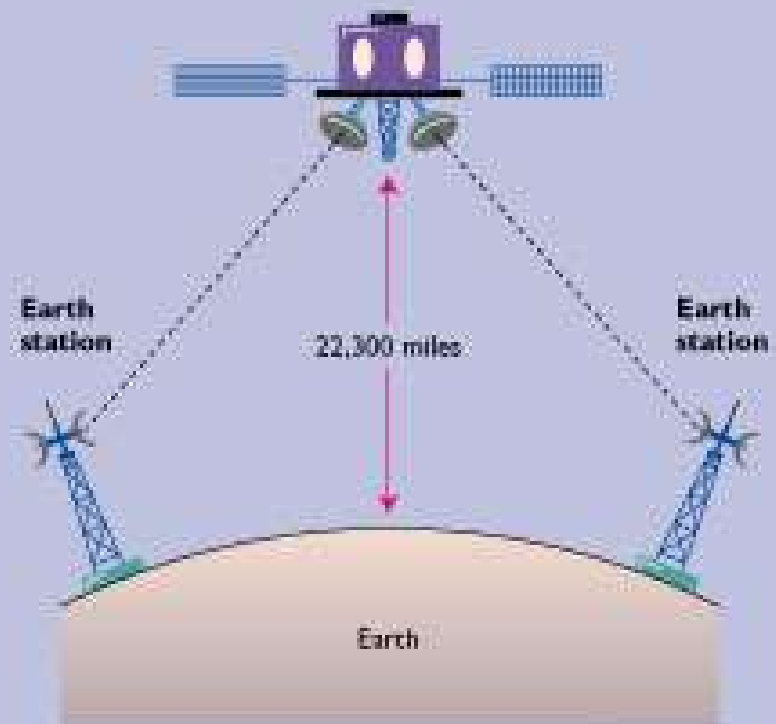
Satellite Transmission



Satellite Transmission



(a)



(b)

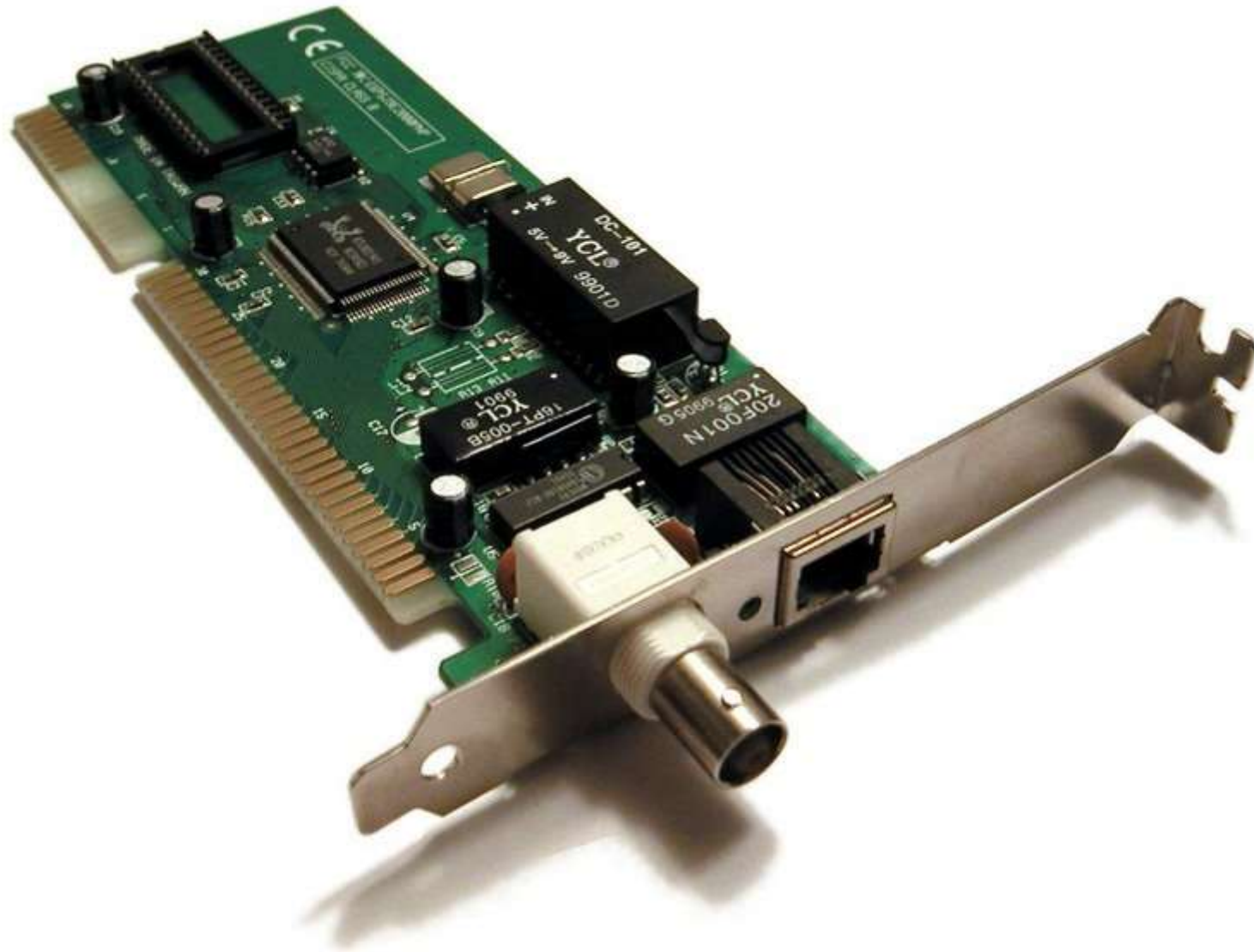
Basic Network Hardware Components

- ❖ *Network Interface Cards (NICs)*
- ❖ *Cables*
- ❖ *Connecters*
- ❖ *Servers*
- ❖ *Workstations*

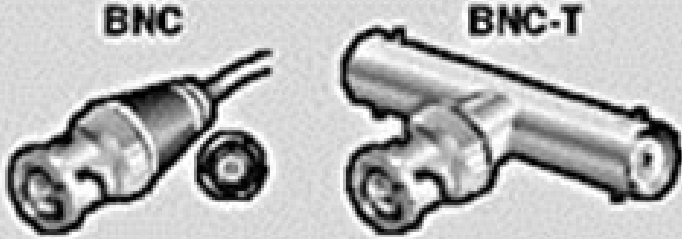
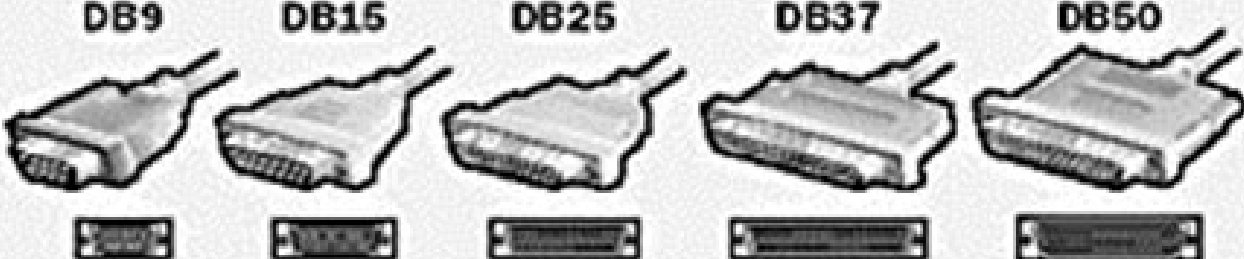
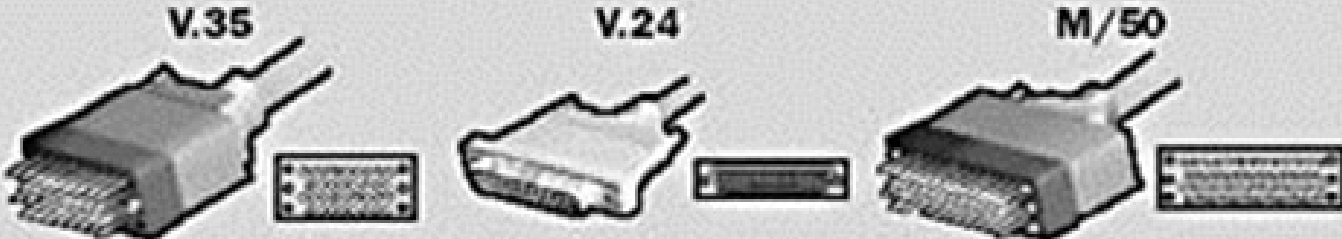

Internetworking Hardware Components

- ❖ *Line drivers or Repeaters*
- ❖ *Transceivers*
- ❖ *Hubs*
- ❖ *Bridges*
- ❖ *Switches*
- ❖ *Routers*
- ❖ *Gateways*

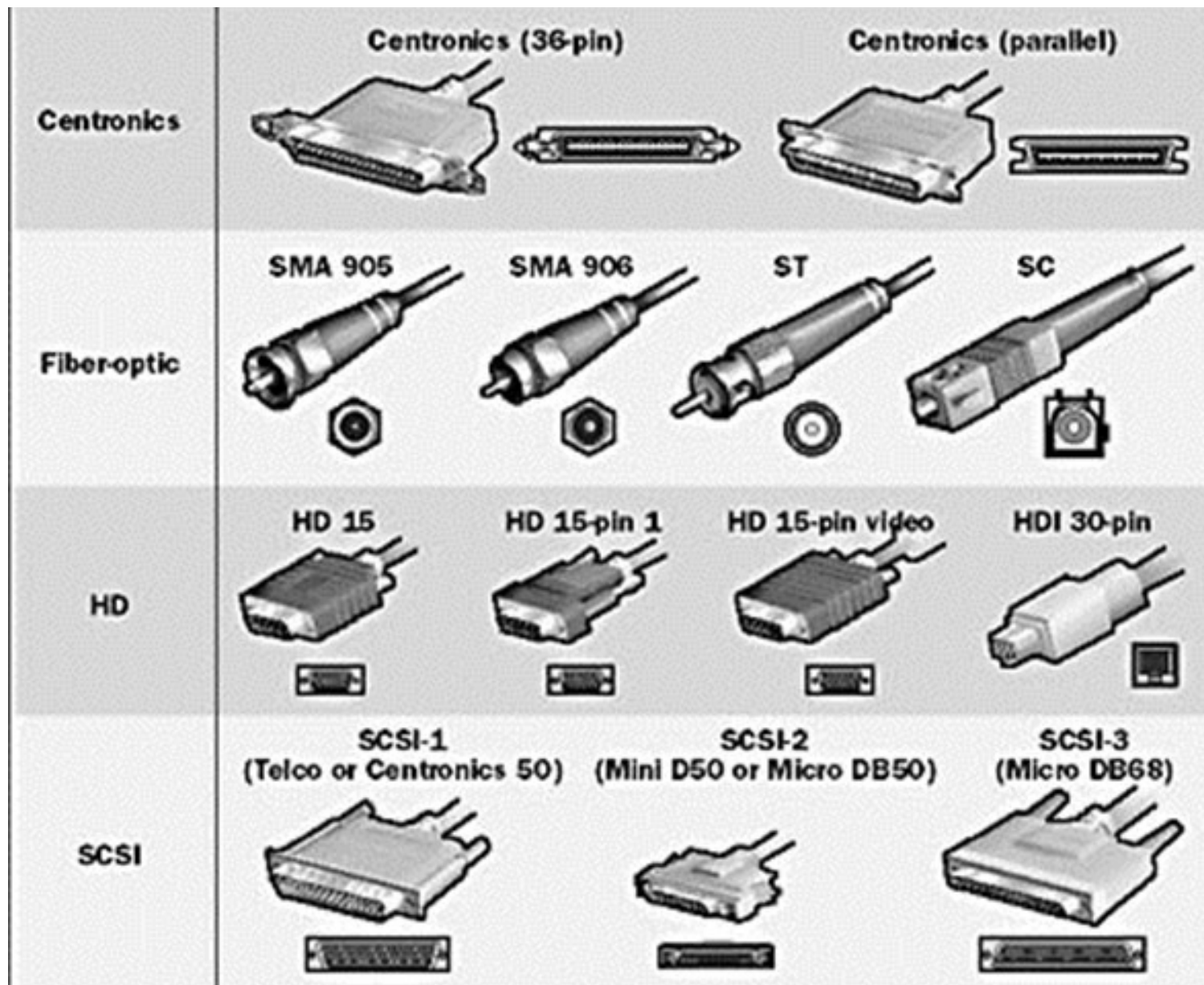
Network Interface Card (NIC)



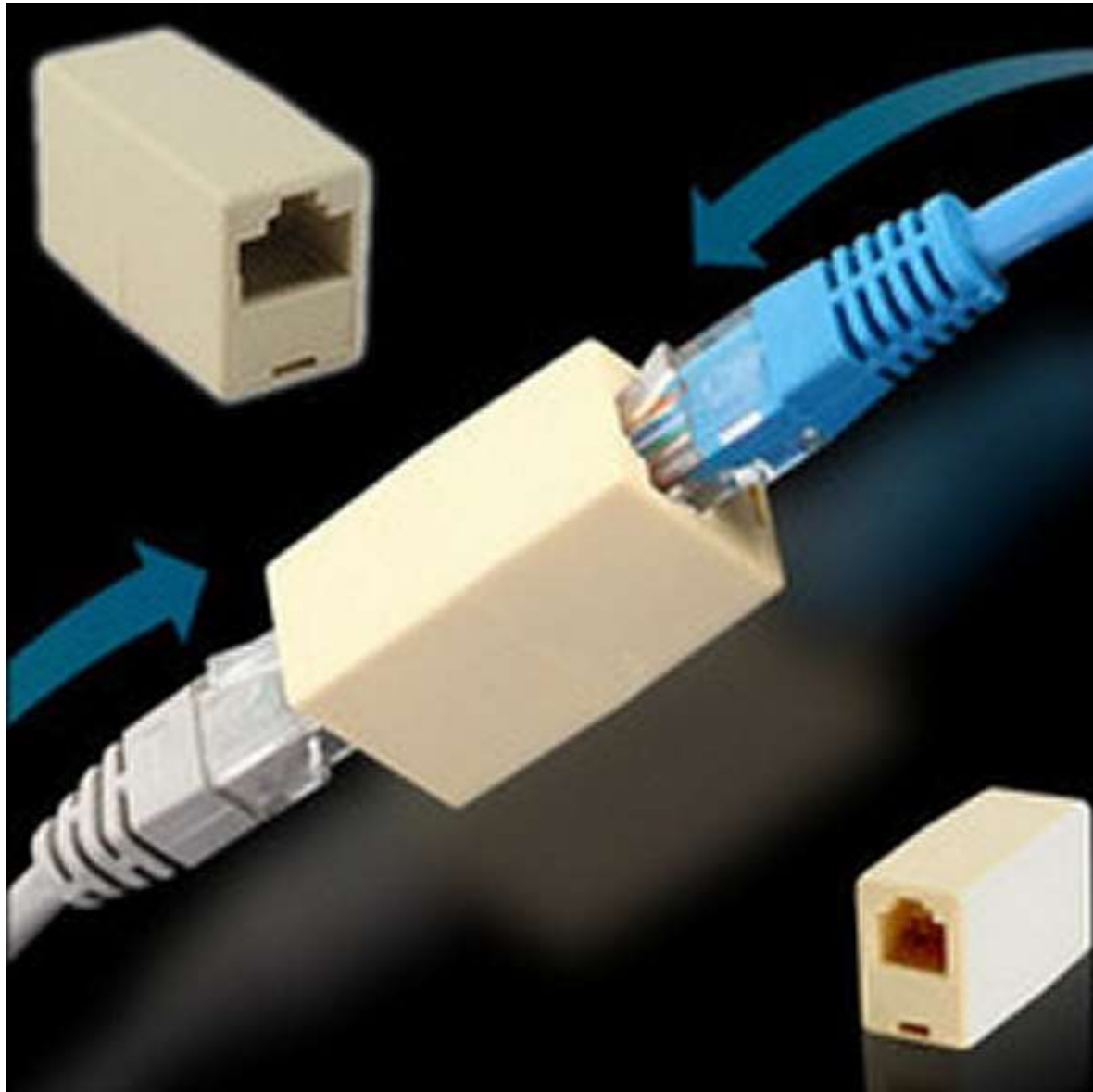
Network Connectors (1)

BNC	 <p>BNC BNC-T</p>
DB	 <p>DB9 DB15 DB25 DB37 DB50</p>
V series	 <p>V.35 V.24 M/50</p>
Modular	 <p>RJ-11 (4-wire) RJ-12 (6-wire) RJ-45 (8-wire)</p>

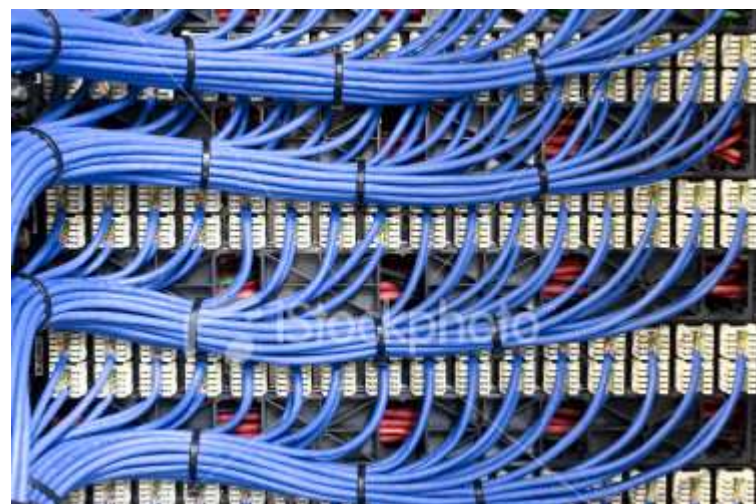
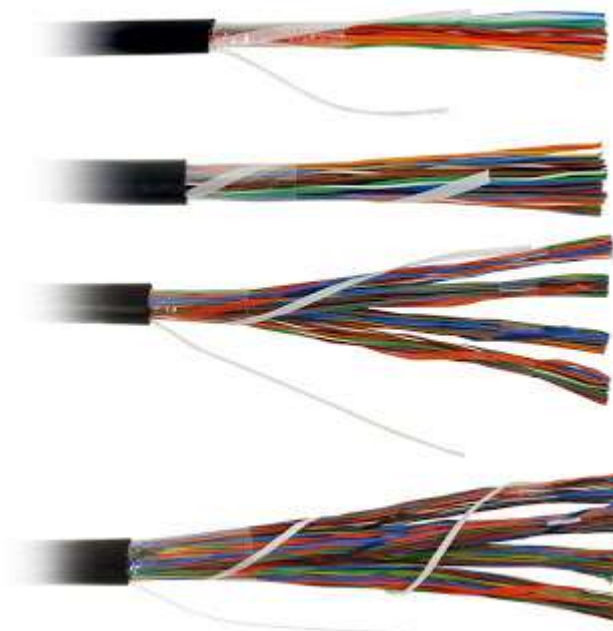
Network Connectors (2)



RJ45 Cable Connector



Network Cables



Network Servers

A network server is a computer designed to process requests and deliver data to other (client) computers over a local network or the Internet.

Examples include Web servers, proxy servers, and FTP servers.

Note: Not only should you learn about servers on the Internet, private network servers for business and personal use are also becoming more common.

Workstations

- ❖ A workstation is a computer designed for professional use by a single user
- ❖ It usually has more capacity than a personal computer, but is not as high-powered as a mainframe computer that is designed to support very complex calculations and multiple users
- ❖ Workstations provide people with computing power for a variety of tasks that may require high power

IP Addresses

“IP” stands for Internet Protocol. IP Addresses serve as the location of websites on the Internet as well as the workstations that are connected to the web. IP addresses are made up of four sets of numbers called “**Octets**”. There are two types of IP Addresses: Static and Temporary. Below is a description of both.

Static IP Addresses

Static IP addresses are found only on servers and remain the same.

A **Domain Name Server** assigns a “human readable” web address to each static IP address to make it more user friendly.

Temporary IP Addresses

Temporary IP addresses are found only on PC's are constantly changing each time it is logged on.

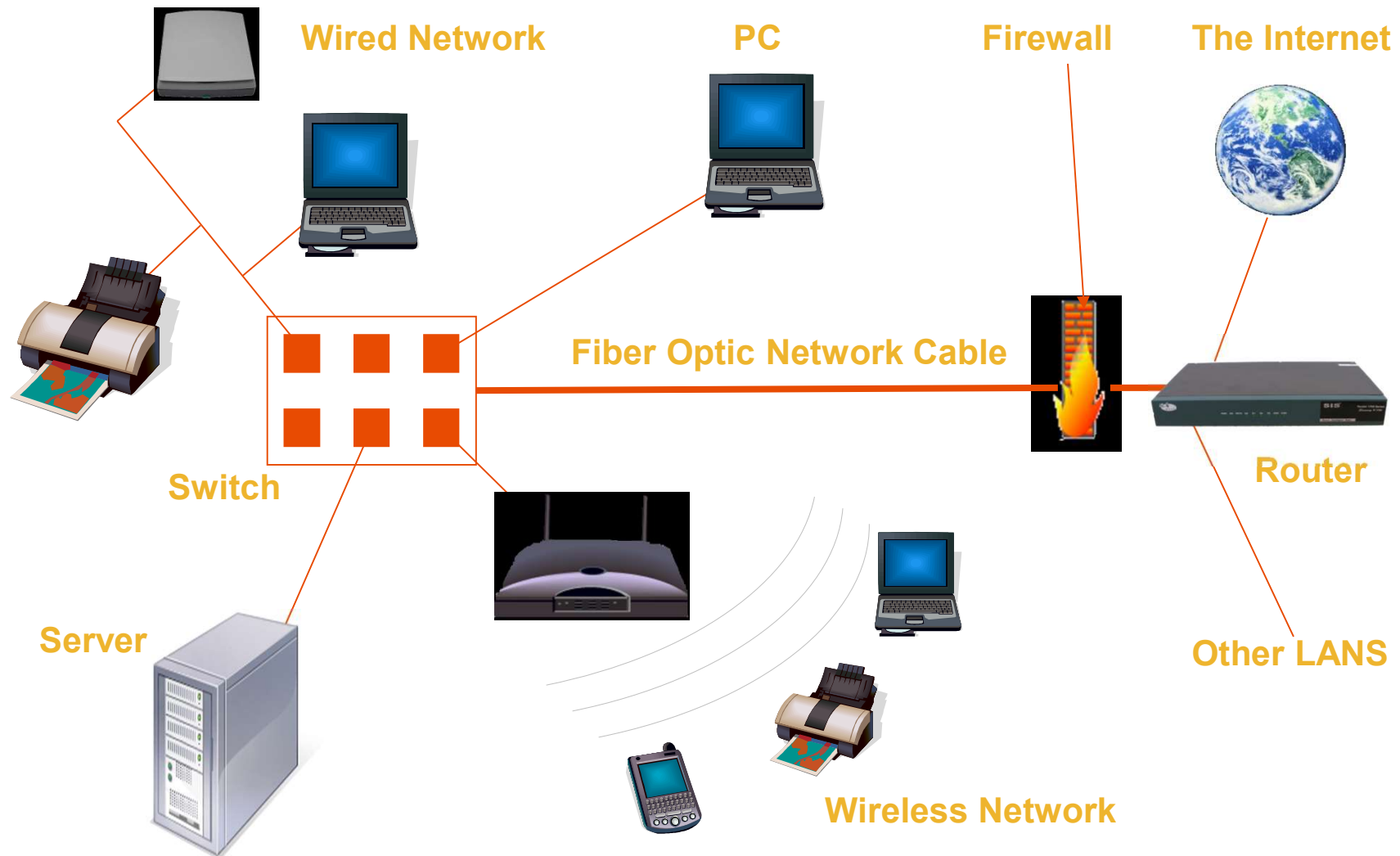
Temporary IP addresses are assigned by an ISP (Internet Service Provider) each time it is logged on to the Internet.

Main Network Hardware Components

Main Network Hardware Components

- ❖ **Hub** – electronic device (with a number of ports) used in a LAN to link groups of computers
- ❖ **Repeaters** (also called amplifiers) – electronic devices that receive signals and amplify and send them along the network
- ❖ **Routers** - electronic devices used to ensure messages are sent to their intended destinations
- ❖ **Gateway** – consists of hardware and/or software that allows communications between dissimilar networks
- ❖ **Bridge** – consists of hardware and/or software that allows communication between two similar networks

Why Interconnect?



Why Interconnect?

- ❖ To separate / connect one corporate division with another.
- ❖ To connect two LANs with different protocols.
- ❖ To connect a LAN to the Internet.
- ❖ To break a LAN into segments to relieve traffic congestion.
- ❖ To provide a security wall between two different types of users.
- ❖ To connect WLAN to LAN
- ❖ Remote Access

Introduction

Many times it is necessary to connect a LAN to another LAN or to a WAN.

Computers within a LAN are often connected using a **hub**

LAN to LAN connections are often performed with a **bridge**.

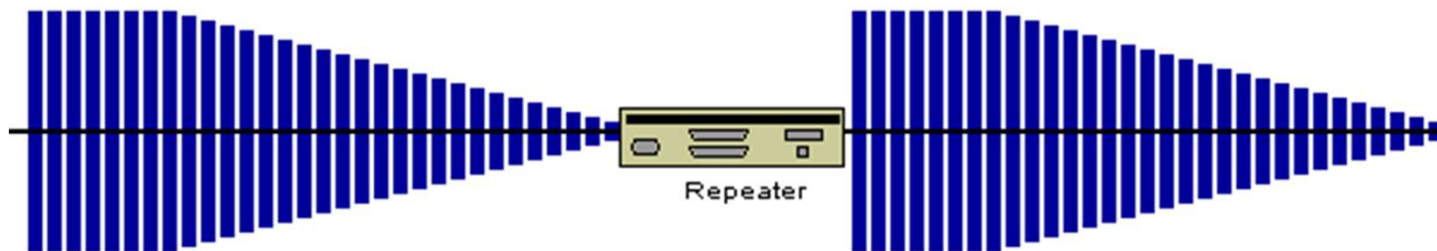
Segments of a LAN are usually connected using a **switch**.

LAN to WAN connections are usually performed with a **router**.

Repeaters

A common problem in the networking world is that of weakening electrical signals. Electrical signals traveling through wires (such as copper wires used in most networks), weaken due to the wire's electrical resistance. This effect limits the lengths of the cable that can be used. A repeater will overcome this limit, when there is a need to connect two computers at a larger distance.

A repeater is connected to two cable segments. Any electrical signal reaching the repeater from one segment, will be amplified and retransmitted to the other segment.



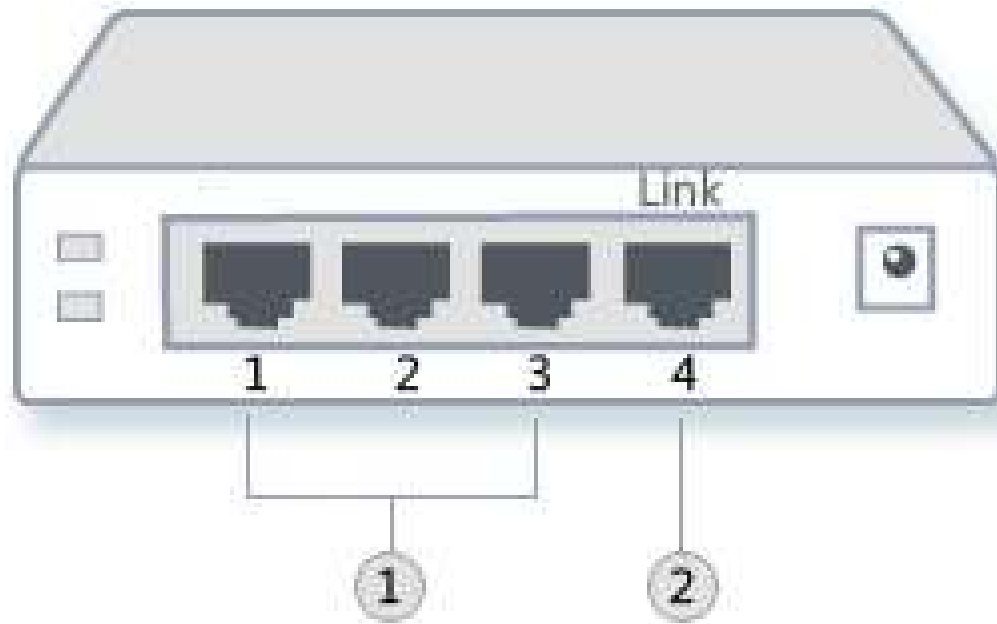
An illustration of a repeater at work

The electrical signal entering the repeater at one end is weakened. The repeater amplifies the electrical signals and resends the data.

Hubs (or Multi-port Repeaters)



Hubs (or Multi-port Repeaters)



- ① Ports for computers
- ② Ports for connecting to a router, another hub or a switch (typically labeled “Link” / “Uplink” / “Out”)

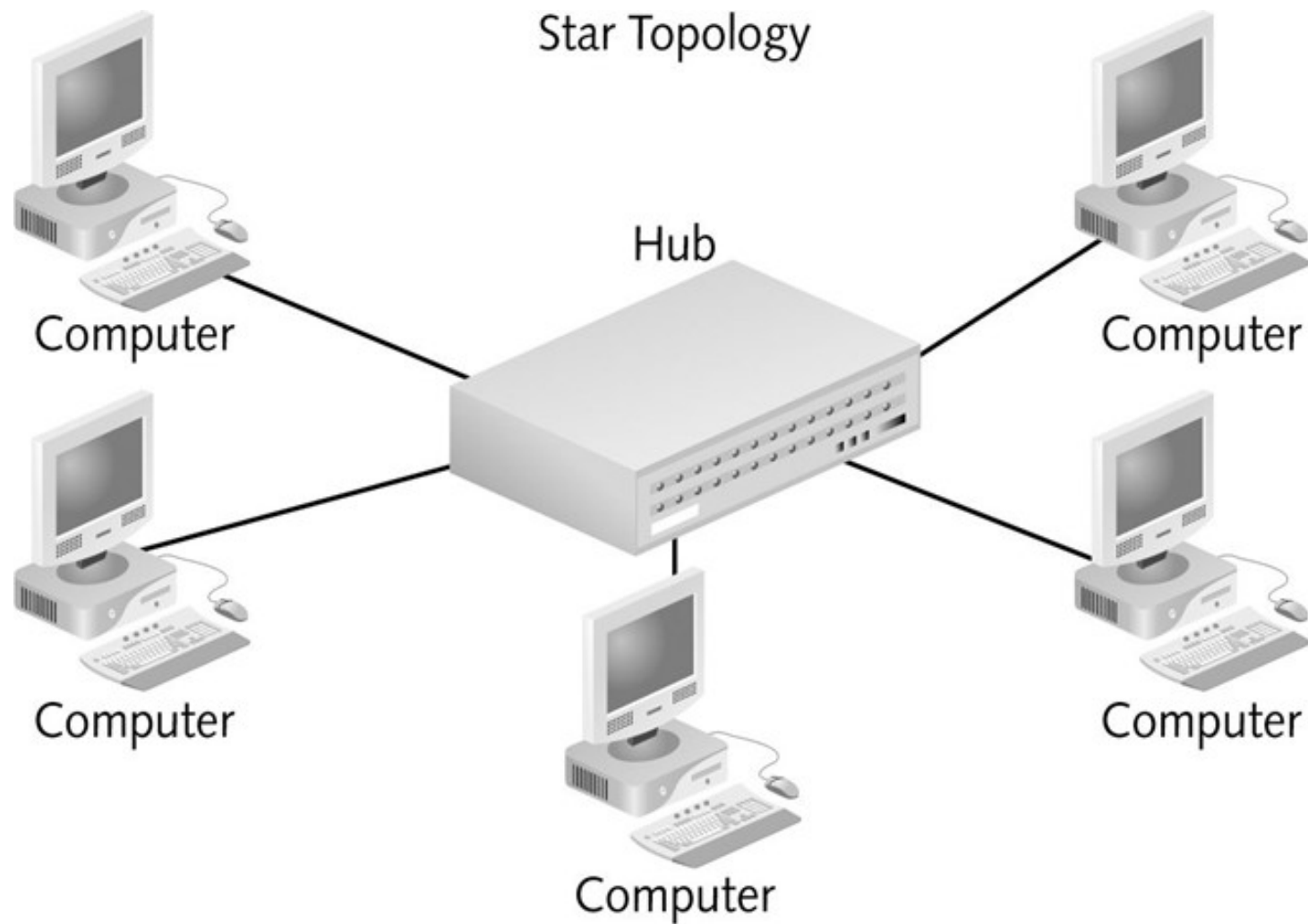
Hubs (or Multi-port Repeaters)

A hub interconnects two or more workstations into a local area network.

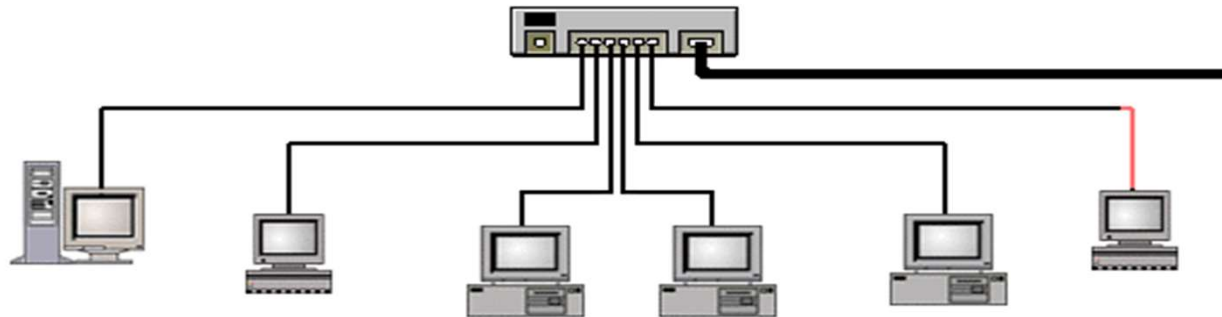
When a workstation transmits to a hub, the hub immediately resends the **data frame** to all connecting links.

Hubs expand one Ethernet connection into many. For example, a four-port hub connects up to four machines.

Hubs



Hubs

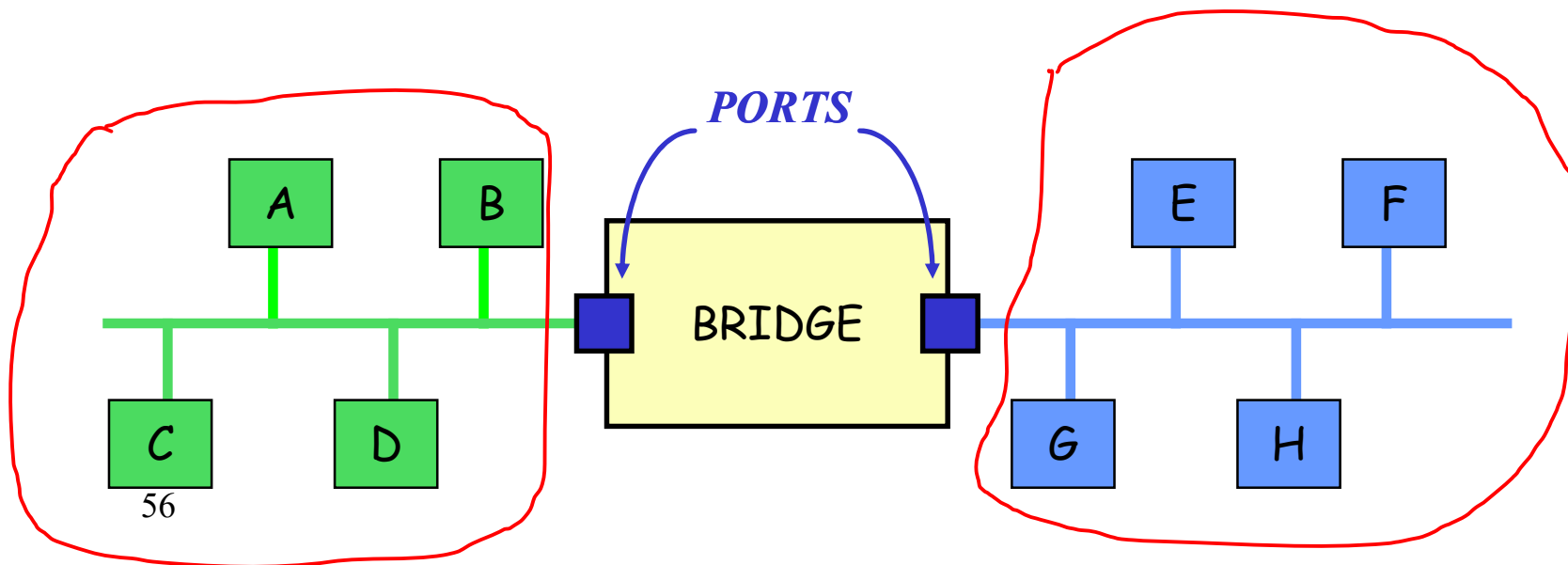


The original Ethernet LANs relied on certain physical characteristics of the cable carrying the network data (usually coaxial cable). New Ethernet technologies introduced new cable types that were unable to fulfill the original physical requirements. New devices - hubs - were introduced to simulate those characteristics.

Simply put, the hub's major function is to replicate data it receives from one device attached to it to all others.

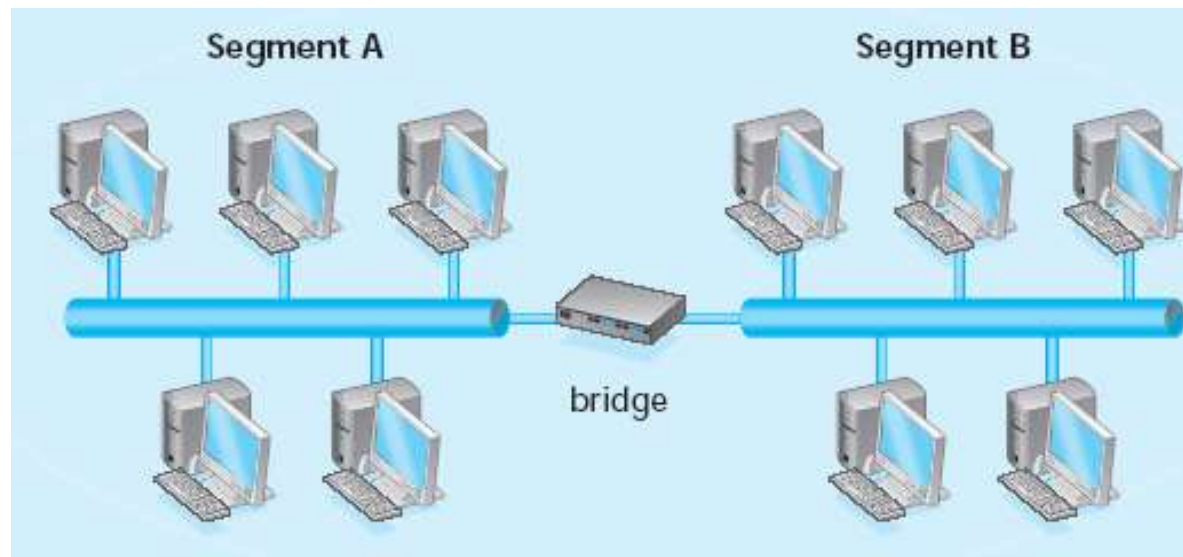
Bridge

- ❖ A device that connects two local-area networks (LANs), or two segments of the same LAN that use the same protocol, such as **Ethernet** or **Token-Ring**
- ❖ A bridge connects networks and forwards **frames** from one network to another.



Bridges

- ❖ Information only cross the bridge if they are addressed for a host on the other side (selective forwarding).
- ❖ No hosts on Segment B will receive information from host to host communication on Segment A as they will be blocked by the bridge.
- ❖ Bridges are usually used on RG58 networks and are not commonly used today except in wireless networks.



Switches (or Multi-port Bridges)

- ❖ A switch divides a LAN so that each host has its own segment.
- ❖ You connect twisted pair cable with RJ45 connectors to ports on a switch. A switch can have as many as 96 ports.
- ❖ Switches filter traffic based on MAC address. Information will only be forwarded to the port that connects to the host with the destination MAC address. To hosts on all other ports of the switch, it appears as there is no network traffic.



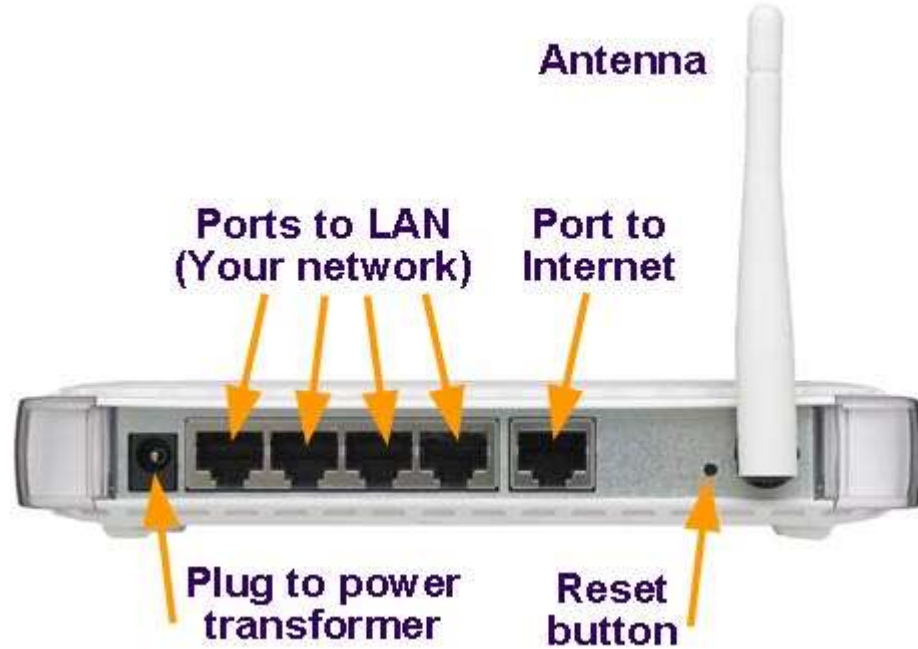
Switches

- ❖ Only when two separate hosts attempt to communicate with the same third host do collisions occur.
- ❖ Switches learn which MAC addresses are associated with particular ports by noting source addresses as frames enter the switch.
- ❖ **Broadcast frames** are forwarded to all ports of a switch.
- ❖ Switches can send and receive information at the same time, so they can send information faster than hubs can

difference between a bridge and a switch

1. Switches have many ports, bridges only have two (or some other small number)
 2. Switches perform forwarding in hardware, while bridges perform it in software
 - bridge may introduce **overhead**
 - A switch must be able to maintain the full wire speed of the medium between any two ports
- ❖ **Some are unsatisfied with these answers because:**
1. The IEEE standards clearly don't state or assume that bridges will have only two ports
 2. There's nothing in the standard that says bridging must or should be done in software

Routers



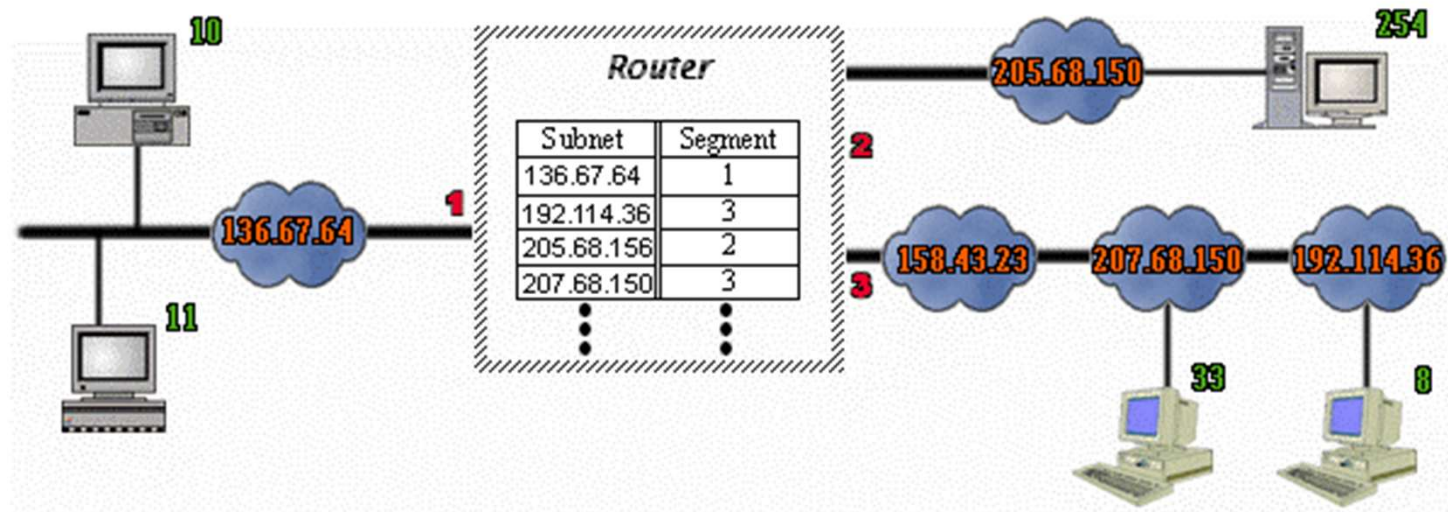
What is a Router Made of?

- ❖ A router has many of the same components as your computer:
 - CPU
 - Memory
 - I/O Interfaces (mostly network interfaces)
 - Operating System

Routers

- ❖ A router is a device that forwards data packets along networks.
- ❖ A router is connected to at least two networks, commonly two LANs or WANs or a LAN and its ISP's network.
- ❖ Routers are located at gateways, the places where two or more networks connect.
- ❖ Routers are the critical devices that keeps data flowing between networks and keeps the networks connected to the Internet.

Routers



- ❖ Routers connect two or more networks and forward data packets between them. When data arrives from one of the segments, the router decides, according to its routing table, to which segment to forward that data.
- ❖ Routers often incorporate firewall functions.

Bridges versus Routers

Routers

- ❖ Each host's IP address must be configured
- ❖ If network is reconfigured, IP addresses may need to be reassigned
- ❖ Routing done via RIP or OSPF
- ❖ Each router manipulates packet header (e.g., reduces TTL field)

Bridges/LAN switches

- ❖ MAC addresses of hosts are hardwired
- ❖ No network configuration needed
- ❖ Routing done by
 - **learning bridge algorithm**
 - **spanning tree algorithm**
- ❖ Bridges do not manipulate frames

Gateway



- ❖ "Gateway" is a term that was once used to refer to a routing device. Today, in the TCP/IP world, the term "router" is used to describe such a device.

The term gateway now refers to special-purpose devices, that perform protocol conversions. Gateways implement application layer conversions of information received from various protocols.

- ❖ Examples of gateways found on today's markets are:
 - **VocalTec Gateway** : A gateway that converts human speech traveling on analog phone lines into local area network protocol data, and visa-versa.
 - **RadVision Gateway** : Converts video from digital phone lines into local area network protocol data, and visa-versa.

Modems



An illustration of data sent using a modem and a regular telephone line.

A modem is a device that converts digital data originating from a terminal or computer, to analog signals used by voice communication networks such as the telephone system. At one end, modems convert the digital pulses to audible tones and convert audio tones back to digital pulses at the other.

The word "Modem" stands for "**MO**dulator-**DE**Modulator".