Computer Networks and Communications

Lecture (04):

LAN Standards,
Physical Connectivity, and Media Access

LAN Standards

Standards are required so that different manufacturers can create equipment that will interoperate without special configuration.

Standards groups include:
ISO. International Organization for Standardization establishes standards for networking operation.
ANSI. American National Standards Institute is the US representative to ISO.
EIA/TIA. Electronics Industries Alliance/Telecommunications Industry Association is an industry based standards group.
IEEE. Institute of Electrical and Electronics Engineers is an international professional organization that sets communications standards. IEEE Project 802 sets standards for cabling and data transmission on local area networks.

Physical Connectivity

Network Interface Card (NIC). Also known as Network Card or Ethernet Adapter. Transmits and receives signals to the LAN. Computers can not communicate on LAN without this device.

Each Network Card has a Media Access Control (MAC) address. This is also known as the physical address or Ethernet address.

MAC address is a unique 12 digit hexadecimal number that is hard coded into each network interface. The first half of a MAC address is the manufacturer's ID. The second half a serial number.

00-04-AC-F3-1C-D4

Manufacturer ID Serial number

Cable and Wireless

Physical cabling is also known as bounded media.

Transmissions are bound to the physical media.
To communicate, hosts ***must*** be physically connected to that media.

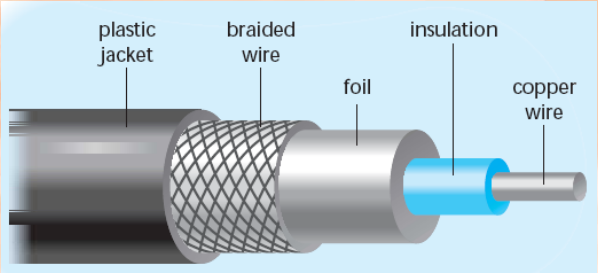
Physical cabling is usually located in a building's plenum.

Wireless network is known as unbounded media.

Transmissions are not bound to a physical cable.
To communicate, hosts ***do not need*** to be physically connected.

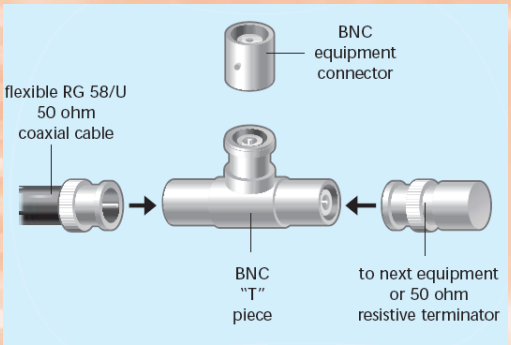
Coaxial Cable

- Coaxial cable is often used in older LANs.
- Known as RG58, Thinnet, and 10Base2.
- Maximum bandwidth of 10 Mbps.
- Maximum segment length of 185 meters (605 feet).
- Maximum of 30 hosts per segment.



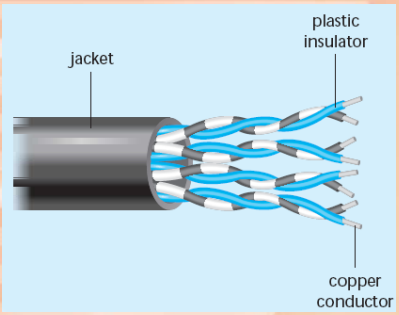
Coaxial Cable

- Hosts on an RG58 network require a network card with an RG58 adapter.
- To add the host to the network, the cable section must have an RG58 connector on both ends with a "T" piece fitted between them.
- Both ends of the segment should be terminated using a a piece of equipment known as a terminator.
- A terminator stops signals on the network echoing back when they reach the end of the segment.



Twisted Pair Cable

- The most common cabling technology in use today.
- Consists of **four pairs** of copper wires **twisted** around each other. Twists are used because they reduce interference.
- Maximum length: 100 meters (328 feet).
- Maximum bandwidth: 1000 Mbps.

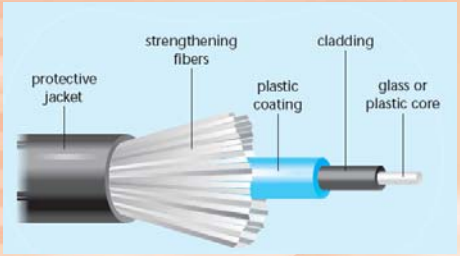


Twisted Pair Cable

- Connect to networking devices such as network interface cards and switches using RJ45 connectors.
- One end must connect to a host, the other to a networking device such as a switch. You can only connect two computers together if you use a crossover cable, which uses different wiring.

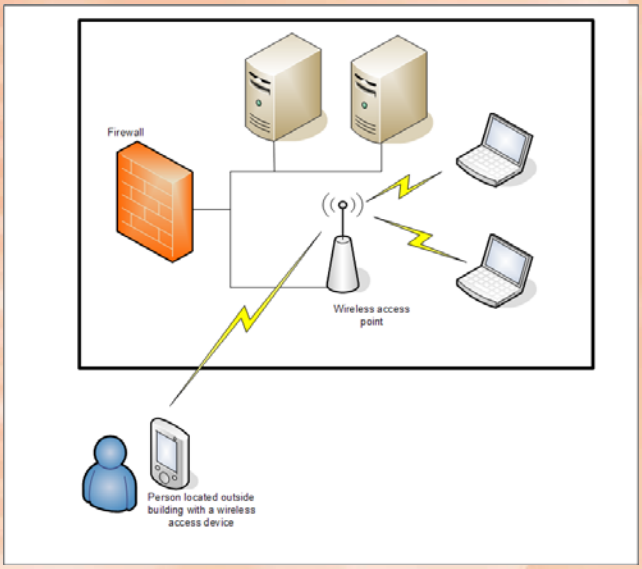
Fiber Optic Cable

- Fiber optic cable has better data security than twisted pair or RG58. You can't intercept the signals without breaking the cable.
- Fiber optic cable is **immune to electromagnetic interference**, something that can cause problems for twisted pair or RG58.
- The disadvantages of fiber optic cable is that it is **very expensive** and that it is **not very flexible**. Bend it too far and it will break the core, rendering the cable useless.
- Fiber optic cable is mostly use as a backbone to connect LANs together, rather than connecting hosts together on a LAN.



Wireless

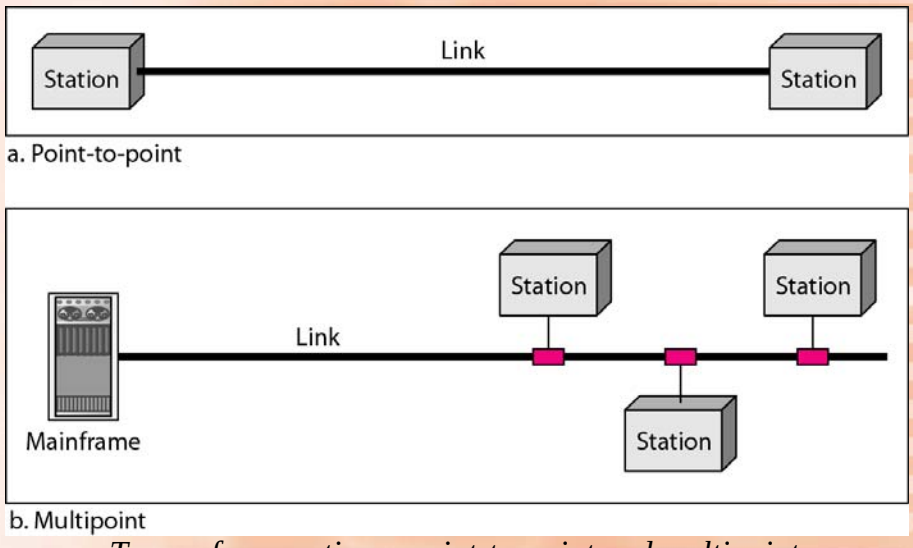
- Wireless networks **do not require** physical infrastructure like cables.
- Wireless networks have **short range**.
- Wireless networks have **limited bandwidth**.
- Transmissions can be **intercepted easily** by a person outside building with a wireless access device.



How to classify networks?

- By Scale
  - Personal area network (PAN)
  - Local Area Network (LAN)
  - Campus Area Network (CAN)
  - Metropolitan area network (MAN)
  - Wide area network (WAN)
- By Connection Method
  - Optical fiber
  - Ethernet
  - Wireless LAN
  - HomePNA
  - Power line communication
- By Network Topology
  - Bus network
  - Star network
  - Ring network
  - Mesh network

Type of Connections



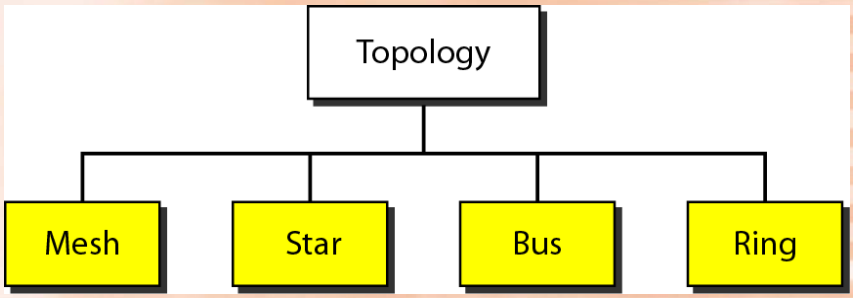
Types of connections: point-to-point and multipoint

LAN Topologies

Physical topology is the actual location and arrangement of physical connections between devices on the network.

Logical topology is the path that a given datagram travels between two devices. Often there is more than one way to get from one host to another.

Physical topology

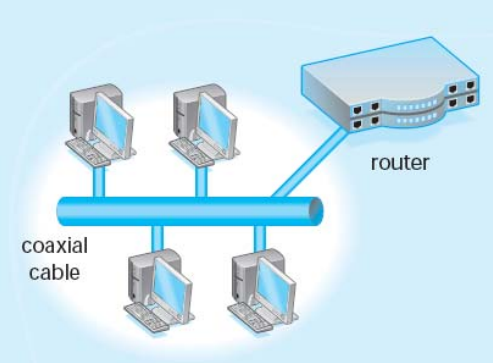


Categories of physical topology

physical topology: design or layout of the network

Bus Topology

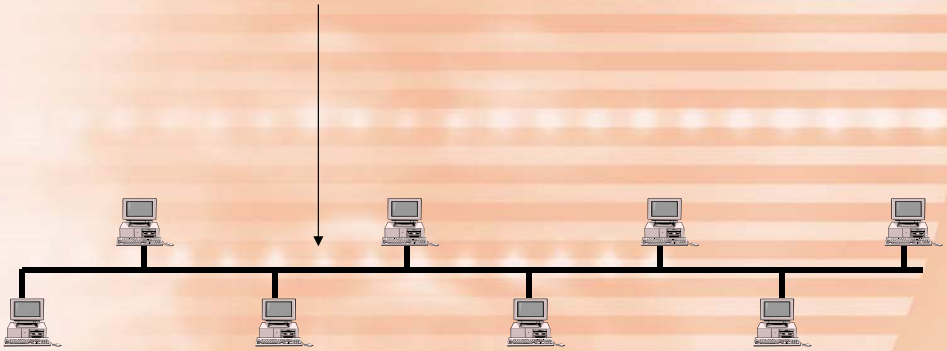
- All network devices connected to a common cable in logical linear fashion.
- Transmissions are sent along the length of the bus segment.



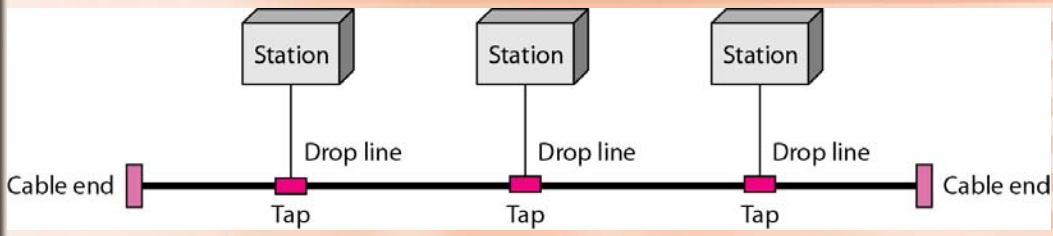
- Adding hosts to the network requires **breaking** the network.
- Failure of **one** host can cause **failure** of network.

Bus Topology

- Each node is connected one after the other (like christmas lights)
- Nodes communicate with each other along the same path called the *backbone*



Bus Topology



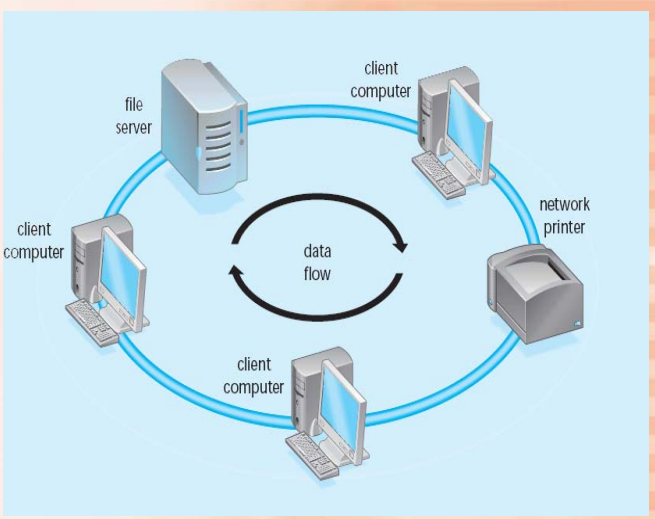
Multipoint

Advantages:
- Easy to install
- Less cables

Disadvantages:
- Hard to detect fault isolation.
- Bus cable is too important

A bus topology connecting three stations

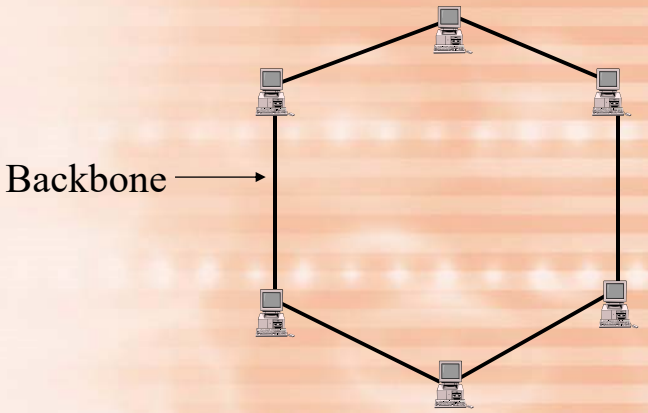
Ring Topology



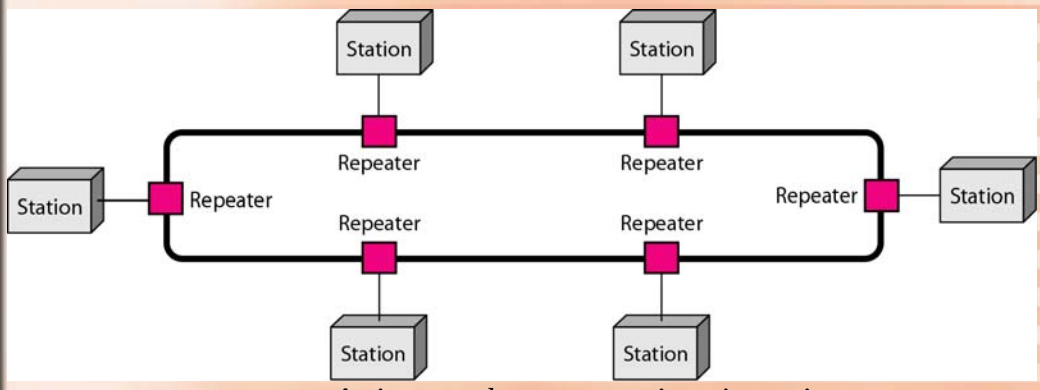
- Network is connected in an endless loop.
- No termination required.
- Uncommon topology today, more common in 1980s.

Ring Topology

- The ring network is like a bus network, but the “end” of the network is connected to the first node
- Nodes in the network use tokens to communicate with each other



Ring Topology



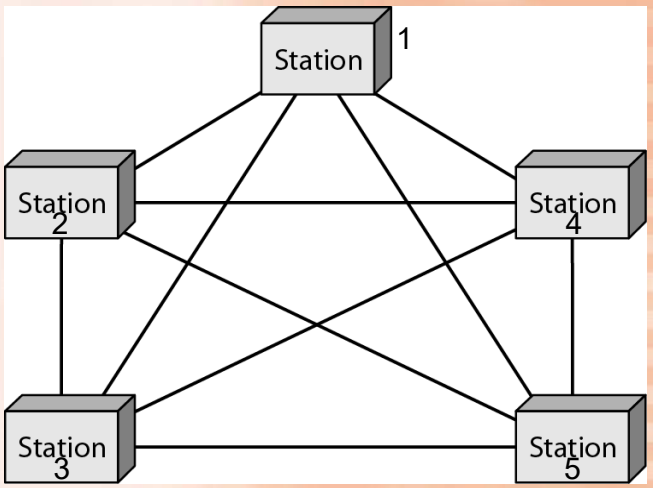
A ring topology connecting six stations

Point to point with 2 devices on both sides

Advantages:
- Easy to install
- Maintain: add move delete
- Fault isolation

Disadvantages:
- Unidirectional traffic

Mesh Topology



A fully connected mesh topology (five devices)

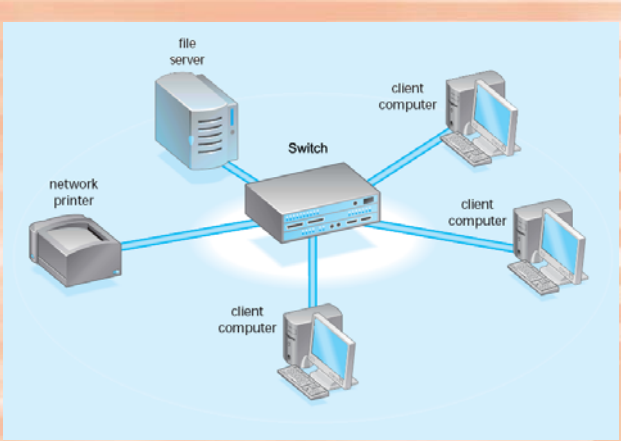
Example: telephone regional offices

Advantages:
- no traffic problems
- Robust. No link failure no effect on others.
- Privacy security
- Easy to detect the abnormal situation.

Disadvantages:
- Amount of cables, i/o ports
- Efficiency and effectiveness
- Space
- Cost

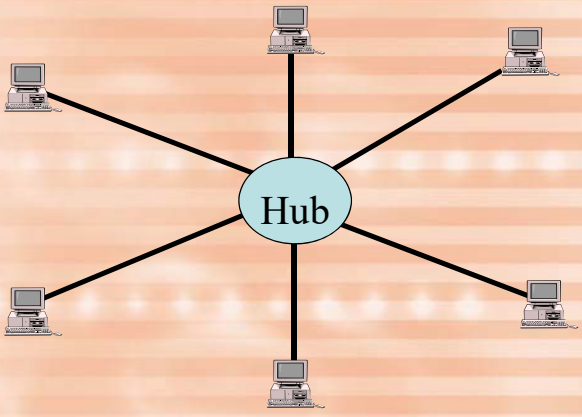
Star Topology

- Connection from each device to a central location, usually a switch.
- Most commonly used physical topology.
- Failure of one cable does not bring down network.

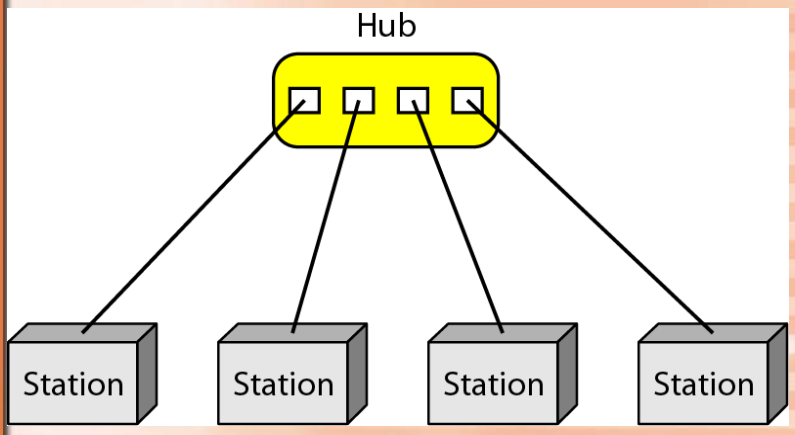


Star Topology

- Each node is connected to a device in the center of the network called a *hub*
- The hub simply passes the signal arriving from any node to the other nodes in the network
- The hub does not route the data



Star Topology



A star topology connecting four stations

Less expensive. One link and I/o port connecting to the hub. No direct traffic between two devices.

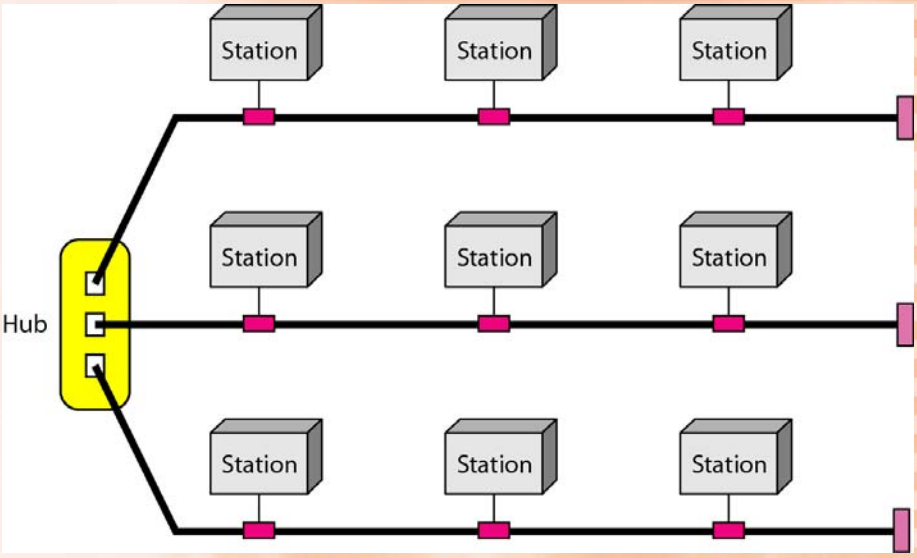
Advantages:

- Easy to install
- Less cables
- Maintain: add, move, delete
- Robustness

Disadvantages;

- Hub is too important
- The hub represents a single source of failure

Hybrid Topology



A hybrid topology: a star backbone with three bus networks

Access Control Methods

- Two primary access control methods exist for computers to communicate with each other over the network
  - Token based access
  - Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

Token based access

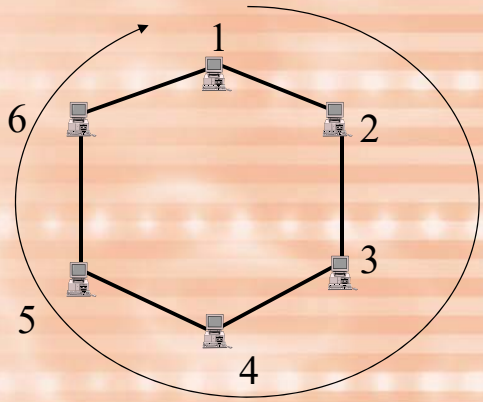
- Used in bus and ring network topologies (token ring)
- Each computer in the network can only send its data if it has the *token.* This prevents collisions that occur when data is sent at the same time over the network
- The token is a special pattern of bits/bit in a frame that is directly detectible by each node in the network
- A computer may only transmit information if it is in possession of the token
- The message is sent to all other computers in the network

Types of LAN's

- The three most popular types of LAN's are:
  - Token ring
  - Ethernet
  - FDDI (Fiber Distributed Data Interface)

Operation of token ring

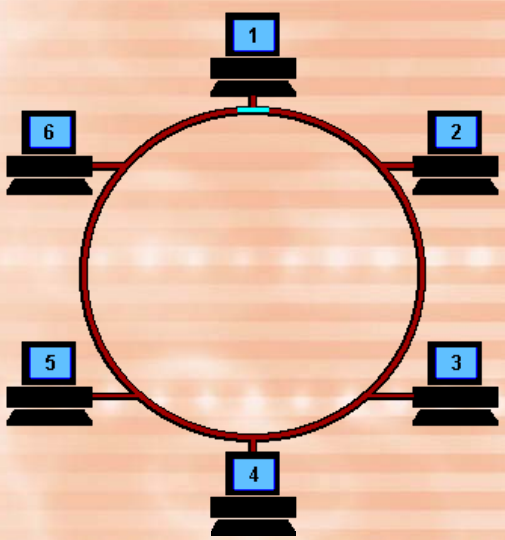
- As an example, suppose node # 1 wants to send information to node # 4 over the network
- Initially, an empty frame (network packet) circulates in the network



- When node # 1 receives the empty frame, it inserts a token in the token bit part of the frame. This operation may just be an insertion of a “1” bit
- The node then inserts the message it wants to send as well as the address of the receiving node in the frame
- The frame is then successively received and examined by each node in the network. First it is sent to node #2. Node #2 examines the frame and compares the address in the frame to its own address. Since addresses do not match, it passes the frame onto node #3, which does the same thing
- When the frame is received by node #4, the address of the node matches the destination address within the frame. The node copies the message and changes the token bit in the frame to “0”
- The frame is then sent over to node #5. This node also compares addresses and sends it to node #6 which does the same procedure
- When node #1 receives the frame, it examines the token bit and recognizes that it has been changed to “0”. Node #1 then concludes that the message has been received by the intended node: node #4. Node #1 then empties the frame and releases the empty frame back into the network for circulation

ui

Let's see an animation of the token ring



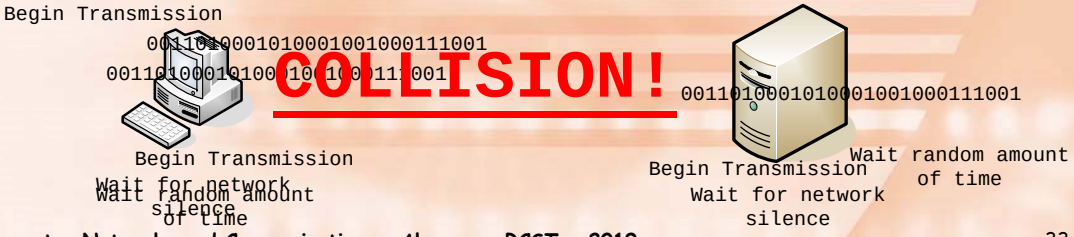
CSMA/CD

- Usually used in a bus topology
- Used in *Ethernet* LAN's
- Unlike the token ring, all nodes can send whenever they have data to transmit
- When a node wants to transmit information, it first "listens" to the network. If no one is transmitting over the network, the node begins transmission
- It is however possible for two nodes to transmit simultaneously thinking that the network is clear
- When two nodes transmit at the same time, a *collision* occurs
- The first station to detect the collision sends a jam signal into the network
- Both nodes back off, wait for a random period of time and then re-transmit

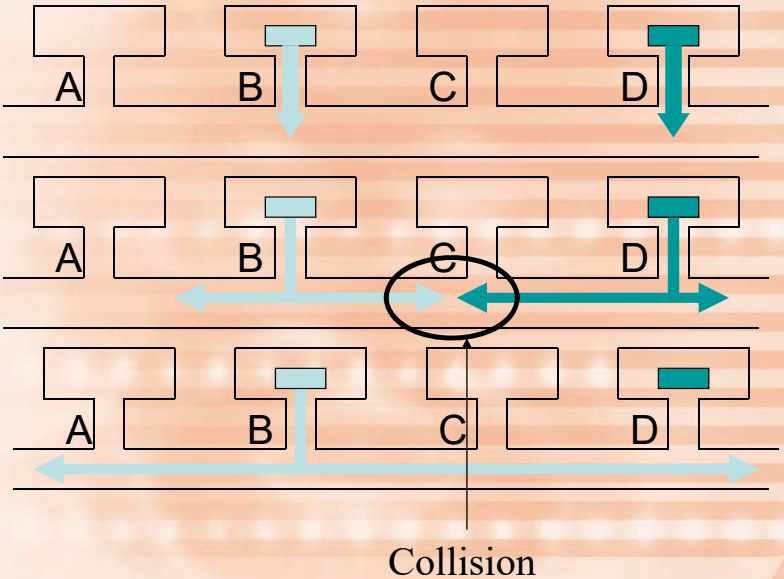
CSMA/CD

Stands for Carrier Sense Multiple Access with Collision Detection.

- Each device listens to media for transmissions. When media is clear, initiates transmission and listens for collision.
- If collision occurs, device waits for random amount of time before attempting transmission again.
- Commonly used on physical networks.



CSMA/CD



CSMA/CA

Stands for Carrier Sense Multiple Access with Collision Avoidance.

- Each device listens to media for transmissions. When media is clear, device sends an intent to transmit signal. As this signal is small, chances of collision are minimized.
- Used often in wireless networking.

Ethernet

- First network to provide CSMA/CD
- Developed in 1976 by Xerox PARC (Palo Alto Research Center) in cooperation with DEC and Intel
- Is a fast and reliable network solution
- One of the most widely implemented LAN standards
- Can provide speeds in the range of 10Mbps- 10 Gbps
- Used with a bus or star topology

Ethernet data packet - datagram drawn on board.

Types of Ethernet LANs

- 10Base-T
  - Operates at 10 Mbps
  - IEEE 802.3 standard
- Fast Ethernet (100Base-T)
  - Operates at 100 Mbps
- Gigabit Ethernet
  - Operates at 1 Gbps
  - Uses fiber optic cable
- 10 Gbps Ethernet
  - Latest development of ethernet
  - Uses fiber optic cable
  - Developed to meet the increasing bandwidth needs of the LAN market
- Wireless Ethernet
  - IEEE 802.11 standard
  - Operates at around 2.4 Gbps

Fiber-Distributed Data Interface (FDDI)

- Fiber-Distributed Data Interface (FDDI) provides a standard for data transmission in a local area network that can extend in range up to 200 kilometers (124 miles).
- The FDDI protocol uses as its basis the token ring protocol.
- In addition to covering large geographical areas, FDDI local area networks can support thousands of users.
- As a standard underlying medium it uses optical fiber (though it can use copper cable, in which case one can refer to CDDI).
- FDDI uses a dual-attached, counter-rotating token-ring topology.

Fiber-Distributed Data Interface (FDDI)

- An FDDI network contains two token rings, one for possible backup in case the primary ring fails.
- FDDI has a larger maximum-frame size than standard 100 Mbit/s ethernet, allowing better throughput.
- A small number of devices (typically infrastructure devices such as routers and concentrators rather than host computers) connect to both rings - hence the term "dual-attached".
- Host computers then connect as single-attached devices to the routers or concentrators.

Summary

• Standards are set by industry, professional and government organizations to ensure that devices can interoperate.

• NICs have MAC addresses and are needed to communicate with other devices on the LAN.

• RG58 cable has a maximum bandwidth of 10 Mbps and is found in older LANs.

• Twisted pair is commonly used today and connects using an RG58 connector.

• Star Topologies are most commonly used today. A switch often sits at the center of a star topology.

• CSMA/CD transmits and then listens to see if there was a collision. CSMA/CA sends an intent to transmit message.

Required Reading

Data and Computer Communications, 10th Edition by William Stallings, (c) Pearson Education - Prentice Hall, 2013

>> Chapter 15 –

Local Area Network Overview

Discussion Questions

- What is the difference between a physical and a logical network?
- What is the difference between a bus and a star topology?
- Which media access method sends an intent to transmit signal?
- What is a MAC address?