COMP476
Networked Computer Systems

Local Area Networks (LAN) Technology

Goals for Today

- Know the different type of networks
- Understand how multiple computers can share the same wires
- Learn some acronyms

Network Types

WAN – Wide Area Networks
MAN – Metropolitan Area Networks
LAN – Local Area Networks
DAN – Desk Area Networks

WAN – Wide Area Networks

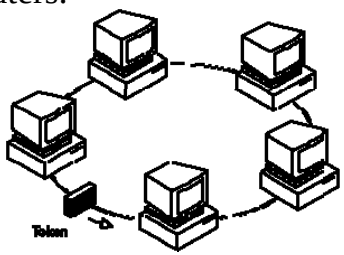
- Operate over long distances.
- Propagation delay is significant.
- Usually owned by a common carrier or telephone company.
- Line speeds are limited by cost and bandwidth.

Example: Frame Relay

LAN – Local Area Networks

- Range limited to about 1km.
- Usually run at high speeds.
- Usually owned by the organization that owns the computers.

Example: Ethernet and Token Ring



MAN – Metropolitan Area Networks

- Range limited to a city or about 50km diameter.
- Similar to LANs but larger.
- Frequently used on university or corporate campuses to connect building LANs.

Example: DQDB and FDDI

DAN – Desk Area Networks

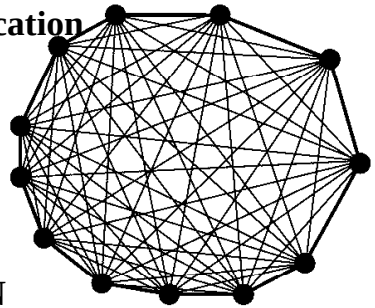
- Range limited to about 1m.
- Run at very high speeds.

Example: USB

LAN Technologies

Point-to-Point Communication

•**Advantage:** Each connection can use its own preferred hardware.
•**Disadvantage:** Requires a connection between every pair of stations or $O(N^2)$ connections.



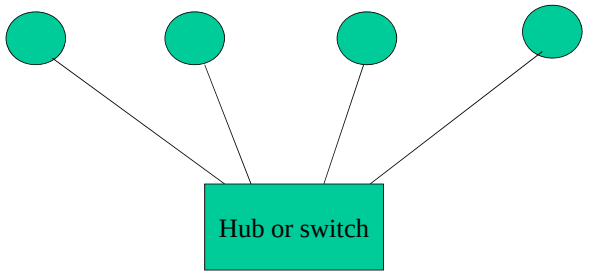
LAN

•Generally use a **shared** communications medium.
•All stations transmit over the same channel.
•Arbitrary connections at high speeds.

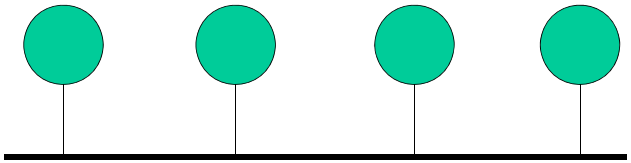
Network Topology

- Defines the different patterns for connecting computers
  - **Star** - All stations are connected to a central switch.
  - **Bus** - All stations connect to a single wire, usually a coax cable.
  - **Ring** - The computers are connected in a circle. Each computer sends data only to its left neighbor and receives data only from its right neighbor.

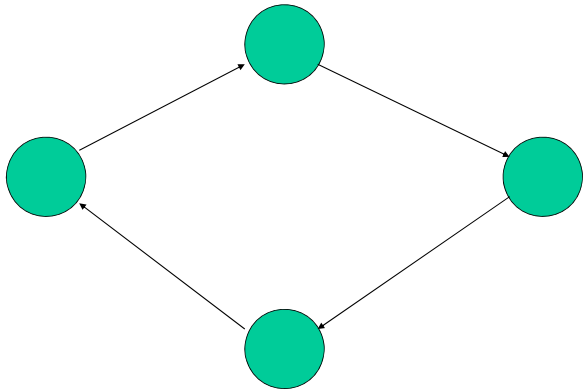
Star - All stations are connected to a central switch



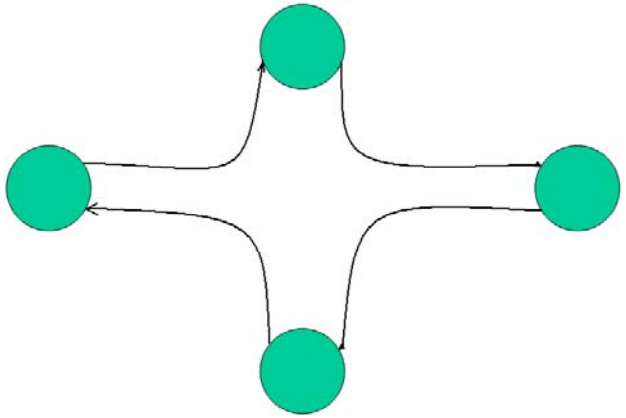
Bus
All stations connect to a single wire



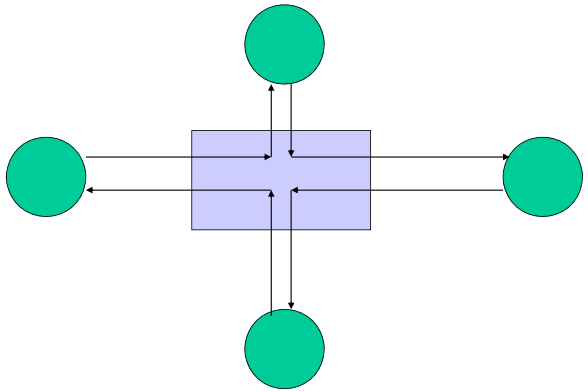
Ring - The computers are connected in a circle



Ring – Bending the wires



Ring with Wiring Hub



Sharing Common Media

There are several ways to share common media. Some methods are:

- Frequency division multiplexing
- Time division multiplexing
- Code Division Multiple Access
- Carrier Sense Multiple Access
- Token based
- Anarchy

Static Channel Sharing

- Time Division Multiplexing and Frequency Division Multiplexing statically divide the channel N-way regardless of which nodes are transmitting at any given time.
- If you divide a **B** bandwidth wire N-ways using FDM, each of the N channels has a maximum speed of **B/N**. Each channel is $1/N^{th}$ as fast as the original wire.

TDM Performance

- Consider a wire with a maximum transmission speed of X divided N ways using synchronous Time Division Multiplexing.
- A given node gets to transmit only once every N time units.
- It takes a node N times longer to send a given amount of data than it would using the full wires capability.

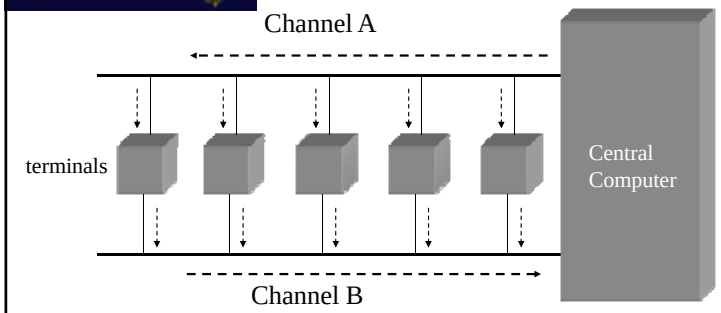
Sharing the Wire

- Only one node can transmit at a time.
- If two or more nodes transmit at the same time, the messages will be garbled.
- The challenge in a LAN is to allow all nodes to transmit at maximum speed without interfering with each other.

Humans Sharing the Bandwidth

- How do a group of people talk without everyone talking at once?

Aloha Networks



Aloha networks were developed at the University of Hawaii for communication to remote islands.

Aloha Networks

- All terminals transmit to the central computer on channel B.
- When the central computer receives a message correctly, it will send an acknowledgement to the terminal on channel A.
- If two stations send something at the same time, the messages would collide and nothing would be received correctly by the central receiver.
- If a node didn't get an acknowledgement, it sent it again after a random wait.

Advantages

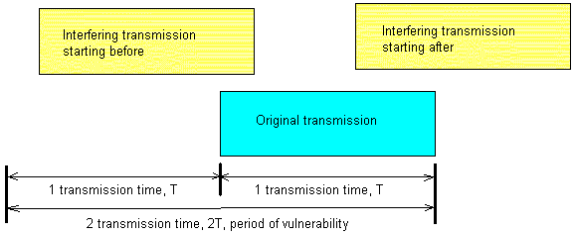
• Network runs efficiently for a small number of users.
• No coordination between sending nodes is required.

Disadvantages

• Collisions drain the capacity of the channel.

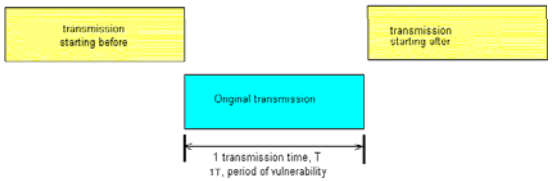
Analysis of Aloha Network

•The throughput of a network is the amount of data that actually gets through the network.
•A node's transmission is successful if another node does not transmit at the same time.

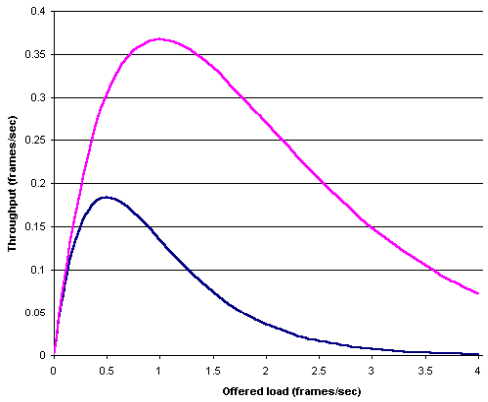


Slotted Aloha

- Slotted Aloha only sends packets during specified time slots.
- This reduces the probability of a collision since packets cannot overlap part way.



Aloha vs. Slotted Aloha



The throughput of **Aloha (dark line)** and **slotted Aloha (purple line)** are plotted here. As the load on the network increase, the throughput increases at first. As the network gets busier, the throughput starts to decline until very little data is successfully received when the network is very busy.

Ethernet

- Uses the **C**arrier **S**ense **M**ultiple **A**ccess with **C**ollision **D**etect (CSMA/CD) protocol.
- Similar to Aloha except that a station senses the line before transmitting.
- This produces better throughput than Aloha because it tries to avoid collisions.
- Ethernet can run as a bus network on coax cables or as a star with twisted pair or fiber.

CSMA/CD Protocol

- The sending station senses the line to see if another transmission is taking place.
- If nothing is being transmitted, the send transmits its frame.
- If another node is currently transmitting, the sender waits until the current transmission ends.
- While the sender transmits, it checks that it is receiving exactly the same signal.
- If the sender detects a collision, it stops, waits a random length of time and tries again.

Ethernet is frequently identified by the speed and media type

- 10Base5 thick coax, 10Mbps
- 10Base2 thin coax, 10Mbps
- 10BaseT twisted pair cable, 10Mbps
- 100BaseT twisted pair cable, 100Mbps
- 100BaseF fiber optic cable, 100Mbps

Token Based LAN

- Token Ring and Token Bus networks do not have any collisions as those encountered in Aloha and Ethernet networks.
- To avoid collisions, the network has only one logical token.
- Only the station that currently holds the token is allowed to transmit.
- The token is cycled between the connected stations until it reaches the next station waiting to transmit.

Advantages

- Token based systems have an advantage when the network is very busy
- Continue to work efficiently at high loads.

Disadvantages

- At low loads, the station must wait for its turn to use the token.
- Limited to predetermined amount of time for transmission.

Token Ring Protocol

- A logical object called the token is continually sent around the ring.
- The station that has the token can send a few frames if it has any to send.
- As a station receives a bit, it stores the bit and sends it to the next station in the ring.
- The sending node does not forward bits.
- Upon sending its frames, the station sends the token to the next station in the ring.

Metropolitan Area Networks

ATM

- A connection-oriented network that does not use shared media.
- An electronic switch provides the connections.
- Uses a Star, usually with fiber optics running at 155Mbps.

Distributed Queue Dual Bus

- Uses a pair of fiber buses.
- It uses 44 byte payloads, which are almost compatible with ATM.
- Nodes send a request for a cell to upstream nodes. The upstream nodes allow an empty cell to pass by for each request received.

Comparison of LANs

	Ethernet	Token Ring	ATM LAN
Transmission Speed	100Mbps	4 or 16Mbps	155Mbps +
Setup	none	none	circuits
avg Delay until transmission	small to nothing	small to moderate	setup time
max delay until transmission	large to infinity	bounded	none
Impact of load	fails at heavy load	bounded	none to capacity

IEEE 802 standards

- **802.3 Ethernet**
- 802.4 Token Bus
- 802.5 Token Ring
- 802.6 Distributed Queue Dual Bus
- **802.11 Wireless LAN**

Maximum Frame Size

Network	Standard	Max payload (bytes)
Ethernet	802.3	1500
Token Bus	802.4	8191
Token Ring	802.5	Max send time ~5000

Standards do not standardize everything