Media Access Control Sub Layer

COMP476
Networked Computer Systems

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

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.

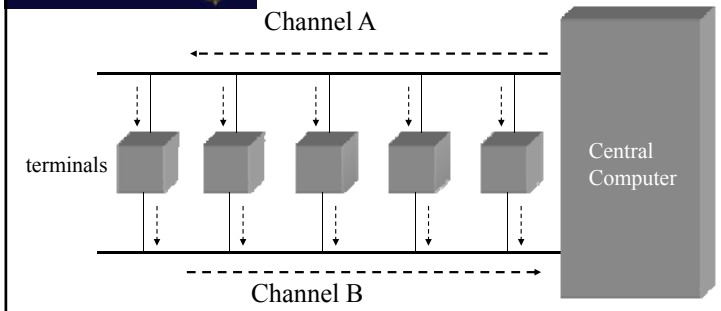
Polling

- Polling relies on a central controller that asks (polls) each station if it wants to send something
- When a station is polled, it can send a data packet or a special short packet indicating it has nothing to send
- The central controller can poll the station in a round robin order or by priority order

Reservation System

- In a reservation system, a common poll is sent to all stations
- Each station indicates, in order, if they want to send something
- Once each station knows who wants to transmit, the transmit in order

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

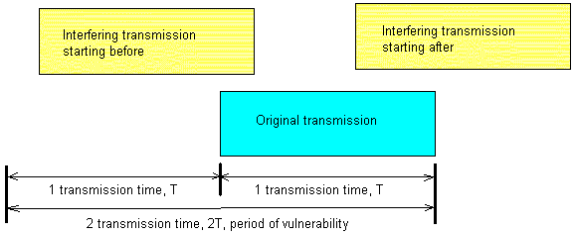
• Network runs efficiently for a small number of users.
• No coordination between sending nodes is required.

Disadvantages

• Collisions drain the capacity of the channel.

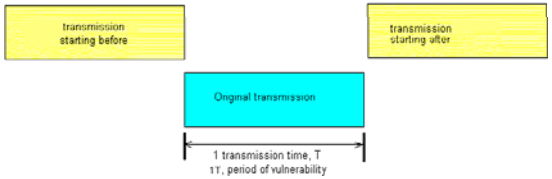
Analysis of Aloha Network

•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.

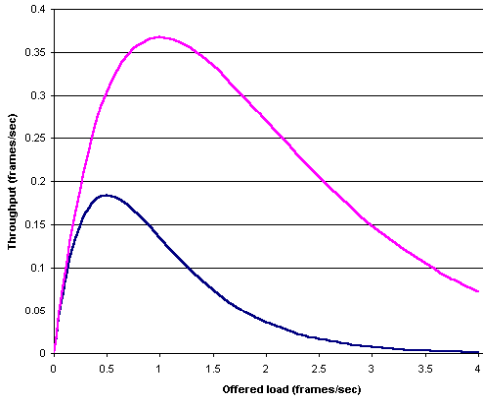


Slotted Aloha

- 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



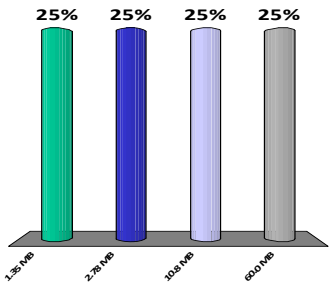
The throughput of **Aloha (dark line)** and **slotted Aloha (purple line)**

Aloha Throughput

- **As the load on an Aloha network increases, 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.**
- **The maximum throughput for an Aloha network is $\frac{1}{2e}$ or 18%**
- **The maximum throughput for a slotted Aloha network is $\frac{1}{e}$ or 37%**

If you have a 1 Mb/s wireless network using Aloha, what is the maximum amount of data you can transmit in one minute?

1. 1.35 MB
2. 2.78 MB
3. 10.8 MB
4. 60.0 MB



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

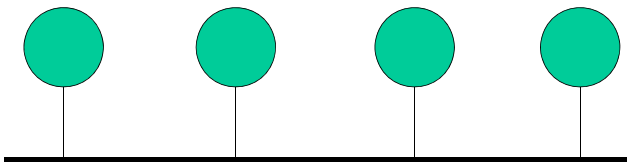
- The sending station senses the line to see if another transmission is taking place.
- If nothing is being transmitted, the sender transmits its frame.
- If another node is currently transmitting, the sender waits until the current transmission ends.
- While the sender transmits, it checks that it is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

Exponential Backoff

- The 8 byte Ethernet preamble helps in detecting collisions
- The first time a station detects a collision, it randomly waits 0 or 1 transmission times
- If it gets another collision, it waits 0 – 3 transmission times
- Another collision makes it wait 0 – 7 times
- Each collision doubles the maximum wait

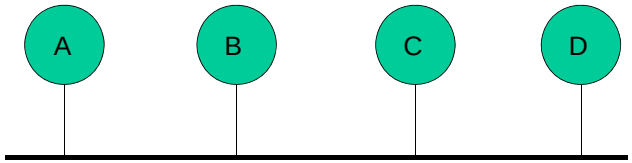
Traditional Coax Ethernet

- Original Ethernet used a shared coax cable.
- The cable length impacted CSMA/CD



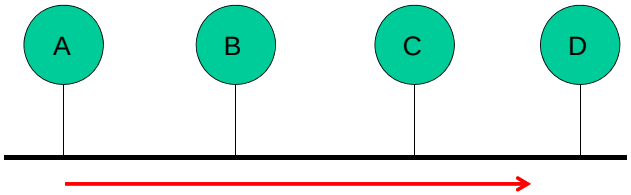
Collision Detection

- To detect a collision, a node has to be transmitting when it receives the signal from another node
- Consider a very long cable



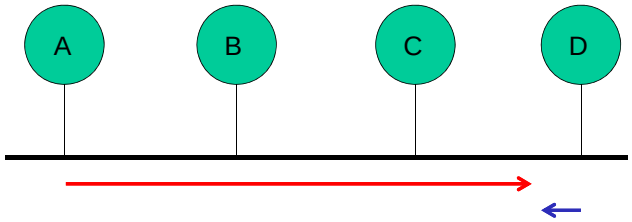
Collision Detection

- A transmits a packet
- The packet propagates down the cable



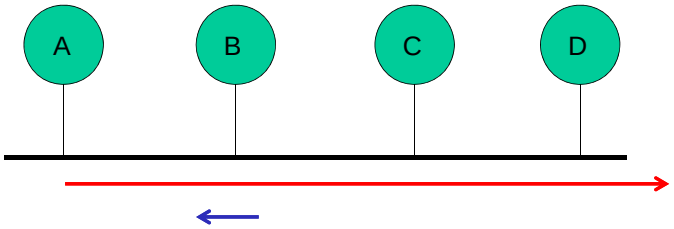
Collision Detection

- Just before the signal from A reaches station D, station D starts to transmit



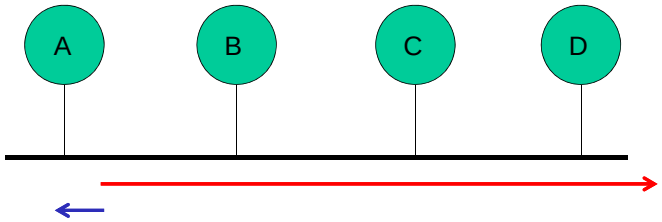
Collision Detection

- Station A continues to transmit because it has not yet received the signal from D
- Station A does not see a collision, but stations D, C then B do



Collision Detection

- Station A completes its transmission just before the signal from station D arrives.
- Station A never observes a collision which is counter to the collision detect protocol



Maximum Cable Length

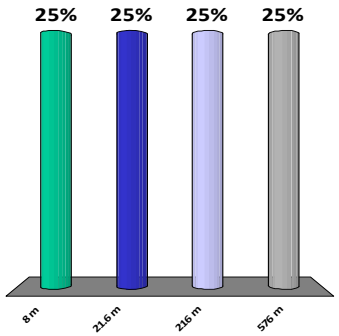
- **To ensure collisions are always detected:**
  Transmission time > 2 * propagation time
- **For a minimum sized Ethernet packet of 72 bytes with a 100M bits/sec transmission**

$$\frac{72bytes*8bits/byte}{10^8 bits/sec} > 2 * \frac{cableLength}{2.0*10^8 m/sec}$$

- **This results in a maximum cable length of 576m**

If the minimum packet size was 27 bytes (1 data byte), what is the maximum cable length?

1. 8 m
2. 21.6 m
3. 216 m
4. 576 m



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

Ethernet Cables

- There are different cable standards for different speed Ethernets

- Cat3 – 10 Mbits/sec
- Cat5 – 100 Mbits/sec
- Cat6 – 1 Gbits/sec
- Cat7 – 10 Gbits/sec

WiFi Networks

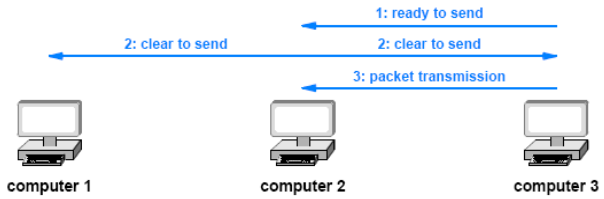
- CSMA/CD does not work as well in wireless LANs because a transmitter used in a wireless LAN has a limited range
- A receiver that is more than δ away from the transmitter will not receive a signal and will not be able to detect a collision

Missed Collisions

- Consider three computers with wireless LAN
- If computer 3 is transmitting a packet to computer 2, computer 1's carrier sense mechanism will not detect the transmission
- Sometimes called the hidden station problem

CSMA with Collision Avoidance (CSMA/CA)

- CSMA/CA triggers a brief transmission from the intended receiver before transmitting a packet
- All computers within range of either will know a packet transmission is beginning



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

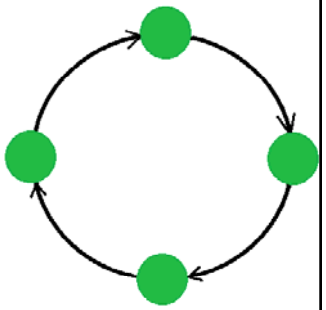
- At low loads, the station must wait for its turn to use the token.
- Limited to predetermined amount of time for transmission.

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.

Token Ring

- Each station receives a bit and sends a bit
- The transmitting station does not forward the incoming bits
- The receiving station sends a bit after the last bit if it received the message correctly



IEEE 802 standards

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