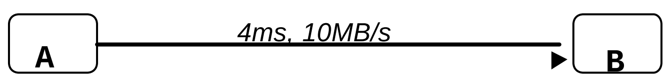
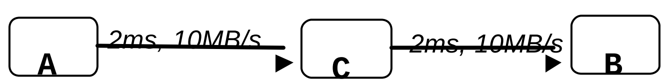
CSE/EE 461 Section 2

Latency in a store-and-forward network



- How long does it take to send a 2kB packet from A to B?



- What if it has to pass through a node C?

Plan for today

- Examples
  - Latency computation
  - Internet Checksum
  - Ethernet Back-off
- Few words about
  - Token Rings
  - Wireless Communication

Solution

- First case:
  - latency = propagation + transmit
  - propagation = 4ms
  - transmit = 2kB * (1s/10MB) = 0.2ms
  - latency = 4.2ms
- second case:
  - latency = 2ms +0.2ms +2ms +0.2ms = 4.4ms

IP Checksum

- Makes sure that the information in the IP header has not been corrupted.
- To compute
  - Break data into 16 bit words
  - Perform one's complement addition on the words.
  - Complement the answer
- To check
  - Break data and checksum into 16 bit words
  - Perform one's complement addition on all of the words
  - Check if this equals –0 (ie, all bits equal to 1)

Sample Checksum

- For simplicity, show the 4 bit word case(real IP uses 16 bit case)
- Assume data:
  - 1001 1101 0010
- What is the checksum?

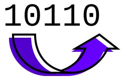
Solution

Do first two first | Add to third | Complement

```
 1001
 1101
+0010
 ????
```

Do first two first

```
 1001
+1101
10110
```



carry back

0111

Add to third

```
 0111
+0010
 1001
```

Complement

0110

Is this right?

```
 1001
 1101
 0010
+0110
 1111
```

YES!!

Ethernet CSMA/CD

- Ethernet transmit rules
  - Don't transmit if you hear someone else
  - If you're transmitting and hear someone else, send a jamming signal and stop
    - Wait a random number of slots between 0 and 2^n-1
    - If collide again, wait a random time between 0 and 2^{n+1}-1 and try again

Back Off Example

Suppose A and B are stations on an Ethernet and they collide on their first attempt to send a frame, and then collide on their second attempt.

- a) What is the probability there are no more collisions and A sends before B?
- b) What is the probability there is another collision (between A and B) before anyone sends successfully?

Solution

A B

Time 0: Both Send simultaneously, collide
A back-off interval {0,1}
B back-off interval {0,1}

Suppose both choose {0}

Time 1: Both Send again and collide

A back-off interval {0,1, 2, 3}
B back-off interval {0,1, 2, 3}

Part a. A sends before B, and no more collisions

What are the possibilities, in which A sends before B

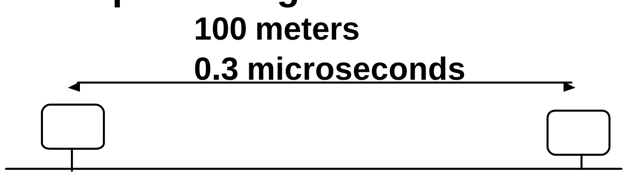
A.B 0.1 0.2 0.3
1.2 1.3
2.3
6 possibilities

*Total Possibilities: 4*4 = 16*

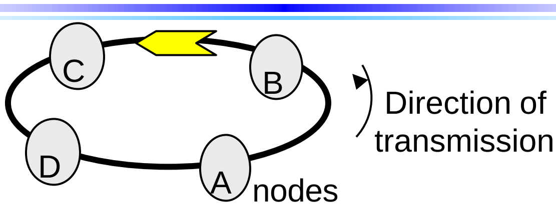
Probability: 6/16

Is it likely we'll really collide?

- If we use CSMA, why do we have collisions?
  - Effectively simultaneous start possible or even likely.
  - **Finite speed of light.**



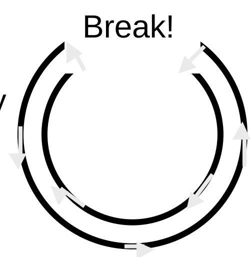
Token Ring (802.5)



- "Permission to send" token rotates around loop
- When token arrives
  - if no data to send, forward the token
  - if data to send, remove token and inject packet
  - remove packet and re-inject token at **sender**
  - Maximum token holding time (THT) bounds access time

FDDI
Fiber Distributed Data Interface

- Roughly a large, fast token ring
  - 100 Mbps and 200km vs 4/16 Mbps LAN
  - Dual counter-rotating rings for better reliability
  - Complex token holding policies for real-time traffic
- Token ring advantages
  - No contention, bounded access delay
  - Support fair, reserved, priority access
- Disadvantages
  - Complexity, reliability, scalability



Why Did Ethernet Win?

- Reliablity
  - Token ring failure mode -- network unusable
  - Ethernet failure mode -- node detached
- Cost
  - Passive tap cheaper to build than active forwarder
  - Volume => lower cost => volume => lower cost …
- Scalability
  - Repeater: copy all packets across two segments
  - Bridge: selectively repeat packets across two segs
  - Switch: bridge k segments; Hub: repeater for k segs

Wireless Communication

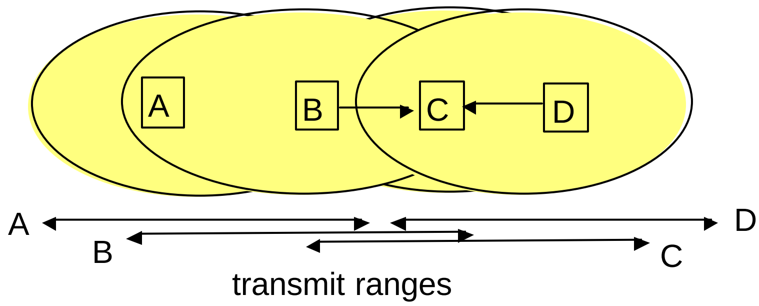
Wireless is more complicated than wired …

1. Cannot detect collisions
   - Transmitter swamps co-located receiver
2. Different transmitters have different coverage areas
   - Asymmetries lead to hidden/exposed terminal problems

CSMA with Collision Avoidance

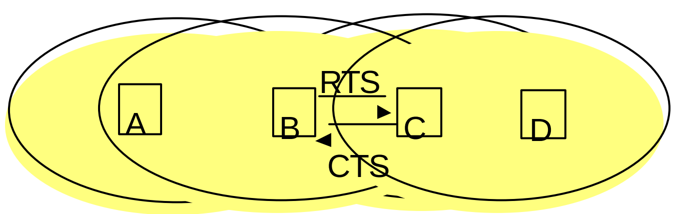
- Since we can’t detect collisions, we avoid them
  - CSMA/CA as opposed to CSMA/CD
- If medium busy, choose random backoff interval
  - Wait for that many idle timeslots to pass before sending
- If a collision is inferred, retransmit with binary exponential backoff (like Ethernet)
  - Use CRC and ACK from receiver to infer “no collision”
  - Again, exponential backoff helps us adapt “p” as needed

Hidden and Exposed Terminals



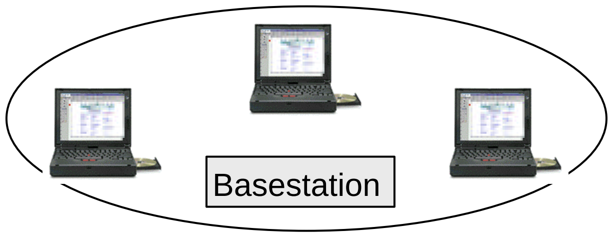
- Hidden terminals: B and D can both send to C but can't hear each other
- Exposed terminals: B, C can hear each other but can safely send to A, D

RTS / CTS Protocols (MACA)



1. B asks C: Request To Send (RTS)
2. A hears RTS and defers to allow the CTS
3. C replies to B with Clear To Send (CTS)
4. D hears CTS and defers to allow the data
5. B sends to C

802.11 Wireless LANs



- Emerging standard: wireless plus wired system or pure wireless (ad hoc)
- Avoids collisions (CSMA/CA (p-persistence), RTS/CTS
- Built on new links (spread spectrum, or diffuse infrared)