Wireless Medium Access

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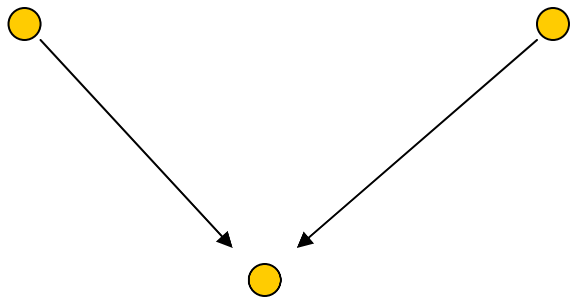
Multi-transmitter Interference Problem

- Similar to multi-path or noise
- Two transmitting stations will constructively/destructively interfere with each other at the receiver
- Receiver will "hear" the sum of the two signals (which usually means garbage)



Medium Access Control

- Protocol required to coordinate access
  - I.E. transmitters must take turns
- Similar to talking in a crowded room
- Also similar to hub based Ethernet

Carrier Sense Multiple Access (CSMA)

- Procedure
  - Listen to medium and wait until it is free (no one else is talking)
  - Wait a random back off time then start talking
- Advantages
  - Fairly simple to implement
  - Functional scheme that works
- Disadvantages
  - Can not recover from a collision (inefficient waste of medium time)

Carrier Sense Multiple Access with Collision Detection (CSMA-CD)

- Procedure
  - Listen to medium and wait until it is free
  - Then start talking, but listen to see if someone else starts talking too
  - If a collision occurs, stop and then start talking after a random back off time
- This scheme is used for hub based Ethernet
- Advantages
  - More efficient than basic CSMA
- Disadvantages
  - Requires ability to detect collisions

Collision Detection Problem

- Transmit signal is MUCH stronger than received signal
- Due to high path loss in the wireless environment (up to 100dB)
- Impossible to “listen” while transmitting because you will drown out anything you hear

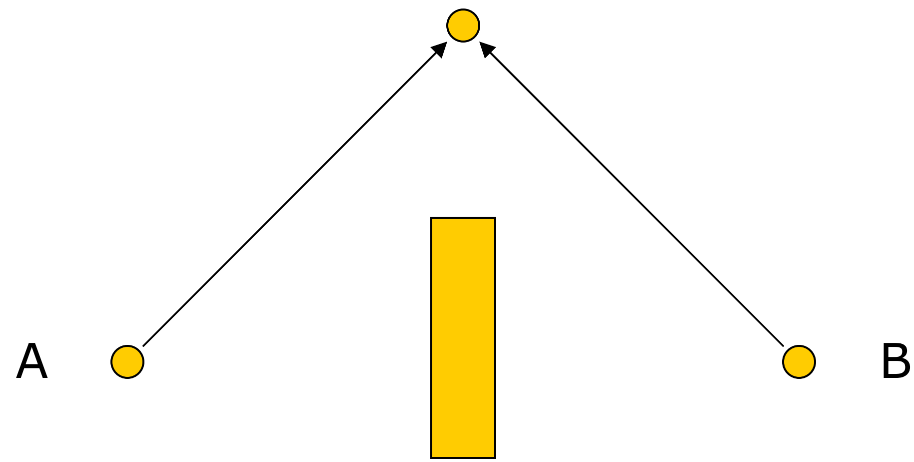
- Also transmitter may not even have much of a signal to detect due to geometry

Carrier Sense Multiple Access with Collision Avoidance (CSMA-CA)

- Procedure
  - Similar to CSMA but instead of sending packets control frames are exchanged
  - RTS = request to send
  - CTS = clear to send
  - DATA = actual packet
  - ACK = acknowledgement

Carrier Sense Multiple Access with Collision Avoidance (CSMA-CA)

- Advantages
  - Small control frames lessen the cost of collisions (when data is large)
  - RTS + CTS provide "virtual" carrier sense which protects against hidden terminal collisions (where A can't hear B)



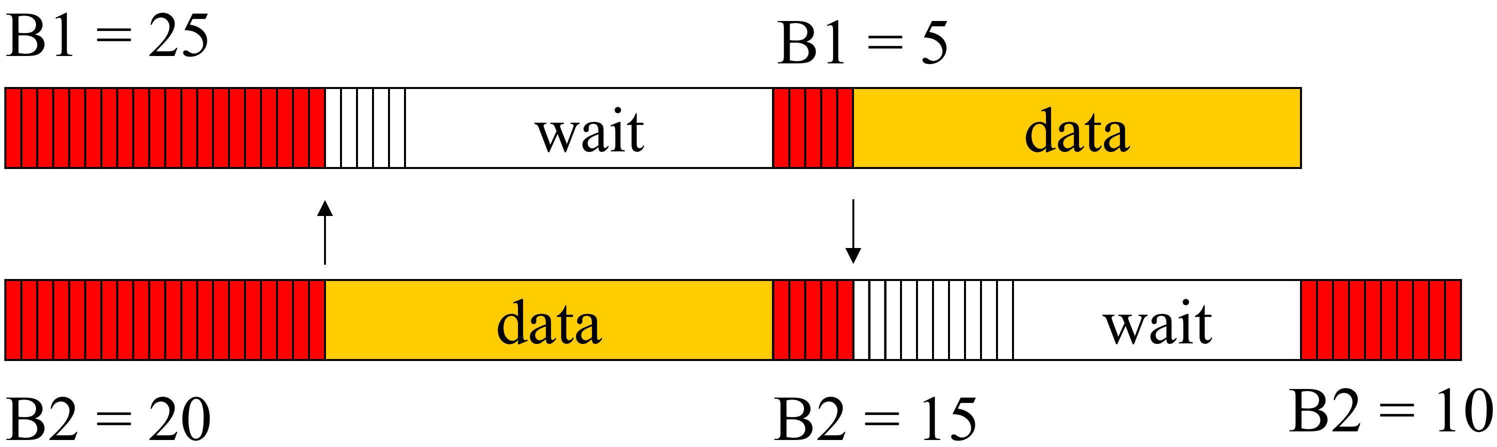
Carrier Sense Multiple Access with Collision Avoidance (CSMA-CA)

- Disadvantages
  - Not as efficient as CSMA-CD
  - Doesn’t solve all the problems of MAC in wireless networks (more to come)

Random Contention Access

- Slotted contention period
  - Used by all carrier sense variants
  - Provides random access to the channel
- Operation
  - Each node selects a random back off number
  - Waits that number of slots monitoring the channel
  - If channel stays idle and reaches zero then transmit
  - If channel becomes active wait until transmission is over then start counting again

802.11 DCF Example



cw = 31

B1 and B2 are backoff intervals at nodes 1 and 2

802.11 Contention Window

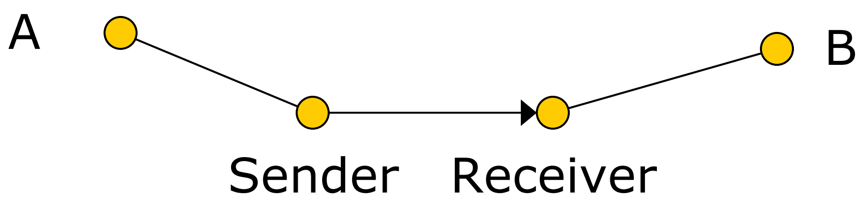
- Random number selected from [0,cw]
- Small value for cw
  - Less wasted idle slots time
  - Large number of collisions with multiple senders (two or more stations reach zero at once)
- Optimal cw for known number of contenders & know packet size
  - Computed by minimizing expected time wastage (by both collisions and empty slots)
  - Tricky to implement because number of contenders is difficult to estimate and can be VERY dynamic

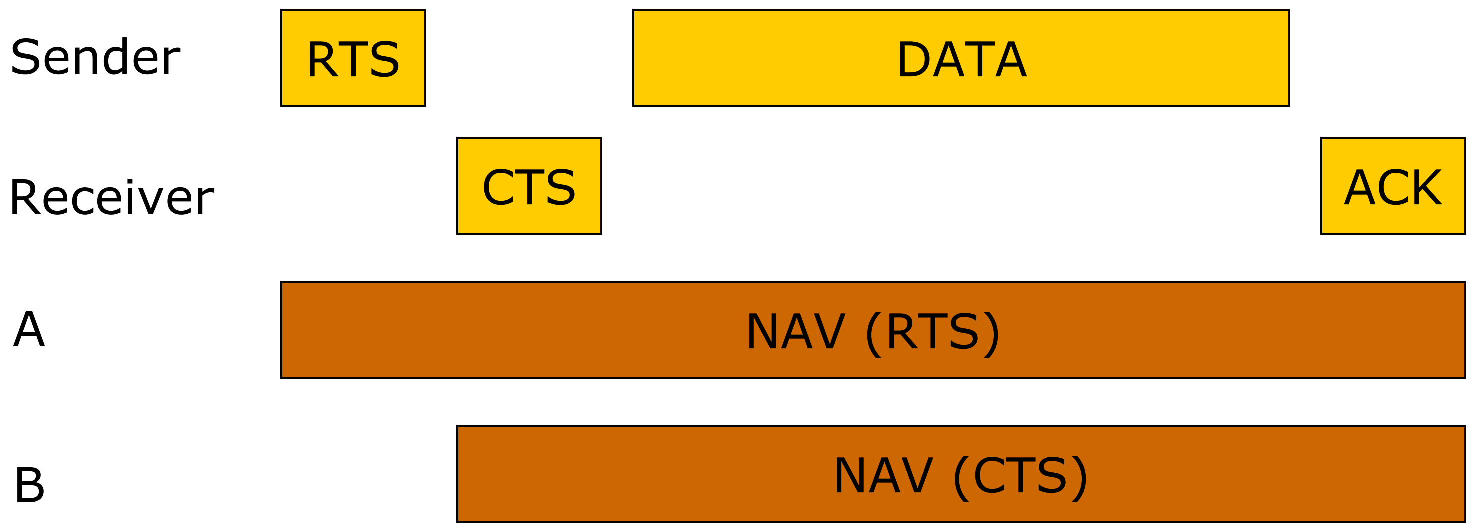
802.11 Adaptive Contention Window

- 802.11 adaptively sets cw
  - Starts with cw = 31
  - If no CTS or ACK then increase to 2*cw+1 (63, 127, 255)
  - Reset to 31 on successful transmission
- 802.11 adaptive scheme is unfair
  - Under contention, unlucky nodes will use larger cw than lucky nodes (due to straight reset after a success)
  - Lucky nodes may be able to transmit several packets while unlucky nodes are counting down for access
- Fair schemes should use same cw for all contending nodes (better for high congestion too)

802.11 DCF (CSMA-CA)

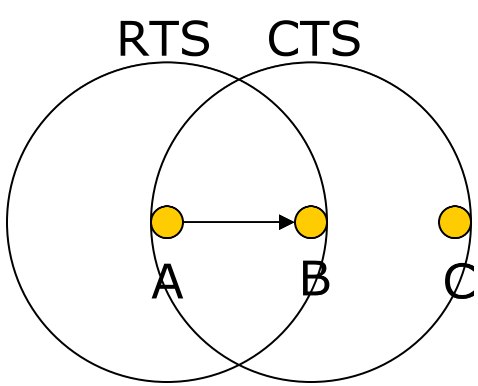
- Full exchange with "virtual" carrier sense (called the Network Allocation Vector)





Virtual Carrier Sense

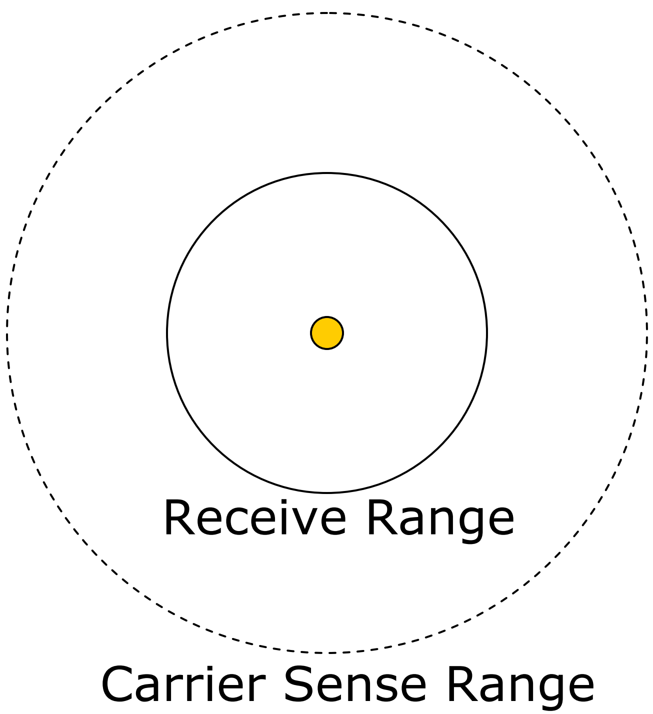
- Provided by RTS & CTS
- Designed to protect against hidden terminal collisions (when C can't receive from A and might start transmitting)
- However this is unnecessary most of the time due to physical carrier sense



Physical Carrier Sense Mechanisms

- Energy detection threshold
  - Monitors channel during “idle” times between packets to measure the noise floor
  - Energy levels above the this noise floor by a threshold trigger carrier sense
- DSSS correlation threshold
  - Monitors the channel for Direct Sequence Spread Spectrum (DSSS) coded signal
  - Triggers carrier sense if the correlation peak is above a threshold
  - More sensitive than energy detection (but only works for 802.11 transmissions)
- High BER disrupts transmission but not detection

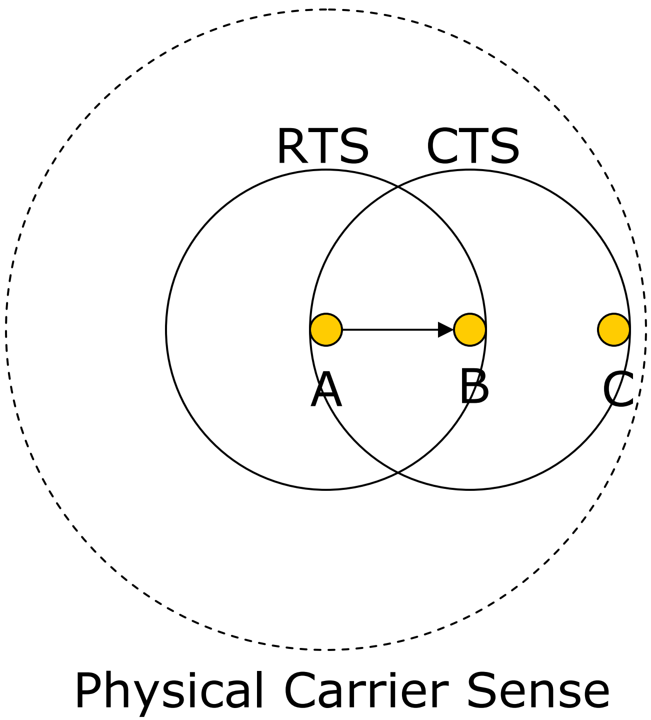
Physical Carrier Sense Range



- Carrier can be sensed at lower levels than packets can be received
  - Results in larger carrier sense range than transmission range
  - More than double the range in NS2 802.11 simulations
- Long carrier sense range helps protect from interference

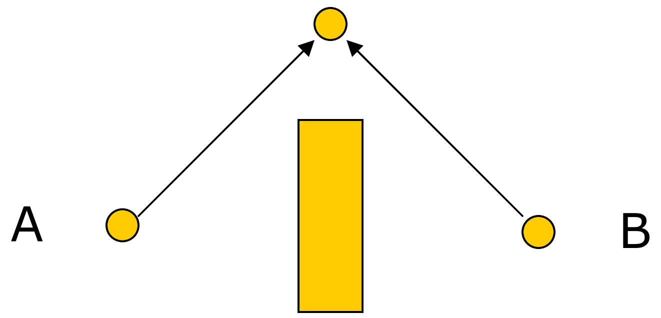
Hidden Terminal Revisited

- Virtual carrier sense no longer needed in this situation



RTS CTS Still Useful Sometimes

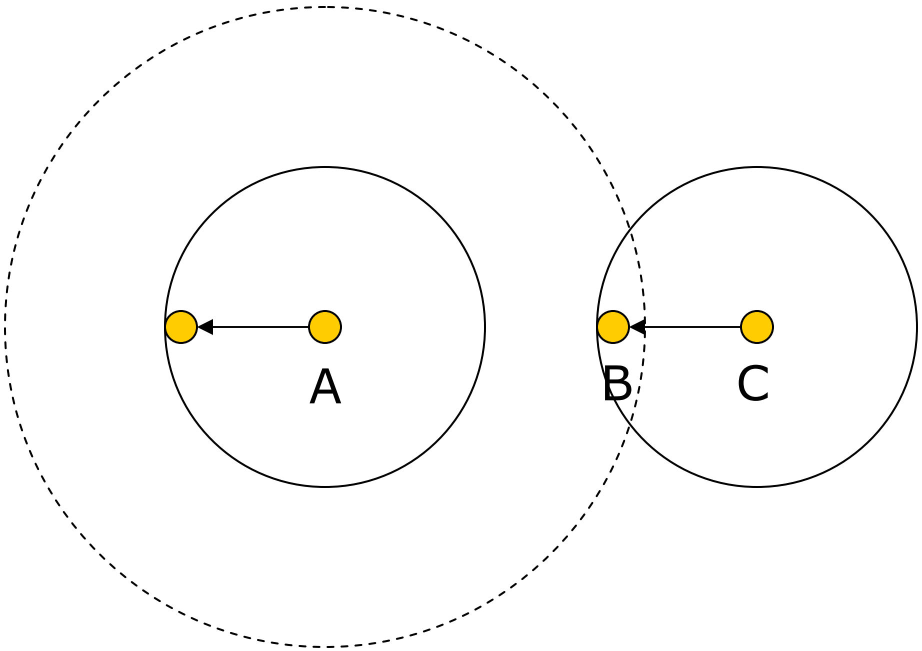
- Obstructed hidden terminal situation



- Fast collision resolution for long data packets

Exposed Terminal Problem

- Hidden terminal is not the only challenge for a distributed wireless MAC protocol
- A blocks B, and C doesn't know what is happening (B is exposed)



Double Exposure Problem

- If A and C are out of phase, there is NO time D can transmit without causing a collision