Medium Access Control

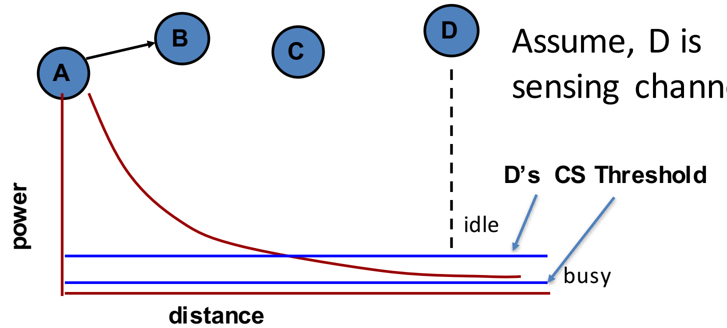
Part II

Revisit Assumptions

- So far, we assumed that all nodes are in close proximity such that
  - They all could sense each other's carrier
  - Two simultaneous transmissions will always interfere to cause collision.
- Let us now relax this assumption.

Carrier Sense Threshold

- If received power is less than P_{CS} (carrier sense threshold), channel is assumed idle, otherwise busy.



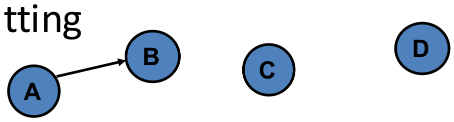
Assume, D is sensing channel

Important Tradeoff

- Lower carrier sense threshold means less spatial reuse or less concurrency.
- On the other hand, higher threshold means more spatial reuse, but more possibility of interference.
- Need a balance for the best performance.

Impact of CS Threshold on Interference

- Suppose C transmits even though A is already transmitting



$$P_t \, g_{AC} \quad \leq \quad P_{CS} \qquad \Rightarrow \qquad P_t \quad \leq \quad \frac{P_{CS}}{g_{AC}}$$

$$\text{Interference } I_{CB} \quad = \quad P_t \, g_{CB} \quad \leq \quad \frac{P_{CS}}{g_{AC}} \, g_{CB} = P_{CS} \, \frac{g_{CB}}{g_{AC}}$$

[Interference at B due to C]

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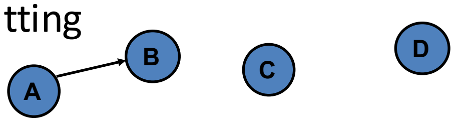
Impact of CS Threshold on Interference

- Suppose C transmits even though A is already transmitting



$$P_t \, g_{AC} \quad \leq \quad P_{CS} \qquad \Rightarrow \qquad P_t \quad \leq \quad \frac{P_{CS}}{g_{AC}}$$

$$I_{AD} \quad = \quad P_t \, g_{AD} \quad \leq \quad P_{CS} \, \frac{g_{AD}}{g_{AC}}$$

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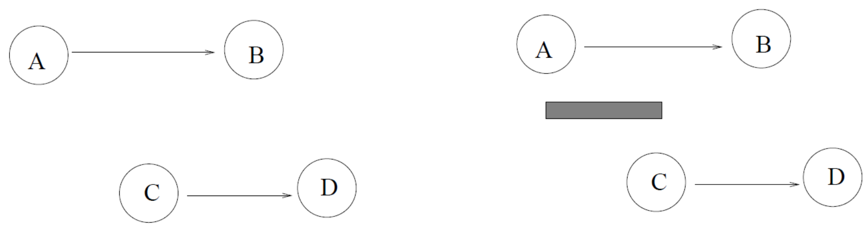
Hidden Terminals

$$I_{CB} \leq P_{CS} \frac{g_{CB}}{g_{AC}}$$



(a) g_{AC} large

(b) g_{AC} small

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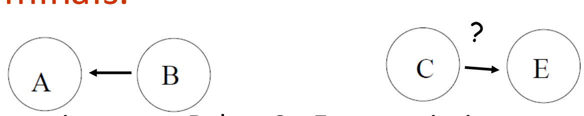
Hidden & Exposed Terminals

- Collisions may occur despite carrier sensing.
- Smaller carrier sensing threshold (P_{CS}) can help.
- But increases the possibility of exposed terminals.



[C can carrier sense B, but C->E transmission cannot collide with B->A transmission as the interference at A from C (or at E from B) is not significant enough.]

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Hidden & Exposed Terminals

- Difficult to eliminate all collisions using carrier sensing alone.
- There is a trade-off between hidden and exposed terminals.
  - Both are bad for performance.
  - Hidden terminal -> transmit but collide, exposed terminal -> do not transmit.
- "Optimal" carrier sense threshold is a function of network "topology" and traffic characteristics.

Two Important Design Elements

1. Contention window size (cw) for backoff. Note that this is a proxy for the transmit probability *p*.

2. Carrier sense threshold P_{CS}.

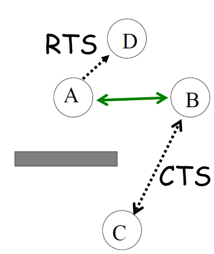
Successful CSMA protocol design would depend on the right setting of these two parameters.

Solutions to Hidden Terminal Problem

- Note that the hidden terminal issue arises as transmitter cannot carrier sense at the receiver, while collisions happen at the receiver.
- Thus, we must somehow carrier sense at the receiver.
- Two approaches
  - Busy tone: receiver sounds a busy tone in a different channel, carrier sense on this tone only.
  - Virtual carrier sensing via RTS/CTS exchange: additional control message exchange to silence any transmitter within range of a receiver.

Virtual Carrier Sensing

- Sender sends RTS to receiver specifying the packet duration
- Receiver responds with CTS and copies the packet duration
- Any host hearing RTS or CTS stay silent until the entire exchange is complete.



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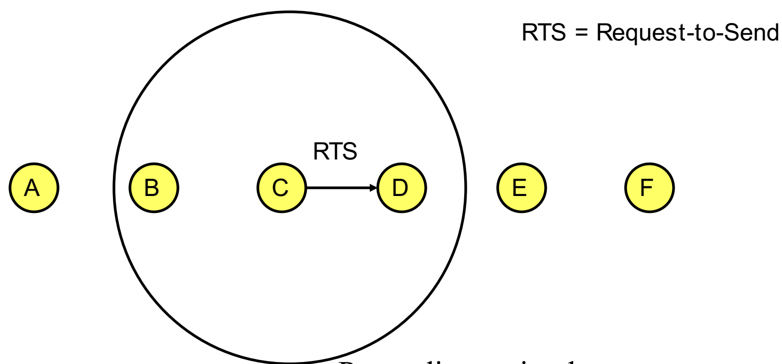

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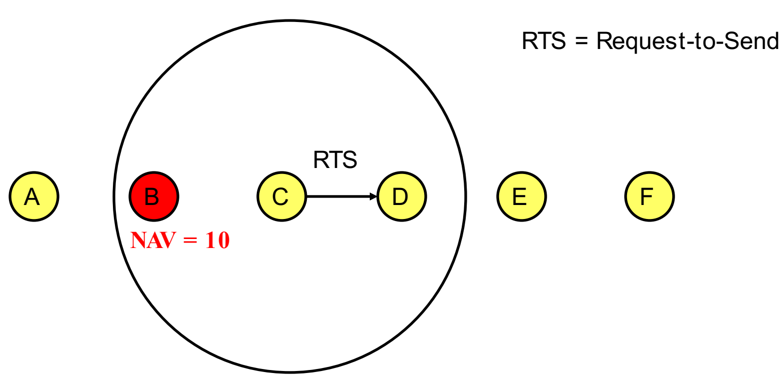

NAV = remaining duration to keep quiet

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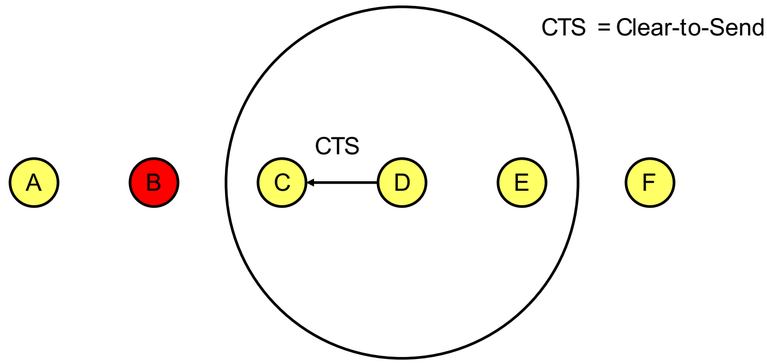

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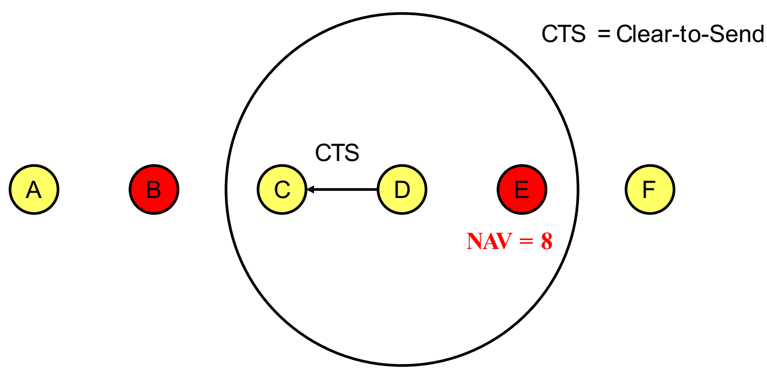

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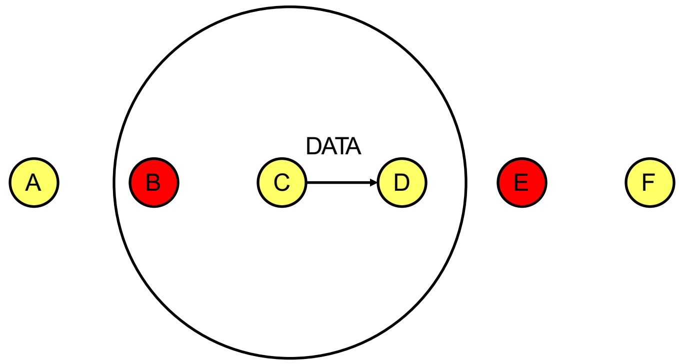
•DATA packet follows CTS. Successful data reception acknowledged using ACK.



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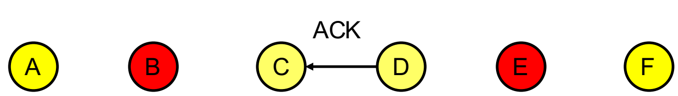

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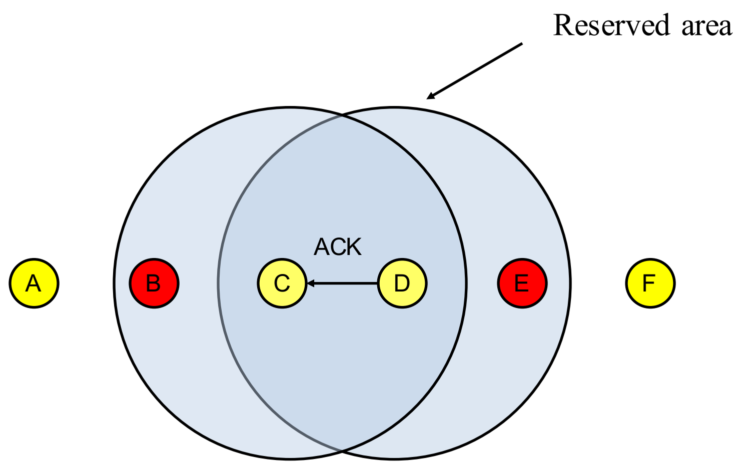
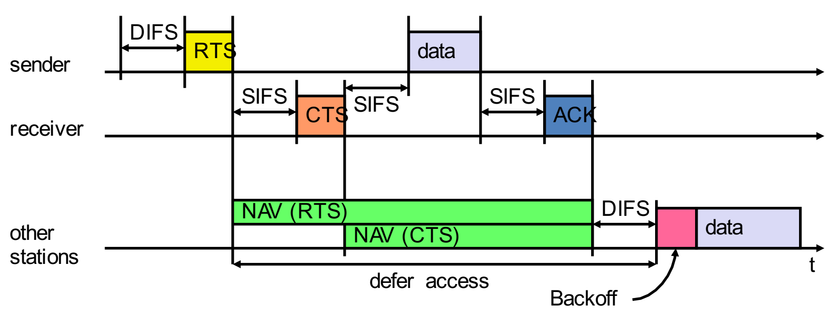


Timing Diagram



- The broad protocol operation is same as in physical carrier sensing.