MACAW

IEEE 802.11 Standard

Reducing Cost of Collisions

- Collisions are expensive
  - How to reduce their cost?
- “Reserve” the wireless channel before transmitting data
  - Send short control packets for reservation
  - Collision may occur for control packets, but they are short → lower collision cost
- Once channel reserved, data transmission (hopefully) reliable
Each backlogged node chooses $R = \text{rand}(0, \text{CW}_\text{MIN})$
- Counts down $R$, while continuously sensing carrier
- Once carrier busy, freezes countdown

Whoever reaches ZERO, transmits RTS
- Receiver replies with CTS

Neighbors freeze countdown, decode RTS, CTS
- RTS contains $(\text{CTS+DATA+ACK})_\text{duration} = T_{\text{COMM}}$
- CTS contains $(\text{CTS+ACK})_\text{duration} = T_{\text{COMM2}}$
- Neighbors remain silent for $\text{NAV} = \min(T_{\text{COMM}}, T_{\text{COMM2}})$ time
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- Sender sends DATA, receiver sends ACK
- All neighbors resume countdown on seeing ACK
  - Sender initiates new countdown \( R = \text{rand}(0, \text{CW} \_\text{MIN}) \)

Handling Collisions

- If no CTS/ACK returns:
  - Indicates collision
  - RTS chooses new \( R_1 = \text{rand}(0, 2 \times \text{CW} \_\text{MIN}) \)
    - Exponential backoff on successive collisions:
      \[ R_i = \text{rand}(0, 2^i \times \text{CW} \_\text{MIN}) \]
  - If successful transmission, reset to \( \text{rand}(0, \text{CW} \_\text{MIN}) \)
BUT IS THAT ENOUGH?

RTS/CTS: Hidden Terminals

- Does it solve hidden terminals?
  - Assuming carrier sensing zone = communication zone

E does not receive CTS successfully → Can later initiate transmission to D. Hidden terminal problem remains.
**Hidden Terminal Problem**

- How about increasing carrier sensing range
  - E will sense signal from C and will defer transmission
    - Avoids collision!!

**Hidden Terminals**

- But what if barriers / obstructions exist?
  - E doesn't hear C ➔ carrier sensing does not help!
Exposed Terminal

- B should be able to transmit to A
  - RTS prevents this

Exposed Terminals

- B should be able to transmit to A
  - Carrier sensing makes the situation worse!

802.11 Observations

- 802.11 does not solve HT/ET completely
  - Only alleviates the problem through RTS/CTS
  - Recommends larger CS zone

- Larger CS zone aggravates exposed terminals
  - Spatial re-use reduces a tradeoff
  - RTS/CTS packets also consume bandwidth
  - Moreover, backoff mechanism is also wasteful

*802.11 is still being optimized...*
*Search for best MAC protocol is still on...*