

## Recitation 8

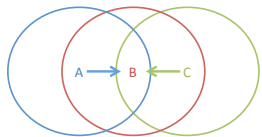
Wireless Networks

### Virtual carrier sensing

- First exchange control frames before transmitting data
  - Sender issues “Request to Send” (RTS), incl. length of data
  - Receiver responds with “Clear to Send” (CTS)
- If sender sees CTS, transmits data (of specified length)
- If other node sees CTS, will idle for specified period
- If other node sees RTS but not CTS, free to send

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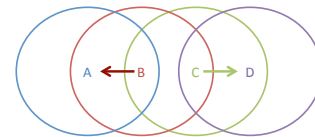
### Hidden Terminal Problem



- A and C cant see each other, both send to B
- RTS/CTS can help
  - Both A and C would send RTS that B would see first
  - B only responds with one CTS (say, echoing A's RTS)
  - C detects that CTS doesn't match and wont send

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### Exposed Terminal Problem



- B sending to A, C wants to send to D
- As C receives packets, carrier sense would prevent it from sending to D, even though wouldn't interfere
- RTS/CTS can help
  - C hears RTS from B, but not CTS from A
  - C knows its transmission will not interfere at B's receiver
  - C is safe to transmit to D

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a. When using RTS/CTS, what prevents a hidden terminal from clobbering the packets that another node is sending?

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*Hidden terminal would see the CTS of the sender's desired destination, but not the RTS of the sender, and choose not to send to the same destination as had sent the CTS.*

(b) When using RTS/CTS, how does an exposed terminal decides it is safe to send?

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*Exposed terminal would see the RTS of another node, but not the corresponding CTS (from the other node's destination), and know it's safe to send.*

2. Why does TCP perform badly on wireless links? What can be done to improve performance without requiring all wired hosts to upgrade to a new protocol?

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*In contrast to wired networks, packet loss in wireless networks is not necessarily a sign of congestion; rather, interference and/or fading may be the cause. Yet, TCP treats packet loss as an implicit sign of congestion and decreases the sending rate. The performance could be improved by employing a TCP proxy at the wireless/wired boundary.*

3. Why are many packet losses in wireless networks detected by a timeout rather than a triple-duplicate acknowledgment? What are the performance implications?

3. Why are many packet losses in wireless networks detected by a timeout rather than a triple-duplicate acknowledgment? What are the performance implications?

*Wireless networks tend to experience periodically sustained packet loss due to interference (e.g. a microwave). This decreases the likelihood that, in the same TCP sending window, some packets are lost while others are successfully delivered. Instead, all of the packets are lost. Some successful deliveries are necessary to trigger the receiver to send duplicate acknowledgments. As such, periodically sustained loss tends to require the sender to rely on retransmission timeout to detect loss. (In addition, many wireless networks have relatively low capacity, leading the sender to have a relatively small congestion window. This also decreases the likelihood that enough packets are successfully delivered to enable detection of an earlier packet loss by duplicate acknowledgments. Similarly, wireless users may do smaller transfers due to limited bandwidth or small screen sizes of smaller graphics needed on smartphones, etc., and small transfers offer less opportunity for multiple packets in flight during the same RTT.)*

In this wireless topology, A, B, C, and D all have equi-sized transmission ranges, while E has a smaller range.

Assume that two nodes' transmissions will interfere if and only if they transmit at the same time and their transmission areas overlap. Further, assume that losses only occur due to collisions.

When D communicates with C, what nodes are *exposed terminals* and what nodes are *hidden terminals*?

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Assume that two nodes' transmissions will interfere if and only if they transmit at the same time and their transmission areas overlap. Further, assume that losses only occur due to collisions.

When D communicates with C, what nodes are *exposed terminals* and what nodes are *hidden terminals*?

**only B is a hidden terminal and there are no exposed terminals**

If A sends data to B and C sends data to D (as fast as they can), and no collision detection mechanism is used, what is the throughput of their transfer as a proportion of their send rate?

A -> B ?

C -> D ?

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A -> B ? **0%**

C -> D ? **100%**

If A sends data to B and C sends data to D (as fast as they can), and CSMA is used, what is the throughput of their transfer as a proportion of their send rate?

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C -> D ?

If A sends data to B and C sends data to D (as fast as they can), and CSMA is used, what is the throughput of their transfer as a proportion of their send rate?

A -> B ? **0%**

C -> D ? **100%**

Now assume a RTS / CTS protocol is used. Assume that the overhead from RTS and CTS packets is small relative to the data transfer. What are the approximate throughputs of the transfer from each node?

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A -> B ? **50%**

C -> D ? **50%**

