CS551
Link Layer Issues for Wireless LANs
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Overview

- **Wireless access and mobility**
  - **force us to rethink many of our assumptions**
- **Focus of this paper:**
  - **link layer issues**
  - **packet delivery and routing**
- **... in combined wired-wireless networks**
  - **... in ad-hoc mobile wireless networks**
  - **transport layer issues**

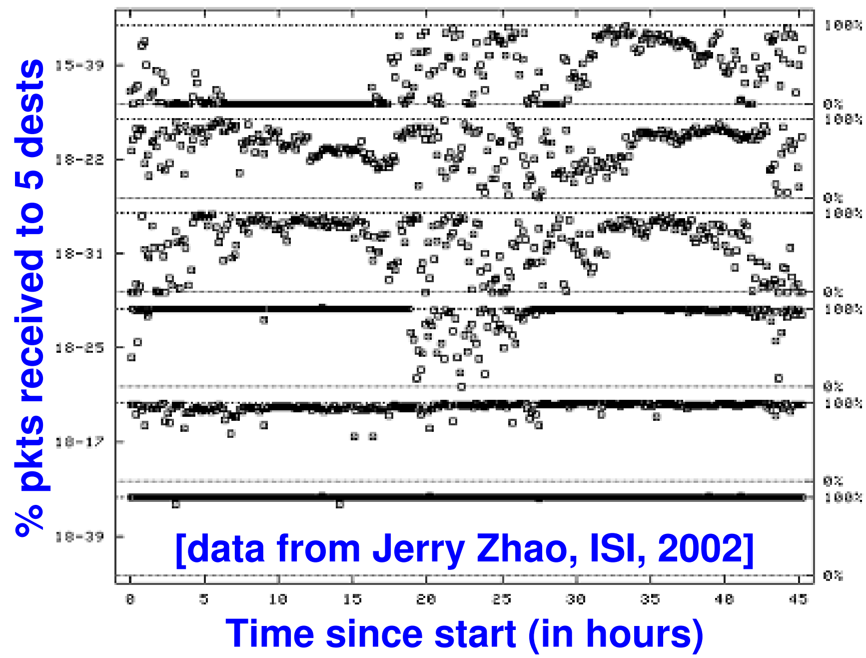
Wireless MAC Options

- Contention-based vs. token-based
  - why contention? because moving nodes could cause frequent token loss
- Base-station vs. ad-hoc
  - why base-station? simpler if you have a leader that can assign things (esp. if non-mobile)
  - why ad-hoc? don’t always have leader
  - MACAW and 802.11 do both

Radio Propagation

- Simple model: fixed tx range
  - propagation can be r^{-3} or r^{-1} (near or far)
  - issues: collisions, capture, interference
  - good simple model, but only an approximation

connectivity from one node to others



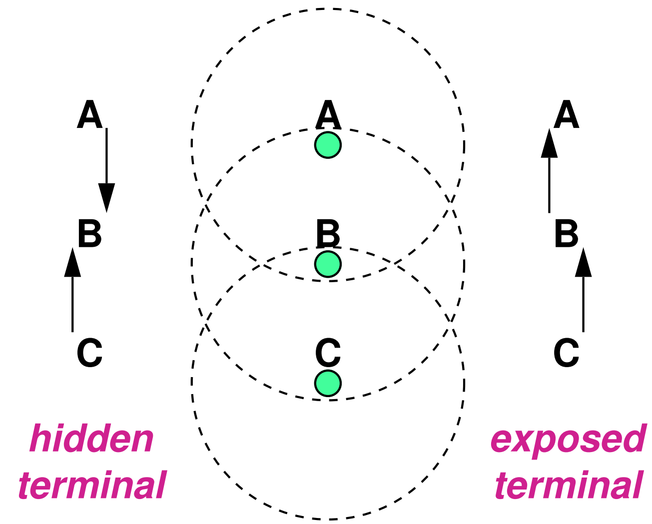
- Reality is much worse
  - Multi-path fading
  - time-varying effects

The Physical Layer

- Token-based or multiple access or spread spectrum
- First study a simple model
  - radio transmission range defined by *cell*
  - a receiver within range can hear transmission
  - interaction of multiple transmitters at receiver
    - *collision:* if receiver is within range of two transmitters, but can't extract either
    - *capture:* one signal stronger than other
    - *interference:* in-range of one transmitter, out of range of another, but can't extract signal
- Other, more complex environmental interactions
  - multipath: reflected signals interfere with original

Carrier Sense in Wireless

- Carrier Sense: before transmitting, check if carrier present
  - works in Ethernet
  - why not for wireless? because receiver and sender "sense" different "carrier"



- Issues
  - *hidden terminal:* A and C do not know that B cannot hear either
  - *exposed terminal:* B is busy sending to A, when does C get to talk to B?

Karn/MACA RTS-CTS

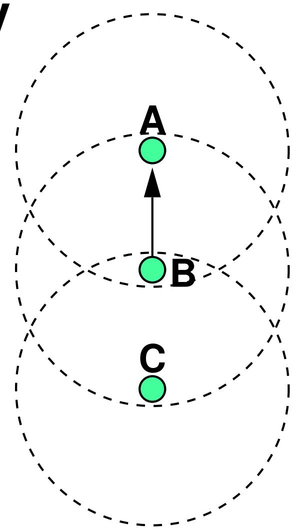
- General solutions
  - link-layer protocols
- Src sends Ready-to-Send (RTS) before data
  - overhearers defer
- Dst replies with Clear-to-Send (CTS)
  - overhearers defer
- RTS around src, CTS around dest, so everyone should be quiet
- Must also deal with collisions, etc.

hidden terminal scenario

A sends RTS
$\Rightarrow$ B gets RTS and sends CTS
$\Rightarrow$ C hears CTS and is quiet (no hidden terminal)

Continuing Fairness Problems

- An exposed terminal may not be able to compete effectively
  - C doesn't know if RTS/CTS was successful,
  - ... so reduced to trying at random times
  - tends to back-off more and more
- Fix:
  - carrier sense
  - ...or a DS (Data Sending) packet (include data length)
- Doesn't solve all fairness issues



B sends RTS

$\Rightarrow$ A gets RTS and sends CTS; but C misses CTS

$\Rightarrow$ B sends DS

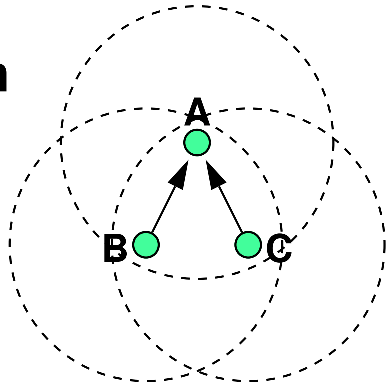
$\Rightarrow$ C hears DS (and data length) and so knows when to try RTS again

$\Rightarrow$ B sends DATA

$\Rightarrow$ C knows to RTS after data

Back-off Issues

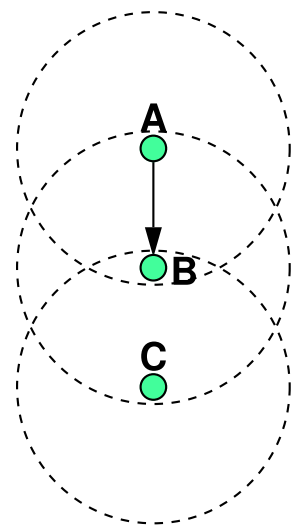
- Back-off algorithm:
  - Back-off counter BO estimates population
  - randomly wait [0,BO] before sending
  - original: binary exponential:
    - BO = 0 after success
    - BO *= 2 after collision



- Problem: channel capture
  - if I succeed, my BO = 0, so I am likely to win again
  - others who fail get slower and slower
- Fixes:
  - share BO (send in each packet)
  - increase multiplicatively, decrease additively ("MILD")
  - per-destination back-off

Adding Link-level ACKs

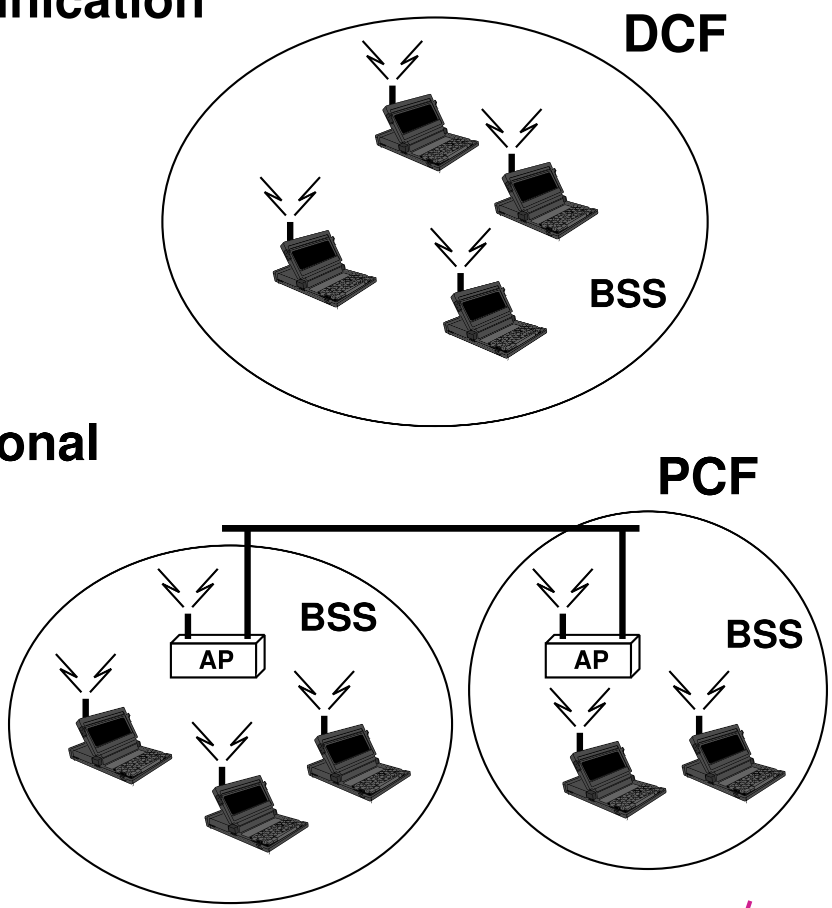
- Wireless losses possible
  - noise or collisions
  - end-to-end argument?
- Add link-level ACK of DATA
  - lost DATA => no ACK => retransmission
  - lost ACK => sender retx RTS, receiver sends ACK instead of CTS
- This approach is also used in 802.11



A sends RTS
$\Rightarrow$ B gets RTS and sends CTS
$\Rightarrow$ A sends DATA
$\Rightarrow$ B sends ACK
$\Rightarrow$ if no ACK, A resends RTS

Commercializing MACAW: IEEE 802.11

- Standard for wireless communication
- MAC-layer uses many of the ideas discussed
  - Basic MAC is a CSMA/CA
    - Carrier-sense and transmit, ACK
  - RTS/CTS exchange is optional
- Allows two modes
  - ad-hoc (DCF: Distributed Coordination Function)
  - base-station (PCF: Point Coordination Function)



802.11 Details

- Much more complex than MACAW
  - because it’s real
  - because it’s designed by committee
- Does not include all MACAW
  - less emphasis on fairness (e.g., no shared backoff)
- In PCF (base station mode), quite different
  - base station polls nodes to see if they have traffic to send
    - can arbitrrate transmissions
- In DCF (ad-hoc mode)
  - CSMA/CA with ACK
  - optional RTS/CTS
  - MILD backoff
  - no DS, RRTS, etc.

Discussion

- Context
  - most currently used ideas had already been developed with MACA
- Impact
  - nice exposition of various fairness issues with wireless MACs
- Good use of simple examples to understand various problems in wireless communication
- No implmentation, unfortunately