CS640: Introduction to Computer Networks

Aditya Akella

Lecture 22 -
Wireless Networking

Wireless Challenges

- Force us to rethink many assumptions
- Need to share airwaves rather than wire
- Mobility
- Other characteristics of wireless
  - Noisy → lots of losses
  - Slow
  - Interaction of multiple transmitters at receiver
    - Collisions, capture, interference
  - Multipath interference

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IEEE 802.11 Wireless LAN

- 802.11b
  - 2.4-2.5 GHz unlicensed radio spectrum
  - up to 11 Mbps
  - direct sequence spread spectrum (DSSS) in physical layer
    - all hosts use same chipping code
  - widely deployed, using base stations
- 802.11a
  - 5-6 GHz range
  - up to 54 Mbps
- 802.11g
  - 2.4-2.5 GHz range
  - up to 54 Mbps
- All use CSMA/CA for multiple access
- All have base-station and ad-hoc network versions

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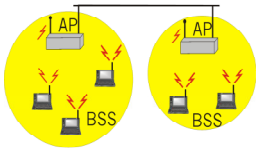
IEEE 802.11 Wireless LAN

- Wireless host communicates with a base station
  - Base station = access point (AP)
- Basic Service Set (BSS) (a.k.a. "cell") contains:
  - Wireless hosts
  - Access point (AP): base station
- BSS's combined to form distribution system



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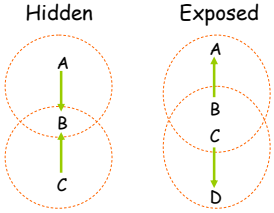
CSMA/CD Does Not Work

- Collision detection problems
  - Relevant contention at the receiver, not sender
    - Hidden terminal
    - Exposed terminal
  - Hard to build a radio that can transmit and receive at same time



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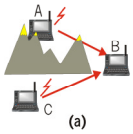
Hidden Terminal Effect

- Hidden terminals: A, C cannot hear each other
  - Obstacles, signal attenuation
  - Collisions at B
  - Collision if 2 or more nodes transmit at same time
- CSMA makes sense:
  - Get all the bandwidth if you're the only one transmitting
  - Shouldn't cause a collision if you sense another transmission
- Collision detection doesn't work
- **CSMA/CA: CSMA with C**ollision **A**voidance



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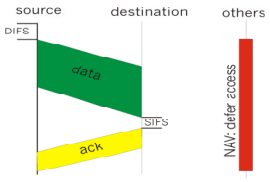
IEEE 802.11 MAC Protocol: CSMA/CA

802.11 CSMA: sender

- If sense channel idle for DIFS (Distributed Inter Frame Space) then transmit entire frame (no collision detection)
- If sense channel busy then binary backoff

802.11 CSMA: receiver

- If received OK return ACK after SIFS -- Short IFS (ACK is needed due to hidden terminal problem)



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Collision Avoidance Mechanisms

- Problem:
  - Two nodes, hidden from each other, transmit complete frames to base station
  - Wasted bandwidth for long duration!
- Solution:
  - Small reservation packets: RTS+CTS
  - Nodes track reservation interval with internal "network allocation vector" (NAV)

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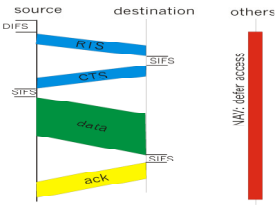
Collision Avoidance: RTS-CTS Exchange

- Explicit channel reservation
  - Sender: send short RTS: request to send
  - Receiver: reply with short CTS: clear to send
  - CTS reserves channel for sender, notifying (possibly hidden) stations
- RTS and CTS short:
  - collisions less likely, of shorter duration
  - end result similar to collision detection
- Avoid hidden station collisions
- Not widely used/implemented
  - Consider typical traffic patterns



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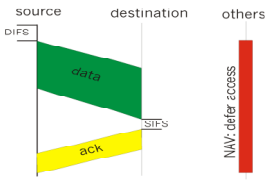
IEEE 802.11 MAC Protocol

802.11 CSMA Protocol: others

- NAV: Network Allocation Vector; maintained by each node
- 802.11 RTS frame has transmission time field
- Others (hearing CTS) defer access for NAV time units
- Reserve bandwidth for NAV time units



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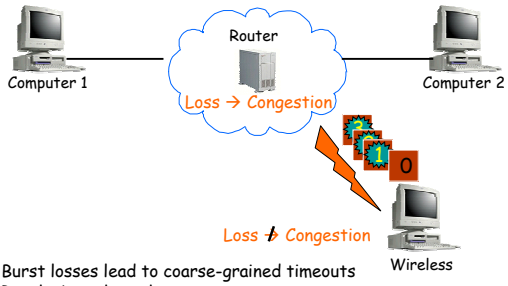
Wireless Bit-Errors



Burst losses lead to coarse-grained timeouts
Result: Low throughput

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TCP Problems Over Noisy Links

- Wireless links are inherently error-prone
  - Fades, interference, attenuation
  - Errors often happen in bursts
- TCP cannot distinguish between corruption and congestion
  - TCP unnecessarily reduces window, resulting in low throughput and high latency
- Burst losses often result in timeouts
- Sender retransmission is the only option
  - Inefficient use of bandwidth

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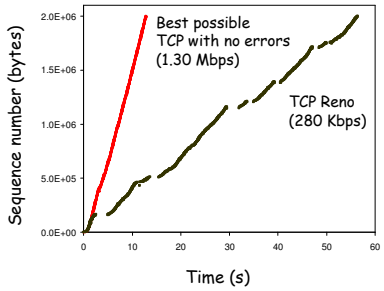
Performance Degradation



2 MB wide-area TCP transfer over 2 Mbps Lucent WaveLAN

Proposed Solutions

- Incremental deployment
  - Solution should not require modifications to fixed hosts
  - If possible, avoid modifying mobile hosts
- End-to-end protocols
  - Selective ACKs, Explicit loss notification
- Split-connection protocols
  - Separate connections for wired path and wireless hop
- Reliable link-layer protocols
  - Error-correcting codes
  - Local retransmission

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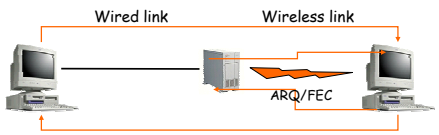
Approach Styles (Link Layer)

- More aggressive local rexmit than TCP
  - Bandwidth not wasted on wired links
- Possible interactions with transport layer
  - Interactions with TCP retransmission
  - Large end-to-end round-trip time variation
- FEC does not work well with burst losses



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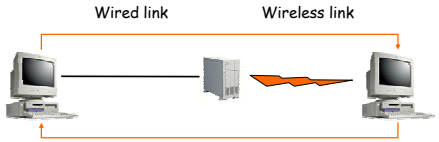
Approach Styles (End-to-End)

- Improve TCP implementations
  - Not incrementally deployable
  - Improve loss recovery (SACK, NewReno)
  - Help it identify congestion (ELN, ECN)
    - ACKs include flag indicating wireless loss
  - Trick TCP into doing right thing → E.g. send extra dupacks



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