CMPE 257: Wireless and Mobile Networking

Katia Obraczka
Computer Engineering
UCSC Baskin Engineering

Lecture 5

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Announcements
Today

• Finish contention-based MAC.
  – MACAW.
  – FLAMA.

• Cover today’s MAC papers.
  – Multi-channel.
  – Directional antennas.
CSMA Variants

• 1-persistent (IEEE 802.3):
  – If medium idle, transmit.
  – If medium busy, keep listening; when medium idle, transmit with probability 1.

• $p$-persistent:
  – Same as above but with probability $p$.

• Non-presistent:
  – If medium idle, transmit.
  – If medium busy, wait a random period before retrying.
MAC: A Bird’s Eye View
Solutions to Hidden/Exposed Nodes in CSMA

- Use control packets:
  - RTS/CTS (Request-To-Send/Clear-To-Send)
  - Used by MACA (Multiple Access Control Avoidance) and MACAW (MACA for Wireless LANs).

- Use both control packets and carrier sense:
  - CSMA/CA, IEEE 802.11
Dynamic Reservation Approaches: Sender- vs. Receiver-initiated

• Sender-initiated:
  – A node wanting to send data takes the initiative of setting up the reservation.
  – Most existing schemes.

• Receiver-initiated:
  – A receiving node polls a potential transmitting node for data.
  – A node can send data after being polled.
  – E.g., MACA-By Invitation.
Single vs. Multiple Channel Protocols

• Single channel protocols: control and data use the same channel.

• Multiple channel protocols: separate channels for control & data transmission; data transmission on separate channels.
Other criteria for classification

• Power-aware.
  – E.g., PAMAS.
• Directional or omnidirectional antennas.
• QoS-aware
  – End-to-end (E2E) delay
  – Packet loss rate (or the probability)
  – Available bandwidth
  – Challenges: lack of centralized control, limited bandwidth, node mobility, power/computational constraints, error-prone nature of wireless media.
MACAW

• [Bharghavan, 1994].
• Proposed as improvement to MACA [Karn, 1990].
• Note that first IEEE 802.11 standard (IEEE 802.11 “legacy”) released in 1997.
MACA

• Introduced CA.
  – RTS/CTS handshake (2-way).
MACA

• If node A wants to transmit to B, it first sends an RTS packet to B, indicating the length of the data transmission to follow.
• B returns A a CTS packet with the expected length of the transmission.
• A starts transmission when it successfully receives CTS.
  – RTS and CTS packets are much shorter than data packets.

• A neighboring node overhearing an RTS defers its own transmission until the corresponding CTS would have been finished.
• A node hearing the CTS defers for the expected length of the data transmission.
MACA (Cont’d)

• Nodes close to sender:
  – If no CTS heard, OK to transmit.
  – Avoid exposed terminal problem: nodes that hear only RTS can transmit simultaneously with RTS sender.

• Nodes close to receiver:
  – Upon hearing CTS, defer till after data.
  – Avoid hidden terminal.

• Binary exponential backoff (BEB).
  – Possible unfair channel allocation (starvation).
MACAW

• Inspired 802.11.
• 2 basic changes to MACA:
  – Additional signaling.
  – Modified backoff algorithm.
MACAW Backoff

• Tries to avoid BEB’s unfairness.
• Proposed fix: sharing congestion information among nodes.
  – Backoff counter information propagated in packet header.
  – After successful transmission, neighbors have the same backoff counter.
Data Transmission in MACAW

• Added ACK.
  – Reliability at layer 2.
  – If ACK not received:
    • Retransmit frame.
    • Increment backoff timer.
Data Transmission in MACAW

- Added small “Data Sending” (DS) control frame.
  - Addresses exposed terminal problem.
  - Example: S1->R1 and S2->R2
    - CTS from R2 may collide with transmission S1->R1.
    - S2 backs-off.
  - Fix: make sure S2 knows RTS-CTS exchange between S1 and R1 was successful.
    - S1 sends small control frame, DS with data exchange duration.
    - When S2 receives DS, defers its transmission.
Data Transmission in MACAW

- Added “Request for Request-to-Send” (RRTS).
- R2 contends on behalf of S2 if it received RTS from S2 if it could not have responded because deferring due to S1->R1 exchange.
- When S2 receives RRTS from R2, proceeds with RTS, etc.
FAMA

- Floor Acquisition Multiple Access.
- MACA: floor acquisition on packet-by-packet basis.
- FAMA:
  - Acquires channel for multiple packet transmissions.
FAMA-NTR

- FAMA non-persistent transmit request.
  - Non-persistent CS + RTS/CTS exchange.
  - Enforces waiting periods at sender and receiver.
    - Waiting period proportional to maximum propagation time.
FAMA-NTR

• Before sending:
  – Node senses channel.
  – If channel busy, backs-off for random period and retries later => non-persistent.
  – If channel free, node sends RTS.

• Node waits CTS for 1 RTT.
  – If CTS not received, node backs-off.
  – Otherwise, transmits data burst (up to a maximum size).
FAMA-NTR

- To allow bursts, receiving station waits after processing each data packet.
  - Waiting period (T) = maximum propagation time.
- Transmitting node waits for 2T after any control frame.
  - Allows enough time for RTS-CTS exchange.