The Shadowing Phenomenon: Implications of receiving during a collision

NEST Retreat, January 2004

Presented by: Kamin Whitehouse

Joint work with: Alec Woo
Fred Jiang
Joe Polastre
Radio Collisions

A

B

C

Got A!

Got B!

Huh??

Got A! Buh??

Got C!
Connectivity-interference Assumption

- Connectivity implies interference
  - Determine back-off times
  - Adjust transmission rates
  - Achieve fairness
  - Improve spatial reuse
  - Manage power consumption
  - Optimize bandwidth
The Shadowing Phenomenon

(a) ASK

Collision
The Shadowing Phenomenon
Contribution

- Shadowing is common
- Existing protocols do not presume shadowing
- Many techniques can exploit shadowing
Collision Detection and Recovery

Stronger Last

Delta t

Preamble Sync Data Crc

Delta t

Preamble Sync Data Crc
Collision Detection and Recovery

- Recovery improves bandwidth/energy
- Detection different from RTS/CTS and Ack
  - More information
  - Applies to broadcast messages
  - Info available at receiver
  - Only works with stronger-last (maximum 50%)
    - Could be augmented with termination symbol
Evaluation of Detection and Recovery

Vary $\Delta t = t_B - t_A$
Collision Detection and Recovery

Vary $\Delta t = t_B - t_A$

$\Delta t = -23\text{ms}$

$\Delta t = +23\text{ms}$
Evaluation of Detection and Recovery

Detection: 42% success

Recovery: 46% success
Implications of Shadowing in Protocol

- **MAC**
  - Acks
  - RTS/CTS
- **Routing**
  - Flooding
  - Clustering
  - Multi-hop Routing
- **Scheduling**
  - Localization
Acks and Shadowing

Got B!

Ack

B

C
RTS/CTS and Shadowing
Spatial Reuse and Shadowing
Localization and Shadowing
Open Questions

- How common are collisions in real life?
- How often does shadowing happen?
- How well does detection and recovery work?
- What is the spatial influence on shadowing?
Flooding Experiment

- 36 nodes in 9 x 4 grid, 2 meter spacing
- Each node transmits once in 25 experiments
- Newest CSMA for TinyOS

- 857 transmissions
- 12687 receptions
- 2036 collisions
- 1142 shadowings
Main Findings

- Detection: ~25% success rate
- Recovery: 30-40% success rate
Main Findings

- **Collisions are common**
  - 15% of receptions were in a collision
  - Up to 40-50% transmissions collided somewhere

- **Shadowing is common**
  - 40-100% of collisions have shadowing
  - As low as 10% of neighbors provide the connectivity-interference assumption
Main Findings

Occurrence of Distance Ratios during Shadowing

- Stronger is Closer
- Weaker is Closer

Number out of 1142 Total Shadowings

Distance Ratios (Farther/Shorter)
Main Findings

Probability of Being Overpowered at -4dBm

Distance (m) vs Probability

- Findings indicate that the probability of being overpowered increases with distance.
- The highest probability is observed at distance 5 meters.
- Probability decreases as distance increases beyond 5 meters.
Future Work

- Fix synch bytes problem
- Add termination symbol
- 802.11, 802.15.4, Bluetooth!
Conclusions

- RF engineers and Protocol Designers must talk!