Understanding and Mitigating the Impact of RF Interference on 802.11 Networks

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Growing interference in unlicensed bands

• Anecdotal evidence of problems, but how severe?
• Characterize how 802.11 operates under interference in practice
What do we expect?

- Throughput to decrease linearly with interference
- There to be lots of options for 802.11 devices to tolerate interference
  - Bit-rate adaptation
  - Power control
  - FEC
  - Packet size variation
  - Spread-spectrum processing
  - Transmission and reception diversity

Key questions for this talk

- How damaging can a low-power and/or narrow-band interferer be?

- How can today’s hardware tolerate interference well?
  - What 802.11 options work well, and why?
What we see

• Effects of interference more severe in practice

• Caused by hardware limitations of commodity cards, which theory doesn’t model

Talk organization

• Characterizing the impact of interference

• Tolerating interference today
Experimental setup

802.11 receiver path

Extend SINR model (in paper) to capture these vulnerabilities
Interested in worst-case natural or adversarial interference
Timing recovery interference

- Interferer sends continuous SYNC pattern
  - Interferes with packet acquisition (PHY reception errors)

![Graph showing throughput and latency vs interferer power for weak, moderate, and narrow-band interferers.]

Dynamic range selection

- Interferer sends on-off random patterns (5ms/1ms)
  - AGC selects a low-gain amplifier that has high processing noise (packet CRC errors)

![Graph showing throughput and latency vs interferer power for narrow-band interferers.]
Header processing interference

- Interferer sends continuous 16-bit Start Frame Delimiters
- Affects PHY header processing (header CRC errors)

Interference mitigation options

- Lower the bit rate
- Decrease the packet size
- Choose a different modulation scheme
- Leverage multipath (802.11n)
- Move to a clear channel
Impact of 802.11 parameters

- Rate adaptation, packet sizes, FEC, and varying CCA parameters do not help

Impact of 802.11g/n

- No significant performance improvement
Impact of frequency separation

- But, even small frequency separation (i.e., adjacent 802.11 channel) helps
  - Channel hopping to mitigate interference?

Talk organization

- Characterizing the impact of interference

- Tolerating interference today
Rapid channel hopping

- Use existing hardware
  - Design dictated by radio PHY and MAC properties (synchronization, scanning, and switching latencies)
- Design must accommodate adversarial and natural interference
  - Test with an oracle-based adversary
- Design overview
  - Packet loss during switching + adversary’s search speed
    - 10ms dwell period
  - Next hop is determined using a secure hash chain
  - Triggered only when heavy packet loss is detected

Evaluation of channel hopping

- Good TCP & UDP performance, low loss rate
Evaluation of channel hopping

• Acceptable throughput even with multiple interferers

Conclusions

• Lot of previous work on RF interference
  – We show 802.11 NICs have additional PHY and MAC fragilities

• Interference causes substantial degradation in commodity NICs
  – Even weak and narrow-band interferers are surprisingly effective

• Changing 802.11 parameters does not mitigate interference, but rapid channel hopping can
Thanks!
Questions?

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