Understanding and Mitigating the Impact of RF Interference on 802.11 Networks

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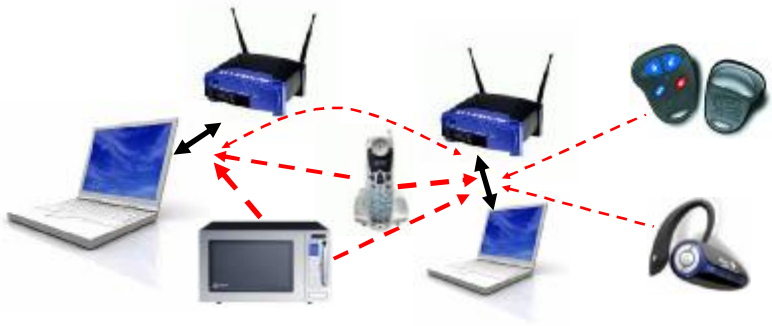
Growing interference in unlicensed bands

- Anecdotal evidence of problems, but how severe?
- Characterize how 802.11 operates under interference in practice



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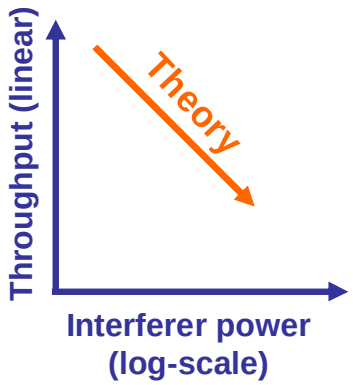
What do we expect?

- 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



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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?

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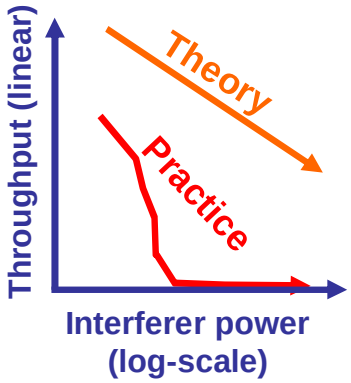
What we see

- Effects of interference more severe in practice
- Caused by hardware limitations of commodity cards, which theory doesn't model



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Talk organization

- Characterizing the impact of interference
- Tolerating interference today

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Experimental setup

Access Point

UDP flow

802.11 interferer

802.11 Client

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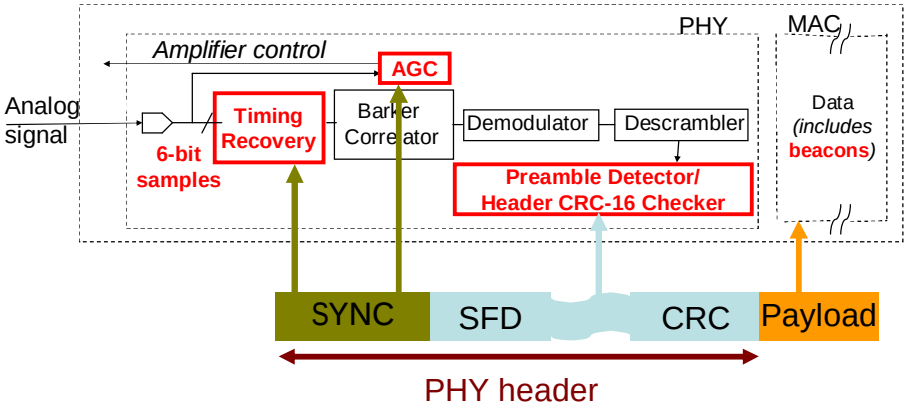
802.11 receiver path



Extend SINR model (in paper) to capture these vulnerabilities

Interested in worst-case natural or adversarial interference

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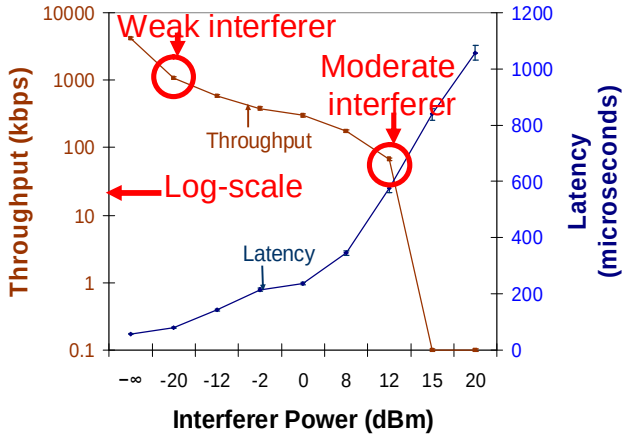
Timing recovery interference

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



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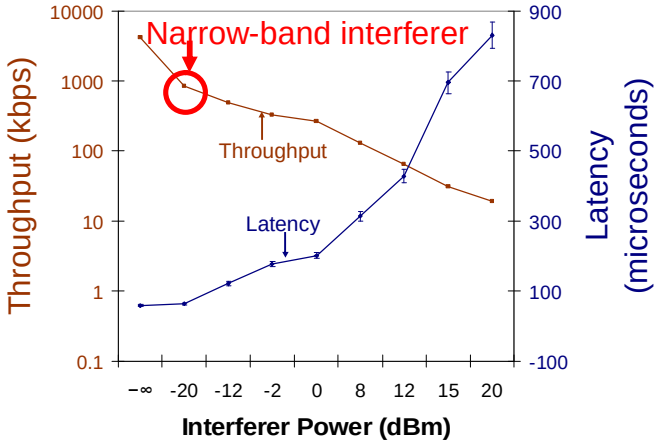
Dynamic range selection

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



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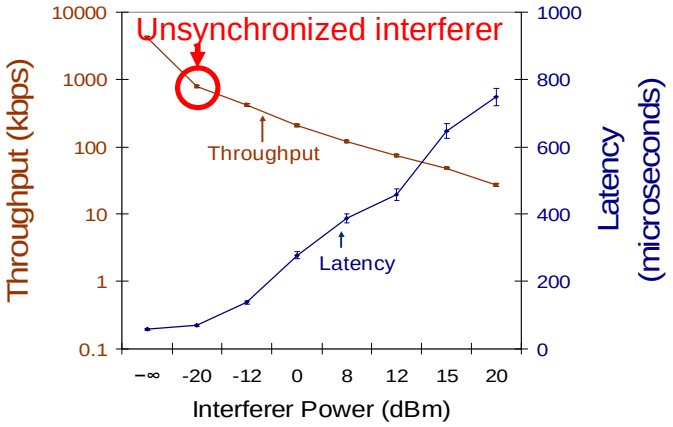
Header processing interference

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



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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

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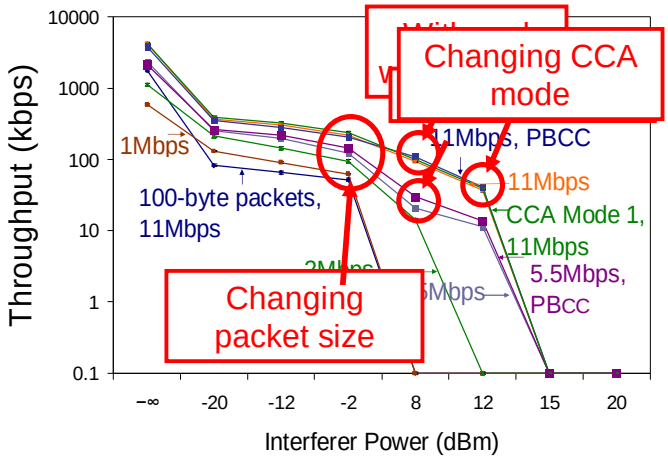
Impact of 802.11 parameters

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



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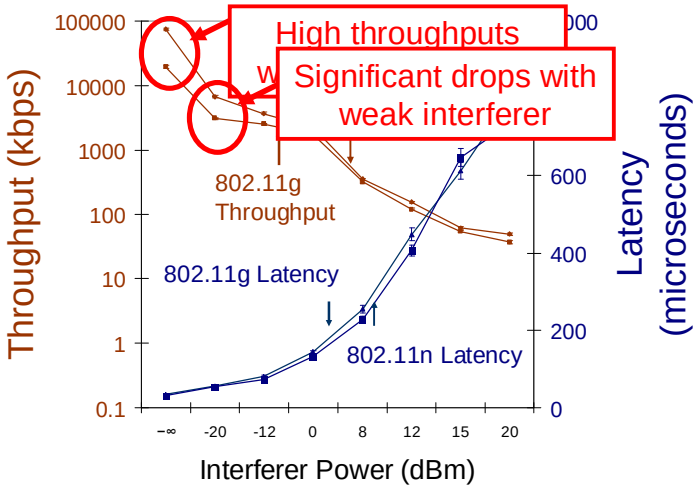
Impact of 802.11g/n

- No significant performance improvement



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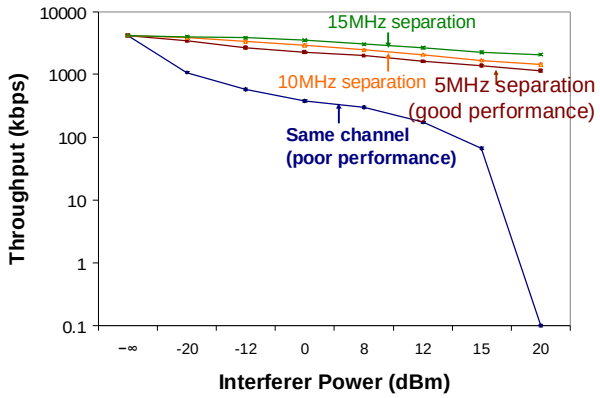
Impact of frequency separation

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



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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 **à** channel hopping
  - Test with an oracle-based adversary
- Design overview
  - Packet loss during switching + adversary's search speed **à** 10ms dwell period
  - Next hop is determined using a secure hash chain
  - Triggered only when heavy packet loss is detected

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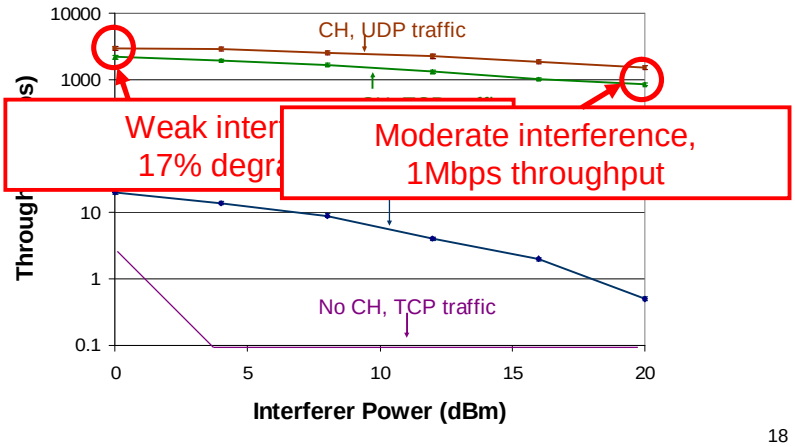
Evaluation of channel hopping

- Good TCP & UDP performance, low loss rate



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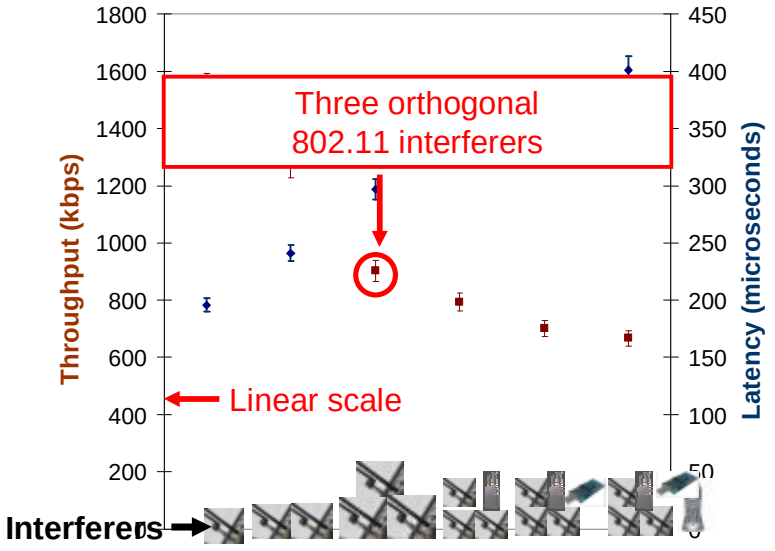
Evaluation of channel hopping

- Acceptable throughput even with multiple interferers



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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

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Thanks!
Questions?

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