

Quantifying, generating and mitigating radio interference in Low-Power Wireless Networks

PhD. Dissertation Defence

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Guimarães, Oct 28, 2015—University of Minho

Why Low-Power Wireless Technology?

- New opportunities to enhance quality of life, boost efficient energy usage, etc
- Intensified innovation with extensive application usage cases, across many industries
- Free rein of technology diversity, operation **constrained** into ISM bands
- Rapid deployment and sustained market adoption

Wireless Devices Proliferation



Research Challenge

- **How** to design reliable and predictable communication protocols for *low-power wireless networks* operating in an *uncontrollable shared wireless medium*?

Current Practice

- PRR is **the** metric used for link quality estimation
- PRR is affected by many factors
- There is a need to assess interference impact on PRR, **isolated** from other factors
- Lack of systematic validation of low-power protocols **under interference**

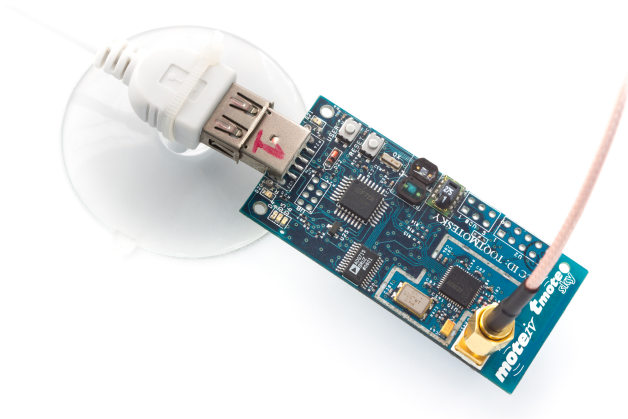
Dependable Low-Power Wireless

- Requires accurate **interference quantification**
- Radio resource adaptation to **mitigate interference**
- Extensive **experimentation** and **validation**

Thesis Contributions

- JamLab: a solution to **augment** a low-power wireless testbed with repeatable interference generation
- CQ: a wireless channel quality metric to meaningfully **quantify** interference
- **Packet size** and **erasure codes** adaptation based on our channel quality metric
- Constructive Baseband Interference (**CBI**) to the rescue?

JamLab: Interference Emulation and (Re)Generation



TmoteSky sensor node, based on CC2420 Low-Power Radio

JamLab: Interference Emulation and (Re)Generation



JamLab deployment on SICS Testbed (Kista, Sweden)

JamLab Augmented Testbeds

- Low-cost infrastructure for **repeatable** and **realistic** interference emulation
- Aids in **designing interference mitigation** techniques
- Starting point for **development** and **testing** of dependable low-power solutions

Wireless Channel Quality Metric (CQ)

- Relies on receiver **channel energy detection**
- Does **not** require **packet transmissions**: no side effect on the channel—**scales** with node density
- Based on the **temporal** channel availability
- Accounts for **interference only**
- Meaningfully **quantifies** the channel quality: **strong correlation** with **PRR**

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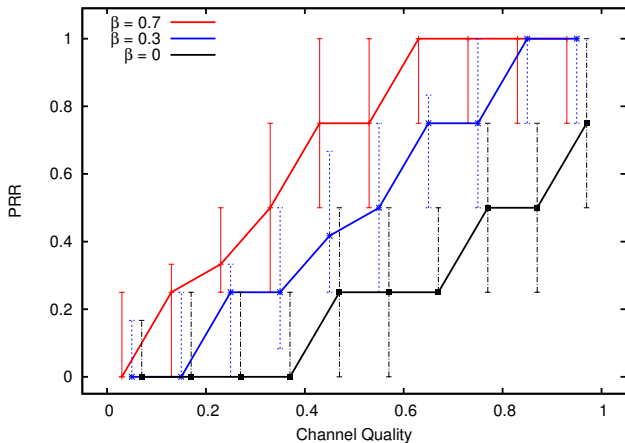
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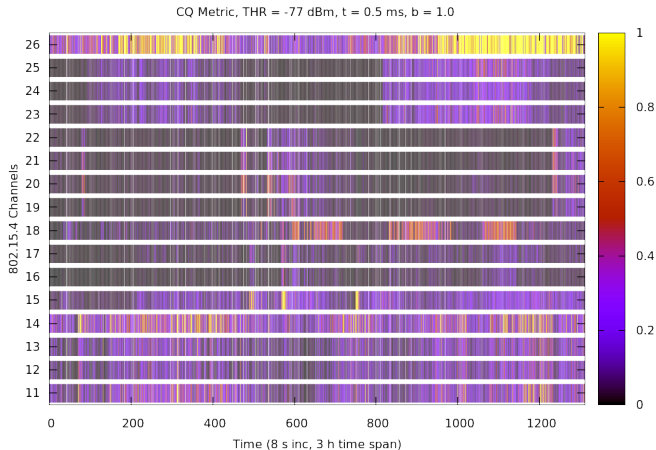
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Quantifying Interference (CQ)

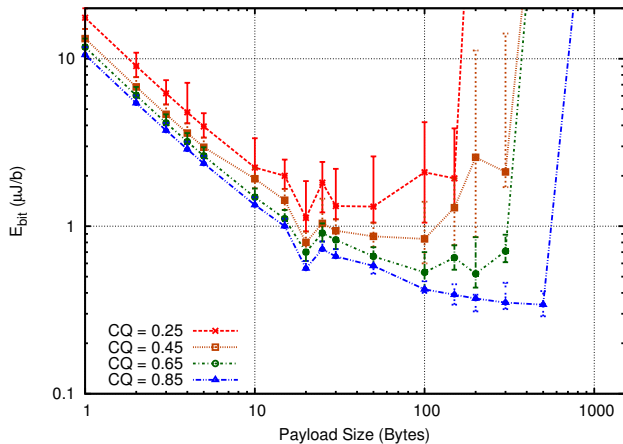


Measurements and Interference Traces (CQ)

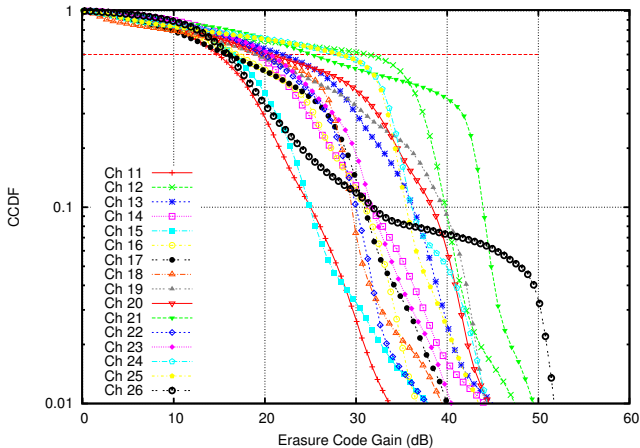


Nov. 2010, Library of the Faculty of Engineering University of Porto

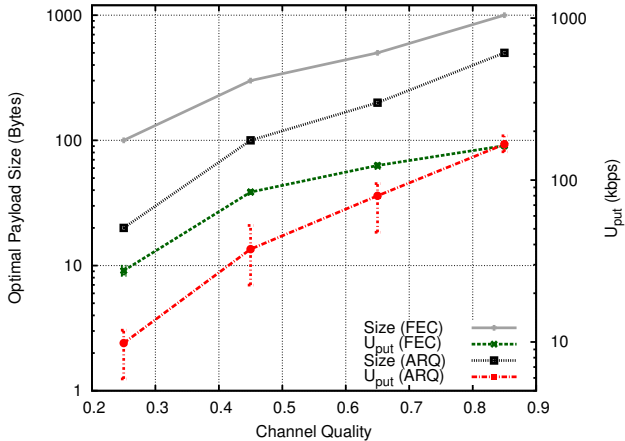
Resource Adaptation: Packet Size



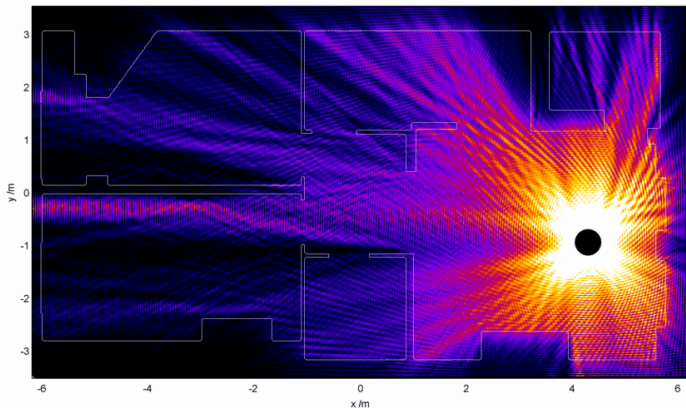
Resource Adaptation: Why Erasure Codes?



Erasure Code Adaptation



CBI: Carrier Propagation and Sender Diversity



Helmhurts by Jason Cole (ICL)

CBI Scalability

- As the number of concurrent repeaters increases, the **composite signal** becomes **vulnerable to noise**
- Link quality is compromised, **unless** there is enough **power imbalance**

Wireless Configuration

