A Case For Node-Local Runtime Parameter Adaptation in Wireless Sensor Networks

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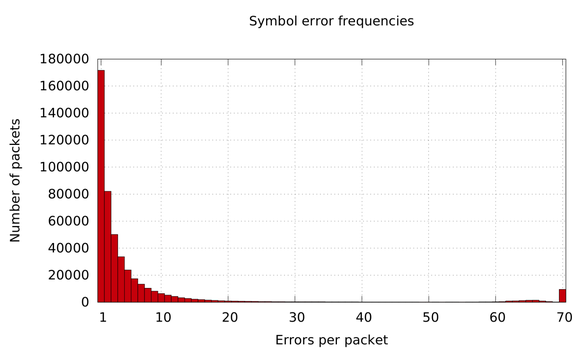
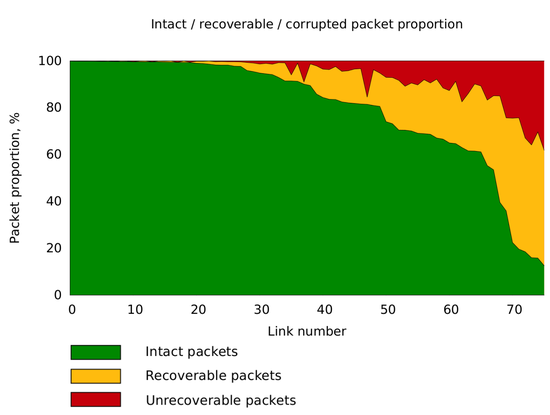
Motivation

- Radio signal reception close to the noise floor results in **corrupted** packets
- Many of such packets have only a **few** bits corrupted

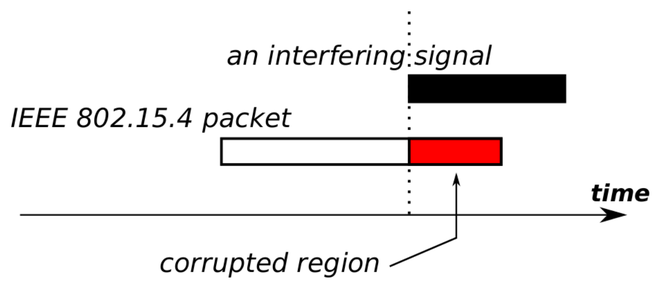




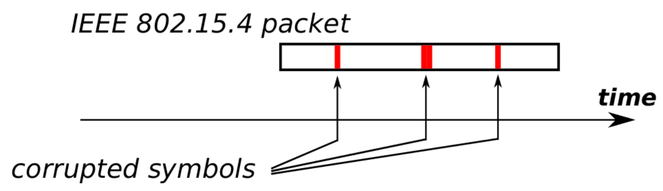
Error frequencies in data are taken from a real WSN node outdoor deployment

Packet corruption causes

Cause A: external interference
Pattern: bursty errors
Effect from applying Hamming code: small or negative



Cause B: weak links
Pattern: independently distributed symbol errors
Effect from applying Hamming code: great!

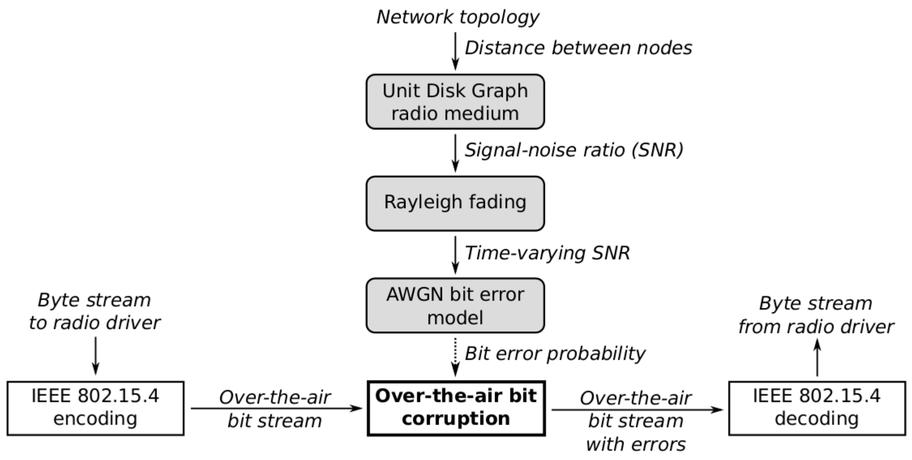


Bit error model

- AWGN (Additive White Gaussian Noise) channel
- OFDM QPSK modulation (IEEE 802.15.4 for 2.4 GHz band)
- Take into account the MSK transformation, used in COTS WSN radio chips (Texas Instruments CC2420, CC2520, and other)
- Error probability for over-the-air bit:

$$P_b = \frac{2^{k-1}}{2^k - 1} \sum_{n=1}^{M-1} \binom{M-1}{n} \frac{(-1)^{n+1}}{n+1} exp\left[-\frac{n \cdot k \cdot SNR}{n+1}\right]$$

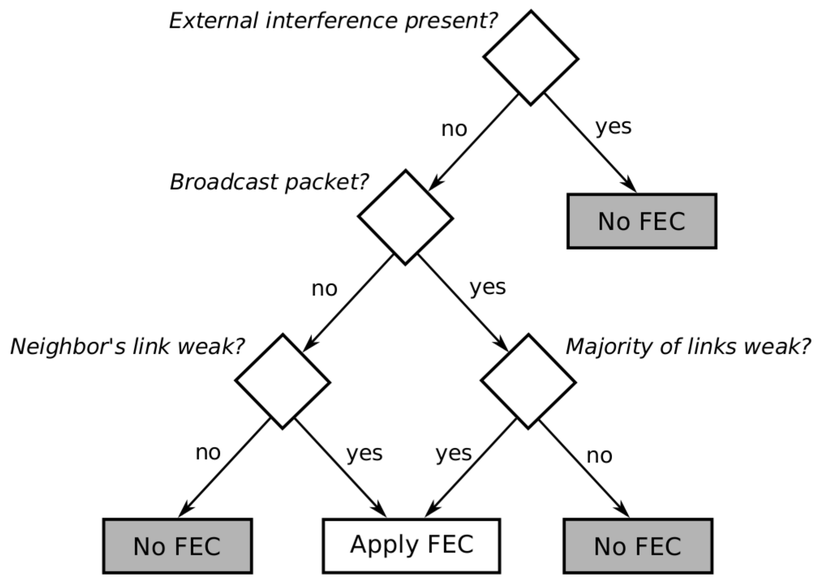
SNR – signal noise ratio
M – OFDM constellation size
k=log$_2$(M) – bits per signal



The bit error model in the simulator

Our approach

- Apply packet loss cause **classification** based on:
  - RSSI, in order to detect weak links
  - CCA (clear channel assessment), in order to detect external interference
- Design a node-local **decision-making** algorithm based on these causes
  - Enable / disable FEC at the link layer
- Apply **Hamming** code (7,4) with interleaving for FEC-enabled packets: well known & computationally cheap!



The decision-making algorithm

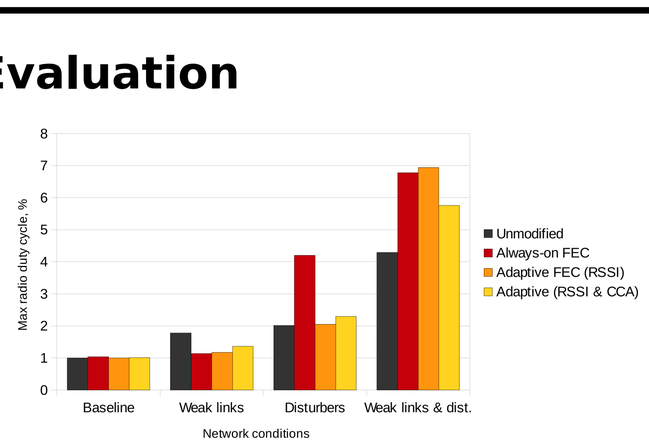
Implementation

- On top of Contiki WSN OS
- Modify ContikiMAC layer to include **classifier** value collection and **FEC** encoding & decoding
- Modify radio driver to accept packets with **invalid CRC**
- Modify Cooja simulator to include our **bit error** model

- We are IEEE 802.15.4 MAC (almost) compatible:
  - MAC frame header always sent in plaintext
  - ACK sent iff the packet can be decoded succesfully

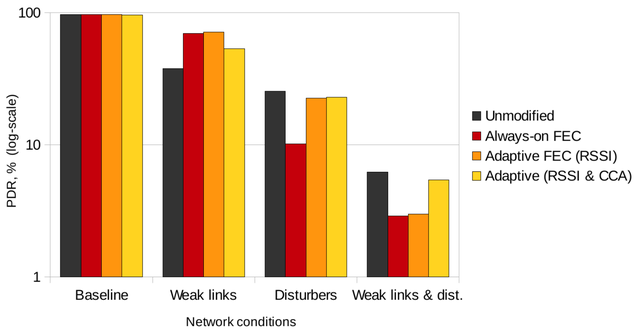
Evaluation

- Preliminary work with a simulator (Cooja)
- Evaluate in multihop networks
- What's the impact on:
  - Hop-by-hop PDR?
  - End-to-end performance?
  - Energy efficiency?



Effects on max radio duty cycle

- Conclusions:
  - Adaptations can lead to and are **required** for reasonable performance
  - Further improvements possible (in decisions, FEC)



Effects on hop-by-hop PDR

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http://www.it.uu.se/research/profun