Link Layer Approach for Reliable Low-Latency Comm. in Wireless Sensor Networks

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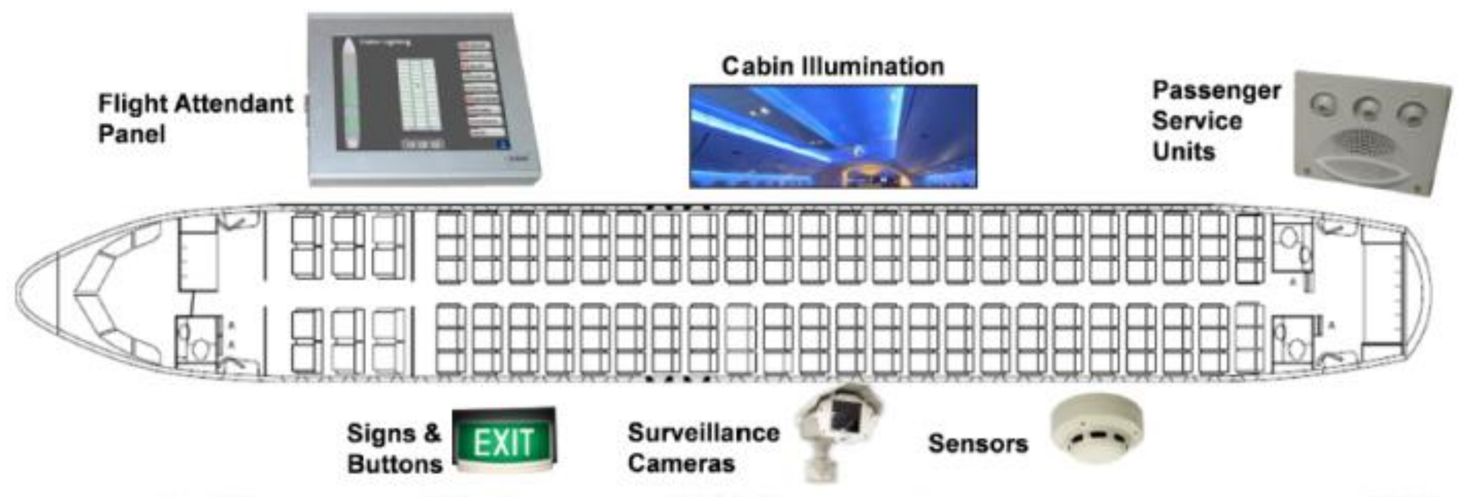
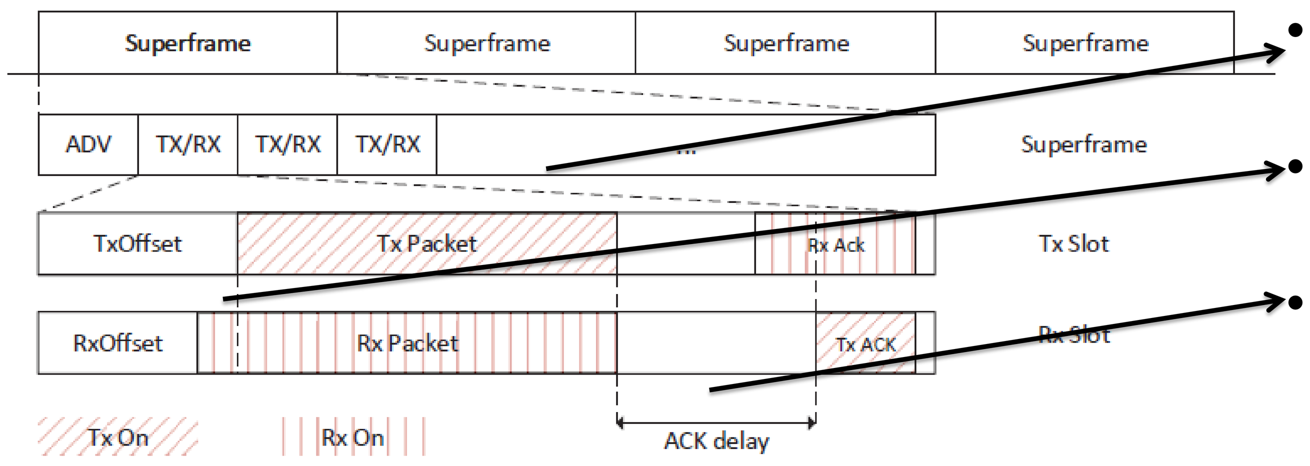
Motivation



- **High interest to migrate wired communication infrastructure to wireless**
  - **Reason[1]:**
    - Decrease weight
    - Low monitoring cost
    - Flexible integration
  - **Problem[2]:**
    - Strict Safety Req.
    - Low Latency Req.
- **Optimize Link Layer for new requirements**
  - **Medium Access**
    - Minimize Slot Size
    - Joining-Random Access
    - Req. Aware Schedule
  - **Error Control**
    - Frequency/Time Diversity
    - Coding/ARQ
    - Equalization

Medium Access



- Requirement aware schedule
- Overhead due to synchron.
- Lossy Communication Overhead

- **Overhead of synchronization loss due to sleeping cycles [3].**
  - How can synchronization be optimized for minimum overhead in a timeslot.
  - Current state: Synchronization via beacon in ADV slot.
  - Can we use cooperative synchronization for more frequent update?
- **Optimum acknowledgement schemes**
  - A General ACK for Star topology
  - Link Based ACK for multi-hop networks.
  - Can we neglect ACK for providing more space for retransmissions?

Error Control– ReTx/Coding

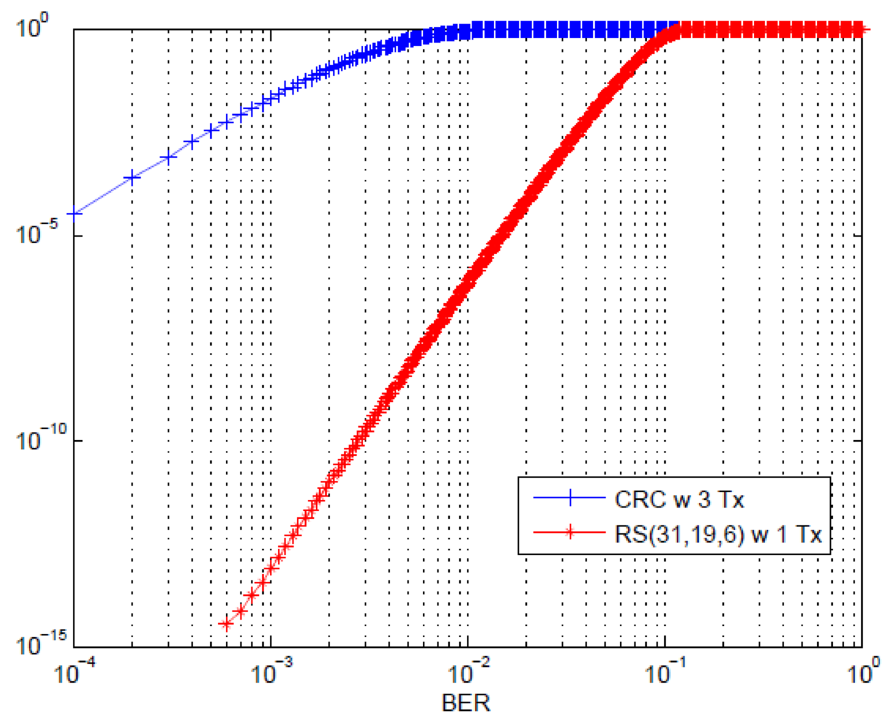


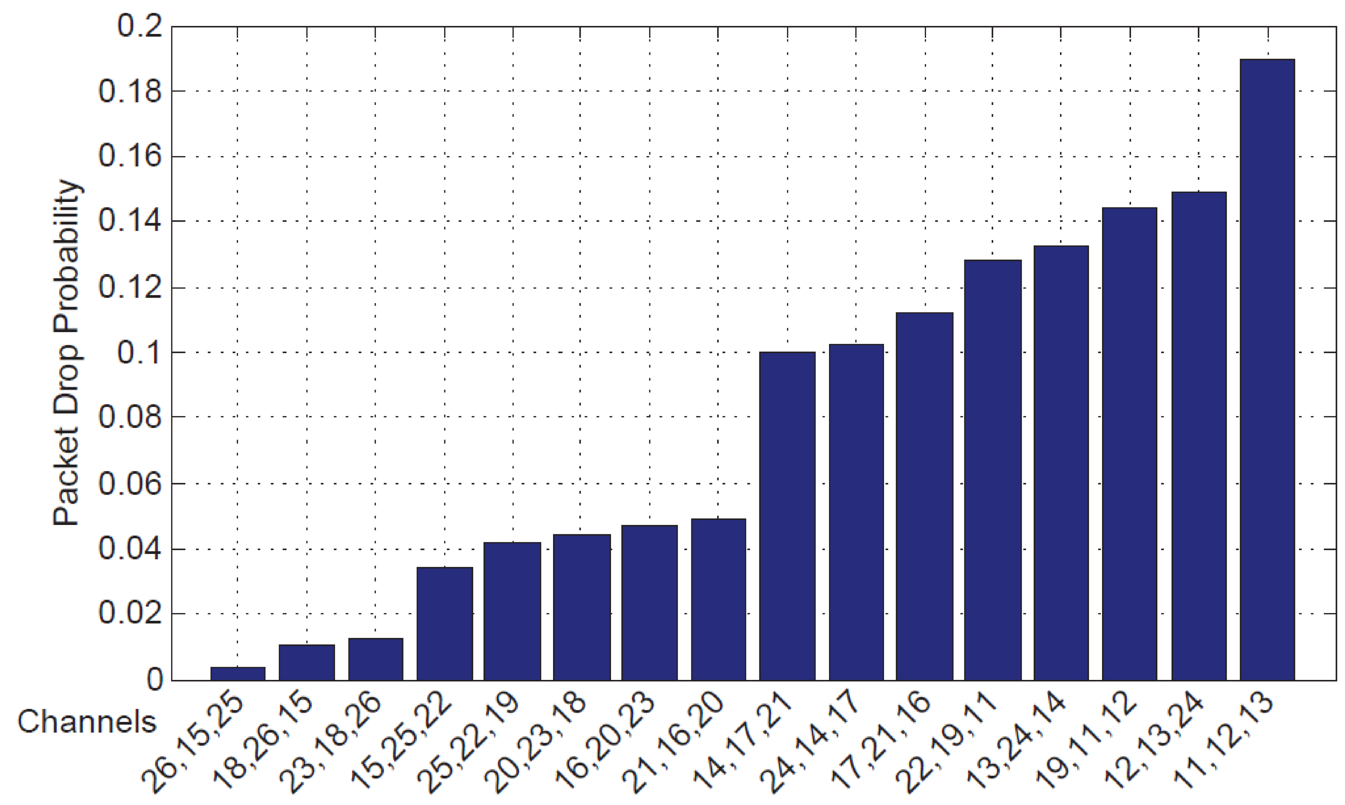
Fig. 1. CRC vs RS comparison

Does coding make sense in WSN ?

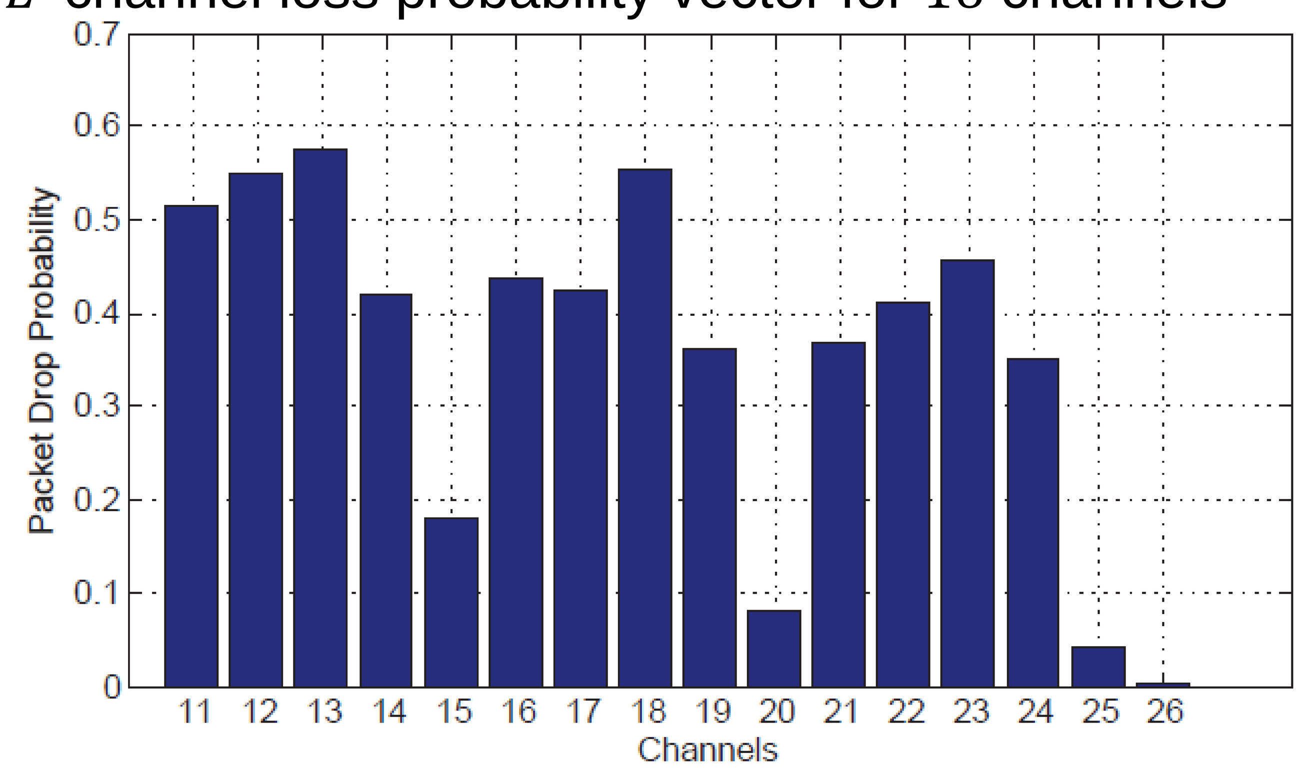
- Asymmetric Burden
  - Sensor: Encoding light-Decoding heavy
  - Actuator: Decoding light Encoding heavy
- Coding tailored on packet size to obtain energy efficiency.

- Reed-Solomon is always better vs 3 Re-Tx.
  - With Static BER
- But **Time-varying channel characteristics**.
  - Re-transmission Loss Correlation
- For WSN combine coding with
  - Co-operative[4],
  - Relay[5],
  - Retransmission[6] in WSN.

Error Control– Frequency Diversity



- Frequency diversity with limited transmission(3) are done in an not-optimized way is TSCH as seen in above figure.
- Clear channels & Interfered channels.
- Minimization Problem with
  - R_i reliability requirement,
  - Np_i number of allowed transmissions and
  - $\vec{L}$ channel loss probability vector for 16 channels



- S is a $16x16$ permutation matrix. →Design parameter
- P is a $16x16$ permutation matrix. Schedule Dependent

$$\sum_{i=1}^{\#App}\left(\prod_{j=1}^{Np_i} SP^j\vec{L} - R_i\right)$$

- Heuristic result.
- Smart Mitigation would be Dynamic Spectrum Allocation
  - Optimum time/freq allocation can be obtained!

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