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The Trade-offs of Cell Over-Provisioning in IEEE 802.15.4 TSCH Networks

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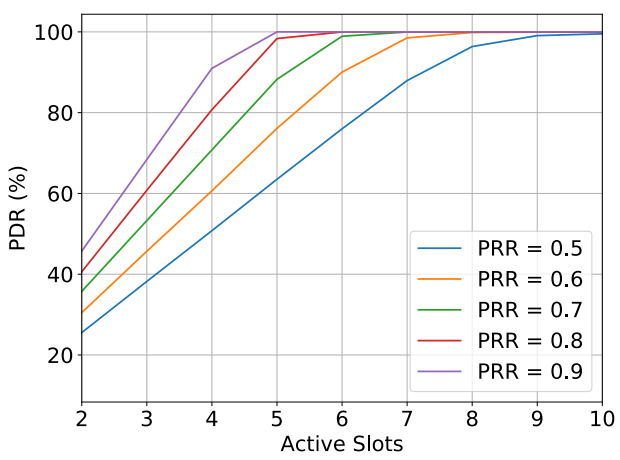
Motivation

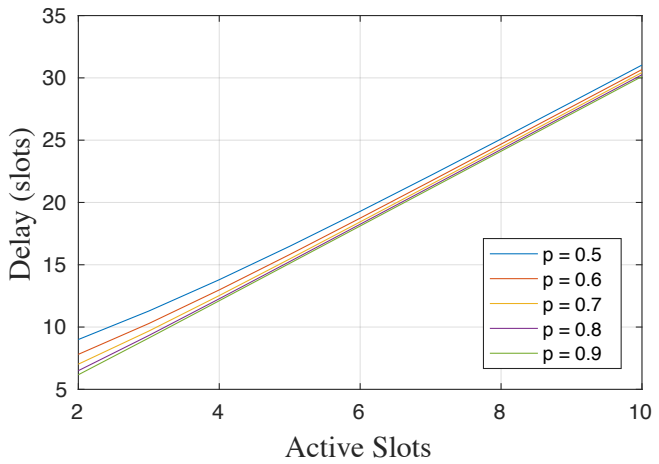
Wireless industrial applications require strict guarantees such as low-delay, jitter performances and reliability close to 100%. However, considering the large number of wireless networks operating in 2.4GHz, the radio technologies are more prone to the external interference, which negatively affect the reliability, and the delay. To tackle the previously detailed issues, Time-Slotted Channel Hopping (TSCH) Medium Access Control (MAC) protocol emerged with IEEE 802.15.4-2015 as an alternative to the proprietary-based industrial standards such as WirelessHART and ISA100.11a. TSCH is based on frequency hopping to avoid the interference, while the medium access is based on a scheduler that repeats periodically to avoid the collisions.
Yet, the majority of the proposed TSCH schedulers are based on traditional collision detection and retransmission in the following slotframe, which essentially increases the end-to-end delay performance. This poster, proposes to allocate consecutive timeslots for a single data transmission, to allow thus, to retransmit the data packet within the slotframe in case of losses, and it presents the potential trade-offs, reliability and delay versus energy consumption, when considering the over-allocation approach.

Performance Evaluation

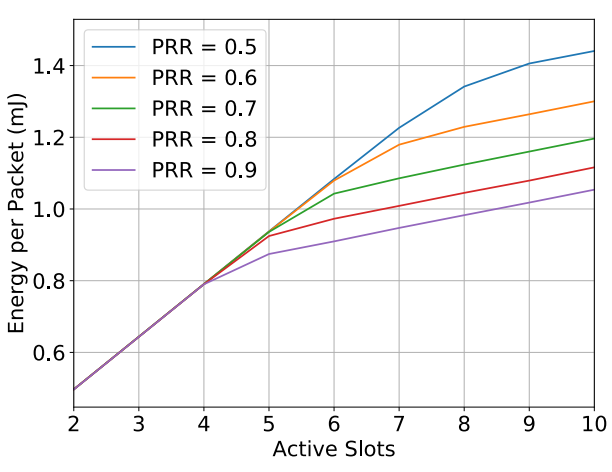
- We employ an open-source numerical TSCH Simulator that simulates star-based TSCH networks with arbitrary TSCH schedules. For each radio link, the simulator allows to configure parameters, such as the maximum number of retransmissions per frame, the queue size, and the link-layer packet reception probability. In this study, we employ the contention-free timeslots only.
- The TSCH Simulator provides results on Packet Delivery Rates (PDR), energy consumption, and energy efficiency defined as the energy required per successfully delivered packet. To evaluate analytically the latency, we denote as ***k*** the level of over-allocation. Each transmission is modeled as a independent Bernoulli trial with the same probability of success for each trial. For simplicity, we assume infinite retransmissions.
- As it can be observed, the lower is the PRR value the more active timeslots are necessary to achieve 100% of network reliability (i.e., Fig. 2(a)), which in turn affects the delay performance due to retransmissions (i.e., Fig. 2(b)) and increases the energy consumption, see Fig. 2(c).
- Fig 2(d) shows the energy per reliably delivered packets, which is a metric that combines reliability and energy consumption. It is observed that increasing the level of cell over-provisioning, has a positive effect on PDR, yet has a negative effect on both delay, due to the other nodes' overprovisioned cells, and energy consumption, due to the increased amount of idle listening.



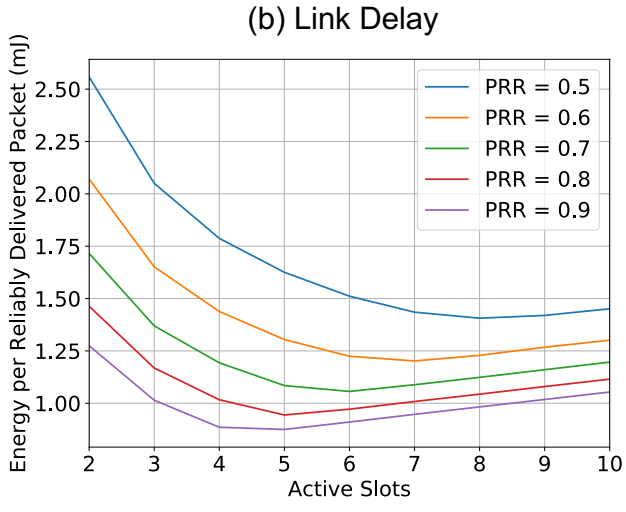
(a) Packet Delivery Rate (PDR)



(b) Link Delay



(c) Energy Consumption



(d) Energy Efficiency

Figure 1: TSCH Performance for various link qualities.

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