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Remote source monitoring over random access channels in IoT systems

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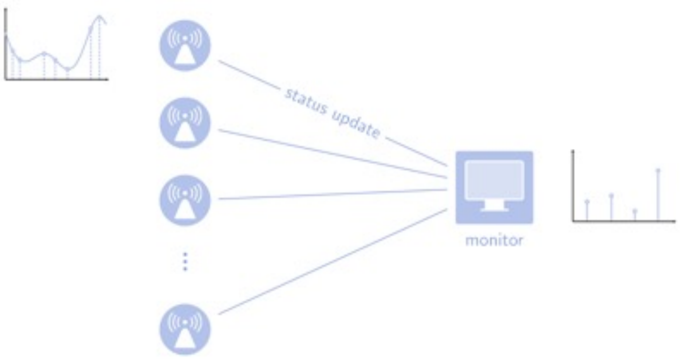
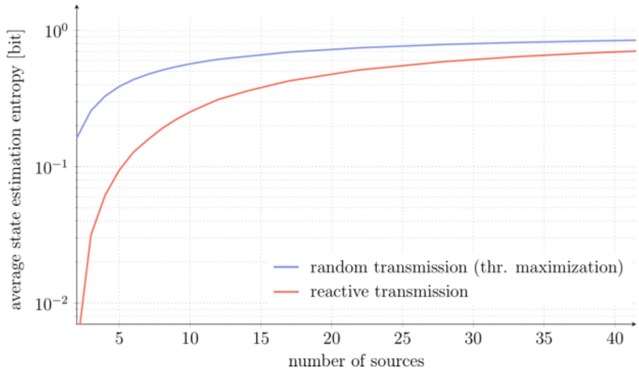
How shall simple random access protocols based on the ALOHA paradigm be designed and tuned when dealing with data relevance in IoT systems?





IoT systems are often employed to remotely monitor the evolution of processes of interest. To this aim, a large number of low-complexity devices may report measurements over a random-access channel to a collecting unit for tracking, control or actuation. In such settings what matters is the ability to provide the receiver with the right piece of information at the right time. The concept of data relevance can have profound implications in the way channel access protocols are designed, pinpointing principles that depart from the ones commonly used for, e.g., throughput maximization.

KEY FINDINGS

We study an IoT system in which a large number of devices share a wireless channel in an uncoordinated manner. Each device monitors an independent stochastic process, modeled as a two-state Markov chain. Time is slotted, and at every slot a device decides whether to transmit a packet containing the value of the corresponding process, with a probability that depends on the present and past state of the source. The receiver estimates the state of each process across time, leaning on the slot outputs it observes. Specifically, we have considered two approaches: a simple decode and hold estimator, which does not require any knowledge of the source statistics, and a more efficient maximum a posteriori solution. In this setup, we analytically characterize the system in terms of different performance indicators to capture data relevance, such as false alarm and detection probability, as well as state estimation entropy, capturing the uncertainty at the receiver on the state of a source. The behavior of different channel access strategies has been discussed, ranging from approaches in which transmission probabilities are oblivious of the source evolution, to solutions that tie the access to source transitions. Important and non-trivial take-aways emerge, highlighting protocol design principles that differ from those commonly used in current IoT implementations.

A. Munari, G. Cocco, G. Liva, "Remote Source Monitoring in IoT Random Access Systems: False Alarm and Missed Detection Probability," in Proc. IEEE Asilomar, 2023.

G. Cocco, A. Munari, G. Liva, "Remote Monitoring of Two-State Markov Sources via Random Access Channels: an Information Freshness vs. State Estimation Entropy Perspective," in IEEE J. Sel. Areas Inf. Theory, Dec. 2023.