Networked Embedded Systems Lab
Prof. Marco Zimmerling

Evaluation of a Neighbor Discovery Protocol for Wireless Sensor Networks

Master Project / Thesis Proposal

In light of growing human population, industrial activities, and energy consumption, it is inevitable to change the way we deal with natural resources to protect our vulnerable ecosystem. This requires continuous, in-depth environmental monitoring to gain insights and keep track of a region's health state. One promising approach for this purpose are Wireless Sensor Networks (WSNs), in which a high number of low-power sensor nodes cooperate to form ad-hoc mesh networks and allow for unattended distributed sensing of diverse physical processes.

A key bootstrapping step in such self-organizing networks is neighbor discovery (ND)—the process by which a sensor node learns about other nodes in its surrounding—as knowledge of neighbors is fundamental to many communication protocols and services. Numerous algorithms have been proposed for this purpose, which vary in performance and complexity as well as their design principles and primary goals. In this project, we consider a simple probabilistic ND algorithm [1], which, due to its simplicity, is particularly interesting for WSNs with resource-constrained nodes. The goal is to investigate the performance of this algorithm in real networks, with a special focus on concurrent transmissions [2]. The latter makes a key difference compared to existing work on ND, where the effect of concurrent transmissions has been oversimplified or modeled in an overly pessimistic manner. Hence, transitioning from simulations to real networks is key to reveal critical modeling inaccuracies.

The student's task is to implement the ND algorithm on a microcontroller and to evaluate its performance in terms of fraction of discovered neighbors in a fixed period of time, time needed to discover all neighbors, optimal transmit probability, etc. The hardware platform is provided in form of single nodes for desk development and debugging as well as special wireless network testbeds (≥ 30 nodes). The student can use an existing software framework (optional), which simplifies basic tasks like clock synchronization and the collection of log data.

One of the key challenges is the creation of a considerable number of diverse test networks. Ideally, the algorithm would be evaluated on a large number of randomly generated networks. However, a static testbed provides only one single network realization. It is the task of the student to find ways to break the static full network into a (high) number of representative sub-networks with different characteristics and to evaluate the algorithm's performance for each sub-network in a meaningful and efficient manner.

Requirements

- Interest in wireless mesh networking.
- Motivation for an *extensive evaluation* of a *given algorithm* in real-world environments.
- Good skills in Python or similar language (for data evaluation and test automation).
- Good skills in C are beneficial, but not essential if the existing software framework is used.

Contact

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References

[1] M. J. McGlynn and S. A. Borbash. Birthday Protocols for Low Energy Deployment and Flexible Neighbor Discovery in Ad Hoc Wireless Networks. In *Proc. 2nd ACM international symposium on Mobile ad hoc networking & computing*, MobiHoc '01, pages 137–145, Long Beach, CA, USA, Oct. 2001.

[2] M. Zimmerling, L. Mottola, and S. Santini. Synchronous Transmissions in Low-Power Wireless: A Survey of Communication Protocols and Network Services. *ACM Computing Surveys*, 53(6):1–39, Nov. 2021.