Company: IMEC

Title: Distributed clock synchronization for energy-efficient wireless sensor networks

Level of topic

- MSc

Master's programs

- Computer Science and Engineering
- Electrical Engineering
- Embedded Systems
- Systems and Control

Duration:

- 9 months

Skills

- Experience with signal processing/machine learning tools
- Knowledge in implementing algorithms with embedded systems
- Proven experience with MATLAB/Python/C/C++
- Previous experience with wireless sensor networks and/or clock synchronization is an added plus.
- Motivated student eager to work independently and expand knowledge in the field
- Good written and verbal English skills

Project description

The rapid advances in technology in the past decade has led to both the miniaturization and affordability of sensor systems, enabling the feasibility of large sensor networks. Time synchronization is one of the fundamental challenges in such a wireless sensor network. The on-board clock at each node, typically cheap crystal oscillators with poor long term stability, tend to drift with respect to each other over time. All the independent clocks aboard these sensor nodes must be aligned to maintain coherent communication and data collection. Traditionally, time synchronization within the network is achieved using broadcasting the reference time at sufficient time intervals. However, for energy-efficient sensor networks (e.g. energy-harvesting sensor nodes) with prolonged sleep periods, the node-level clock may drift over time in the absence of reference information.

The clock drift is typically estimated by posing synchronization as a parameter estimation problem, wherein the inherently non-linear clock at each node is approximated as a linear

model for a short time-period. Thereafter, the regression coefficients i.e., clock offset and drift are estimated using numerous centralized solutions (based on TinySync, MiniSync, TWR protocols). For a large network of energy-efficient nodes however, synchronization must happen locally with immediate neighbors within time-constrained boundaries. The sensor network must achieve the global consensus on timing using local information, which calls for more distributed solutions and protocols. Furthermore, for a large network with multi-hop communication, a single reference may have a ripple effect on the timing errors. In addition, some applications may require a combination of star and/or mesh networks, wherein interference from neighboring networks can be mitigated by accurate synchronization between these clusters. In essence, to avert single-point of dependence, a multi-reference or an optimal clock reference must be chosen dynamically within the network. An optimal algorithm would not only accurately synchronize, but must also be a reliable and energy efficient solution.

Tasks

- Literature survey on the current state of the art for clock synchronization
- Developing algorithm(s) for Distributed clock synchronization
- Simulations to validate the algorithm
- Implementing the solution(s) on the IMEC IoT sensor network
- Testing and analyzing the performance of the implemented algorithm
- Thesis writing and documentation at IMEC-Holst Centre
- (Option) submit the work to a top-ranking publication