CSL: A Low-Power Wireless MAC Protocol for the Internet of Things

Master's Thesis project at RISE SICS, Kista.

The Internet of Things (IoT) is a rapidly developing area, with state-the-art research moving towards standard protocols and systems being adopted by industry. One important aspect of IoT devices is the energy efficiency: since many devices are energy-constrained and communicate using a relatively energy-demanding radio, a large body of research has emerged for energy-saving Medium Access Control (MAC) protocols. The IEEE has standardized different protocols for radio duty cycling, in which the radio can be turned off most of the time when it is not needed: Coordinated Sampled Listening (CSL) and Time-Slotted Channel Hopping (TSCH). Contiki is an operating system for resource-constrained IoT and sensor networks that has had various state-of-the-art MAC protocol implementations for nearly a decade. These protocols were research artifacts, however, and interoperability with other operating systems was consequently limited. In recent years, Contiki has gotten a full-fledged implementation of the standard IEEE 802.15.4 protocol TSCH. CSL protocol support is lacking, however. Additionally, there is limited knowledge regarding how the two protocols compare in performance.

In this Master's Thesis project, the student will implement and evaluate Coordinated Sampled Listening for the Contiki operating system. The implementation comprises the handling of the standard IEEE 802.15.4 packet format for CSL, radio duty cycling, packet queuing, channel hopping, and various other aspects that are common in state-of-the-art MAC protocols for the IoT. Protocols with some similarities to CSL have been implemented for Contiki previously (e.g., ContikiMAC & MiCMAC), which can help to accelerate the student's learning phase of how the implementation should be made.

The scientific goal of this project is to gain an understanding of how CSL performs with various network traffic patterns and how the performance compares to that of TSCH. The evaluation can be made in simulation and in RISE SICS's internal testbed of 25 IoT devices. Contiki's COOJA simulator can emulate the hardware of real IoT devices, so that the same system implementation can be evaluated in both the testbed and in the simulator. We expect the student to benefit from this work by gaining knowledge of IoT networking, the Contiki operating system, and the basics of conducting an experimental evaluation. In case of a highly successful project, the student's work may be developed into an academic paper. To help the student along the way, SICS will provide expert knowledge of the technologies used as part of the project, as our researchers are the primary authors of much of the relevant software. The student will be given a workplace alongside other Master's Thesis students in RISE SICS's office in Kista, Stockholm.
Start time: As soon as possible.

In summary, the tasks of the Master's student are the following:

- Study how duty-cycling MAC protocols work and how the different layers of the IoT networking stackworks, with focus on the most relevant protocol implementations in the Contiki operating system.
- Learn how to program Contiki software and how to use resource-constrained IoT devices.
- Implemented IEEE 802.15.4's Coordinated Sampled Listening MAC protocol in Contiki.
- Conduct an experimental evaluation using both simulated and real nodes where CSL's performance is compared to IEEE 802.15.4's alternative low-power MAC protocol TSCH. The student may also compare CSL against other similar low-power-listening MAC protocols, such as ContikiMAC.
- Describe the technical background, the CSL implementation, the evaluation, and the lessons learned in a Master's Thesis.

Competence
We are looking for a bright student with good grades that has completed all the courses to start the M.Sc. project. Strong skills in C programming are required, as is good spoken and written English. Experience with embedded systems, software design, and network protocols are highly beneficial.

Applications should include a brief cover letter, CV, and recent grades. In your application, make sure to give examples of previous programming or other projects that you consider relevant for the position. Candidates are encouraged to send in their application as soon as possible. Suitable applicants will be interviewed as applications are received.

Project Supervisors:
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Description of the hosting research group NES
Our current research focus is on the Internet of Things and wireless sensor networks. Among the group's key technologies and systems are the Contiki operating system, uIP stack , Coffee file system, Antelope DBMS, ContikiRPL, Orchestra/TSCH, SICSLoWPAN, lightweight implementations of various security protocols, and the IoT cloud service SICSthSense. The NES group conducts projects together with industrial and academic partners from Sweden and across the world.

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