



CROWNSTONE

In-network localization

Internship Master Student

Topic

Crownstone is a startup that develops tech in power outlets. The Crownstone chip can be put on top or behind a power outlet and obtain information about current and voltage patterns from devices that are plugged into it. Moreover, it is able to react to the presence of people.

The current implementation of localization using Crownstones is done on the smartphone. The smartphone use fingerprints of RSSI values of the incoming BLE at multiple locations in a room to indicate that this is that particular room. A user has to walk around in the living room, kitchen, etc. and uses supervised labels that are used by a simple, naive Bayes classifier.

The challenge is to have the indoor localization done in the network itself. If the smartphone sends occasionally a beacon signal, multiple of the Crownstones can receive the signals. The Crownstones form a mesh to communicate among each other. By defining an integrated protocol that have Crownstones scan for smartphones (or other wearables) and at the same time communicate the necessary information with the other Crownstones using a mesh protocol, we have the possibility to do in-network localization. For application areas this means that a home can react upon the location of someone if they carry a smartphone, a wearable, but also to provide asset tracking.



Function description

It is your task to work embedded programming part of this problem. Your responsibility is to define a protocol that takes into account (1) the communication over the mesh with respect to bandwidth and other resources, (2) scanning on those moments over those channels that are optimal for localization, and (3) the in-network collection and classification of signal strengths in such way that localization is possible on a room level. This all needs to operate in real-time on resource constrained Nordic chips (nRF52832).

The academic problem description should be formulated together with your supervisor:



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Hypothesis [that's your task! :-) make sure it is falsifiable and quantifiable]

We expect you to start with a literature study. The problem should be defined in a thorough manner and solved using C/C++ on the devices itself. Almost all of our code is open source ([github](#)). You will be part of the Crownstone team, including the scrum sessions, so we are making sure that your contribution will actually end up in the products itself.

There will be plenty opportunities for challenging side projects. For example:

1. We have already algorithms designed in matlab to detect the presence of people by distortions on the 2.4 GHz spectrum. They need to be ported to the Crownstone hardware. It would allow a smart home to know if people are present without them carrying anything on them. A perfect companion to the current system where we know who is present, but where they have to carry something on them.
2. The implementation of an Arduino runtime environment, including updates over the air from the Arduino graphical user interface.
3. Interfacing multiple smart home BLE devices in our infrastructure. We are planning on integrating radiator valves, door sensors, lights, etc. This means integration on all levels from integrating the devices into the Crownstone mesh to the graphical user interface.
4. Developing additional hardware devices. Crownstone is developing several products for other companies. One of them is a touch-based display that can also be mounted on a wall socket. The planning of Crownstone regarding its own hardware concerns a 3-phase version of the Crownstone and a device that is directly connected to the internet using LoRA, SigFox, 2G, 4G LTE, or 4G NB-IoT.

Background

This internship is an initiative of Crownstone.

Crownstone (2016) is a startup in Rotterdam that brings technology to detect people and devices into every building. The Crownstones estimate a person's position through the smartphone. The Crownstones measure current and voltage to detect devices and examine their usage (<http://crownstone.rocks>).

Function requirements

A student in the master Computer Science, Electrical Engineering, or related disciplines. For us, personal motivation is just as important as experience. Fluent English is essential. It is *not* required to speak Dutch, but appreciated of course.

Knowledge about the following topics is desired:

- Protocol design (wireless protocols, mesh protocols, gossip protocols);
- Hardware experience (ARM and all kind of computer architectures);



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- Embedded programming skills (C/C++).

For further information, see <https://crownstone.rocks>. Many master students have graduated at the Almende Group (of which Crownstone is a spin-off), see our hall of fame at <https://crownstone.rocks-hall-of-fame>. Your task is to find your own academic supervisor. We have worked with among others prof. Robert Babuska, prof. Pim Haselager, assist. prof. Rico Mockel, assist. prof. Kurt Driessen, assist. prof. Y (Wolf) Song, assist. prof. Dap Hartmann, assist. prof. Gerard Vreeswijk, prof. Bart de Schutter, assist. prof. Dimitri Jeltsema, prof. Nikolaus Correll, assist. prof. Marco Wiering, and are looking forward to collaboration with you and your supervisor!

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Anne van Rossum anne@crownstone.rocks	Your academic supervisor(s)