Demo Abstract: Realistic Simulation of Radio Interference in COOJA

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***Abstract*—Radio interference drastically affects the reliability and robustness of wireless communications. As wireless sensor network protocols are frequently designed and tested in simulation environments first, it is important to have simulation tools that provide means to study the impact of radio interference.**

Radio propagation models available in simulation environments are however often too simplistic, and can hardly capture the complexity of the real world. To increase the realism of simulations, we incorporate recorded interference traces into existing simulation models.

We extend the COOJA simulator with the generation of realistic interference sources in the simulation environment. We add new features, such as an interference-aware propagation model and loading of interference traces, which can be captured and recorded through a mote-based application.

In our interactive demo, we show the generation of interference patterns produced by devices operating in the 2.4 GHz band such as microwave ovens, Bluetooth, and Wi-Fi. We will monitor, capture, and record the ongoing interference at runtime, and load the recorded traces in our extended COOJA version. We then show how to use the captured patterns to simulate and study the impact of radio interference on sensornet communications and routing trees.

I. Introduction and Motivation

Radio interference considerably affects the reliability and robustness of wireless communications, hence representing a major problem in wireless sensor networks. The strong growth of the number of devices operating in the ISM bands increases the congestion in the radio spectrum, leading to poor performance, packet loss, and reduced energy-efficiency [1].

As wireless sensor networks also operate on these crowded ISM bands, it is necessary to design and develop protocols that are robust to radio interference. Sensornet protocols are frequently designed and tested in simulation environments first, and it is therefore important to provide simulation tools that offer accurate means to study the impact of radio interference.

Modeling radio propagation and interference is complex due to the large number of variables involved, ranging from the device(s) operating concurrently on the frequency of interest, their position, modulation, and transmission scheme, to the characteristics of the environment and the presence of moving objects or static obstacles. In certain scenarios with an excessive number of such unknown parameters, e.g. in a crowded shopping center or lively street, the creation of models that accurately reflect reality is therefore almost impossible.

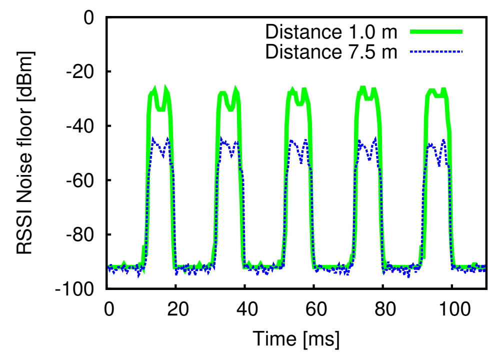

Fig. 1. Interference recorded from a sensor mote scanning channel 23 in presence of an active Lunik 200 Microwave Oven. Ovens typically emit frequencies with a periodic pattern, and for this particular model, the period is approximately 20 ms.

Instead of attempting to create more precise and realistic radio models, we augment existing simulation tools with the playback of realistic interference traces. We use off-the-shelf sensor motes to scan the radio channel and record the interference patterns, and we then play back the recorded traces directly in the simulation environment. Such traces can be added on top of any existing radio model, improving significantly the level of realism when simulating the impact of radio interference on sensornet protocols and communications.

II. COOJA Extensions for Realistic Interference Simulation

We enrich the COOJA simulator [2] with the generation of realistic interference sources in the simulation environment.

We upgrade the Multi-path Ray-tracer Medium (MRM) to correctly implement co-channel rejection according to the results of Dutta et al. [3]. Co-channel rejection is a measure of the capability of the receiver to demodulate a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted modulated signal. Proper handling of co-channel rejection enables us to simulate the correct reception of a packet in presence of interference.

Unwanted signals are represented by (pre-)recorded interference traces in COOJA. Such traces are used to improve the realism of sensornet simulations. Using, for example,

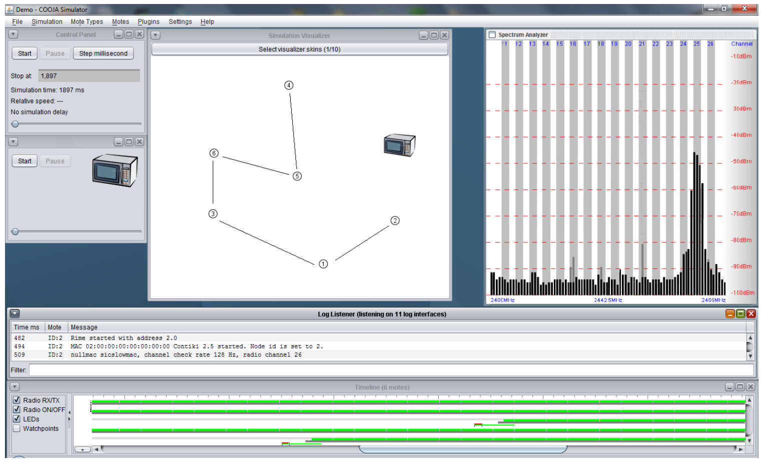

Fig. 2. Screenshot of COOJA with the proposed application.

pre-recorded interference traces that resemble the patterns generated by typical appliances operating in the crowded 2.4 GHz ISM band, the user can arbitrarily place a number of Wi-Fi and Bluetooth devices as well as microwave ovens inside the simulation environment. We assume the signal propagation can be modeled with the widely used log-normal model [4].

III. Demo Description

In this demo, we monitor, capture, record, and play back the ongoing interference at runtime.

We first show how to capture interference using a high sampling rate. We use off-the-shelf sensor nodes and measure the RSSI noise floor, i.e., the RSSI in absence of packet transmissions in both time and frequency.

As we are interested in detecting also short transmissions such as Wi-Fi beacons, we boost the CPU speed, optimize the SPI operations, and compress the RSSI noise floor readings. We achieve a sampling frequency of approximately 60 kHz (3.5 kHz) when scanning one (all) 802.15.4 channels. Figure 1 shows a sample interference trace recorded from a sensor mote scanning channel 23 in presence of an active microwave oven in the neighborhood.

To collect the RSSI noise floor readings, we attach two sensor motes to the laptop running COOJA. We use Maxfor MTM-CM5000MSP nodes, widely used sensor motes equipped with the CC2420 radio transceiver. The two nodes run Contiki [5]: the first node is used to scan the channel of interest and record the interference traces at runtime; the second node is used to give the user a snapshot of the ongoing interference in the whole 2.4 GHz spectrum as in [6].

We also pre-record several interference traces and build an object library of interfering devices available as new disturber mote types, including different models of microwave ovens as well as Bluetooth and Wi-Fi devices.

Finally, we create several simulation environments and show the impact of realistic radio interference on sensornet communications and routing trees. Figure 2 shows a screenshot of the COOJA simulation.

IV. Conclusions

In this demo we show how to monitor, capture, and record the ongoing interference in real time using COOJA. We then use the captured patterns to simulate and study the impact of realistic radio interference on sensornet communications and routing trees.

Acknowledgments

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