Experimental RSS Harvesting: Platform, Scenarios, and Data Format

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Abstract

This document describes the experimental platform used to collect Radio Signal Strength (RSS) samples in different scenarios, also presented in the document. Furthermore, the data format used to store RSS measurements is described.

I. Testing platform

All the experiments have been performed by using TmoteSky sensor nodes.[1] These devices are equipped with the Chipcon wireless transceiver CC2420 implementing the IEEE 802.15.4 standard (PHY and MAC layers). The CC2420 transceiver operates in the 2.4 GHz ISM band using O-QPSK modulation with *Direct Sequence Spread Spectrum* (DSSS) coding that encodes each symbol of 4 bits into 32 chips, thus providing a process gain of 9 dB. The radio module supports a maximum bitrate of 250 kbit/s, with -94 dBm of sensitivity, and provides two measurements related to the received signal quality, namely Radio Signal Strength Indicator (RSSI) and Link Quality Indicator (LQI). In accordance with IEEE 802.15.4 standard, the RSSI value is averaged over 8 symbol periods ($128\ \mu s$). Moreover the CC2420 supports transmission on 16 equally spaced 5 MHz wide orthogonal channels with carrier frequencies $f_c = 2405 + 5c$ MHz, with $c = 0, \ldots, 15$.

The transceiver makes use of a patch antenna, integrated on the board. The integrated antenna is not isotropic by design. However, the board is also equipped with an SMA connector for an external antenna that can be activated in place of the patch antenna by changing the electrical contacts of a capacitor. We made this hardware modification to a certain number of boards that were then equipped with a DN-70100 omnidirectional external antenna, produced by Digitus. The external antenna is 19.7 cm long, with a diameter of 12 mm, and provides a gain of 5 dBi (reception).

A simple communication protocol has been designed and developed in order to collect RSSI samples over all the channels within the 2.4 GHz band of IEEE 802.15.4.

II. Testbeds

The scenarios considered for the experimental campaign are four providing different environmental conditions; in particular we choose indoor and outdoor locations, we tested the communication with patch antennas and external isotropic antennas and we moved sensors at different distances among themselves and from the floor.

Room: In this setup we used 4 sensor nodes, each equipped with the external isotropic antenna, placed on cones at 30 cm from the floor. Nodes were programmed to exchange 10 packets in each direction with any other, in a certain RF channel. A delay of 100 ms were forced between consecutive transmissions from the same node. The operation was repeated on 16 different RF channels, while keeping the nodes in the same positions. Then, nodes were moved in different positions and the whole process was repeated anew. Overall we collected $20 \times 12 \times 16 \times 6 = 23040$ RSSI samples.

Desk: The setup used two TmoteSky nodes with integrated antenna, placed on a long desk. One node was fixed, the other was moved along a straight line with discrete steps of 20 cm, by keeping the same orientation with the first node. For each position, transmit power has been varied over 8 different levels corresponding to transmit power levels of $\{0, -1, -3, -5, -7, -10 - 15, -25\}$ dBm. Similarly, all 16 RF channels supported by the nodes were spanned. For each position, power level, and RF channel nodes exchanged 8 packets either ways.

Aisle: Five sensor nodes were deployed on cones at 30 cm from the floor in an aisle and another mote was used to collect RSSI samples at 26 stations placed every 50 cm along a pice-wise linear path of approximately 13 meters that crossed the aisle. All nodes were equipped with external antennae. We collected both fixed-to-fixed and mobile-to-fixed two-ways RSSI measurements over all the 16 RF channels supported by the transceivers, for a total of approximately 4800 samples. In this environment there was no furniture so that the reflections of the transmitted signal were mainly due to the floor, walls and ceiling.

Lab: Using similar settings as Setup #4, we deployed seven sensor nodes on cones in a wide lab, approximately $10\text{m}\times 6\text{m}$. One mobile node was moved in different positions in the lab. All nodes were equipped with external antennae. We collected both fixed-to-fixed and mobile-to-fixed two-ways RSSI measurements over all the 16 RF channels supported by the transceivers, for a total of approximately 11000 samples. This environment was occupied by furnitures, electronic equipments, and people.

Outdoor: Using the same devices as in the previous Setup, we deployed five nodes uniformly into a 15 m$\times 8$ m outdoor area, at 80 cm from the floor. Another node was moved through the area. We collected approximately 4800 RSSI samples over 16 different RF channels.

[1]"Tmote sky: Ultra low power IEEE 802.15.4 compliant wireless sensor module", available on http://www.eecs.harvard.edu/~konrad/projects/shimmer/references/tmote-sky-datasheet.pdf

In all the experiments we can assume the presence of the LOS path between each couple of nodes. Moreover the nodes were deployed at the same height, so that we cover only the case of 2–dimensional network deployment.

III. Data format

RSS data have been formatted in MATLAB matrices M with the following structure.

```
M(:,1) = packet seq number
M(:,2) = transmitter identifier
M(:,3) = receiver identifier
M(:,4) = RF channel id
M(:,5) = Radio Signal Strength Indicator (RSSI) for tx-->rx transmission
M(:,6) = Link Quality Indicator (LQI)  for tx-->rx transmission
M(:,7) = distance between tx and rx  [m]
```