abstract

The Internet of Things is finally blooming through diverse applications, from home automation and monitoring to health tracking and quantify-self movement. Consumers deploy more and more tiny connected devices that provide complex services.

In this scenario, positioning these intelligent objects in their environment is necessary to provide geo-localized services, as well as to optimize the network operation. However, indoor positioning of devices using only their radio interface is still very imprecise.

Indoor wireless localization techniques often deduce from the RF signal attenuation the distances that separate a mobile node from a set of reference points called landmarks. The received signal strength indicator (RSSI), which reflects this attenuation, is known in the literature to be inaccurate and unreliable when it comes to distance estimation, due to the complexity of indoor radio propagation (shadowing, multi-path fading, ...). However, it is the only metric that will certainly be available in small and inexpensive smart objects.

In this thesis, we therefore seek for algorithmic solutions to this problem: is it possible to achieve a fair localization using only the RSSI measure provided by low-quality hardware? To this extent, we first study the behavior of the RSSI, as reported by real hardware (IEEE 802.15.4 sensor nodes), in different indoor configurations and confirm that the relationship between RSSI and distance depends on many factors. Even the battery pack attached to the devices increases attenuation.

In a second step, we demonstrate that the classical log-normal shadowing propagation model is not well adapted in indoor case, because of the RSSI values dispersion and its lack of obvious correlation with distance. We propose to correct the observed inconsistencies by developing heuristics to filter irrelevant samples. We also introduce an RSSI-based positioning approach that uses a maximum likelihood estimator conjointly with a statistical model based on statistical machine learning.

In a third step, we propose an accurate distributed RSSI-based localization algorithm that refines the positions estimated by a wireless node. This algorithm is composed of two online steps: an initial computation of an approximate position of the node by a distributed version of the gradient descend method, followed by a pairwise gossip protocol to refine the initial estimated position of the node. Simulation and experimental results obtained on a real testbed conclude to a centimeter-level accuracy without any central computation point, tedious calibration or intervention from a human.

***Index terms*— Indoor Localization, ad-hoc localization, distributed localization, sensor networks, RSSI, Log-normal Shadowing, Experimentation**

List of publications

[1] **N.A. Dieng, C. Chaudet, M. Charbit, L. Toutain, and T. Ben Meriem. Experiments on the rssi as a range estimator for indoor localization. In *New Technologies, Mobility and Security (NTMS), 2012 5th International Conference on*, pages 1–5, 2012.**

[2] **N.A. Dieng, M. Charbit, C. Chaudet, L. Toutain, and T. Ben Meriem. A multi-path data exclusion model for rssi-based indoor localization. In *Wireless Personal Multimedia Communications (WPMC), 2012 15th International Symposium on*, pages 336–340, 2012.**

[3] **N.A. Dieng, M. Charbit, C. Chaudet, L. Toutain, and T. Ben Meriem. Indoor localization in wireless networks based on a two-modes gaussian mixture model. In *in IEEE 78th Vehicular Technology Conference (VTC 2013 Fall)*, pages 1–5, Las Vegas, USA, sep 2013.**

[4] **N.A. Dieng, C. Chaudet, L. Toutain, and T. Ben Meriem. Evaluation and comparison of rssi based indoor localization algorithms. In *5e Colloque National sur la Recherche en Informatique et ses Applications (CNRIA'13)*, Zinguichor, Senegal, apr 2013.**

[5] **N.A. Dieng, C. Chaudet, L. Toutain, T. Ben Meriem, and M. Charbit. No-calibration localization for indoor wireless sensor networks, ijahuc 2013. *International Journal of Ad Hoc and Ubiquitous Computing: Special Issue on Localization, Positioning and Coverage in WSNs*, 14, 2013.**