# Demo Abstract: RadiaLE: a framework for benchmarking link quality estimators

Nouha Baccour[12], Maissa Ben Jamâa[1], Denis do Rosário[25], Anis Koubâa[23], Mário Alves[2], Leandro B. Becker[5], Habib Youssef[5], and Hossein Fotouhi[2]

[1] ReDCAD Research Unit, National school of Engineers of Sfax, Sfax, Tunisia.
[2] CISTER Research Unit, Politécnico do Porto (ISEP/IPP).
[3] Al-Imam Mohamed bin Saud University, Riyadh, Saudi Arabia.
[4] Prince Research Unit, University of Sousse, Sousse, Tunisia.
[5] Federal University of Santa Catarina, Brazil.
Email: nabr@isep.ipp.pt

## 1 Introduction

Link quality estimation is a fundamental building block for the design of several different mechanisms and protocols in wireless sensor networks (WSN). A thorough experimental evaluation of link quality estimators (LQEs) is thus mandatory. Several WSN experimental testbeds have been designed ([1–4]) but only [3] and [2] targeted link quality measurements. However, these were exploited for analyzing low-power links characteristics rather than the performance of LQEs.

Despite its importance, the experimental performance evaluation of LQEs remains an open problem, mainly due to the difficulty to provide a quantitative evaluation of their accuracy. This motivated us to build a benchmarking testbed for LQE - RadiaLE, which we present here as a demo. It includes (*i.*) hardware components that represent the WSN under test and (*ii.*) a software tool for the set up and control of the experiments and also for analyzing the collected data, allowing for LQEs evaluation.

## 2 RadiaLE Overview and Demo Scenario

RadiaLE allows the performance evaluation of LQEs by analyzing their statistical properties, independently of any external factor, such as collisions and routing. These statistical properties impact the performance of LQEs, in terms of reliability and stability. Reliability refers to the ability of the LQE to correctly characterize the link state. Stability refers to the ability to resist to transient (short-term) variations (also called fluctuations) in link quality.

RadiaLE hardware components involve a set of TelosB motes (49 motes in our experiments), connected to a control station (PC) via a USB tree, for controlling and collecting data from the motes without interfering with the wireless communications. In order to evaluate the performance of LQEs, the first step is to establish a rich set of links with different qualities. The second step is to create a bidirectional data traffic over each link, enabling link measurements through

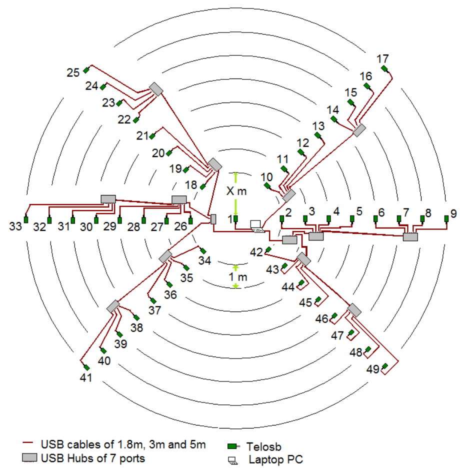


**Fig. 1.** Nodes circular topology

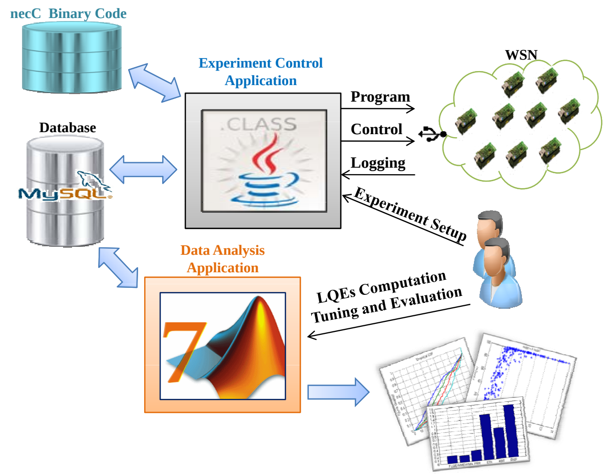


**Fig. 2.** RadiaLE software components

packet-statistics (e.g. packet sequence number, from received and sent packets) collection. Finally, the evaluation of LQEs is performed using the collected data.

To establish the links we setup a single-hop network, where nodes $N_2..N_m$ are placed in different circles around a central mote $N_1$, as shown in Fig. 1. The distance between two consecutive circles is denoted as $y$ (m), and the circle nearest to $N_1$ has a radius of $x$ (m). Since distance and direction greatly affect link quality, by placing nodes $N_2 \ldots N_m$ at different distances and directions from the central node $N_1$, the underlying links $N_1 \longleftrightarrow N_i$ will have different qualities.

The experimentation is ensured by our RadiaLE software tool, which is illustrated in Fig. 2. It contains two independent applications: 1. *Experiment Control* (ExpCtrApp) Java application used for motes programming/control, network configuration and data logging into a MySQL database; 2. *data analysis* (DataAnlApp) Matlab application for data analysis/processing and tuning LQEs. The above facilities are described next.

**Motes programming**: A nesC application defines a set of protocols for any bidirectional communication between the motes and between the motes and the ExpCtrApp. The ExpCtrApp automatically detects the motes connected to the PC and programs them by installing the nesC application binary code. **Network configuration**: The ExpCtrApp enables the user to specify network parameters (e.g. traffic pattern, packets number/size, inter-packet interval, radio channel, transmission power, link layer retransmissions on/off and max. count). These settings are transmitted to the motes to start performing their tasks. **Link measurements gathering**: Motes exchange data traffic in order to collect packet statistics such as sequence number, RSSI, LQI, SNR, time stamp or background noise, which are sent via USB to the ExpCtrApp in the PC, which stores these log data into a MySQL database. **Motes control**: ExpCtrApp exchanges commands with the motes to control data transmission according to

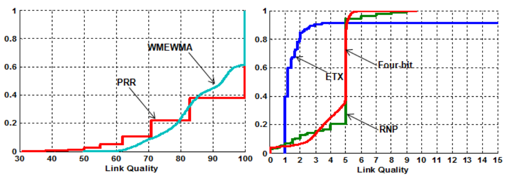


**Fig. 3.** Empirical CDFs of LQEs, based on all links.

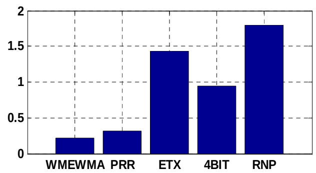


**Fig. 4.** Stability of LQEs.

the traffic pattern set at the network configuration phase. The ExpCtrApp also provides: (*i.*) a *network viewer* to visualize the network map and the link quality metrics (e.g. PRR, RSSI) in real-time; and (*ii.*) a *database inspector* to view raw data retrieved from the motes in real-time. **Data analysis**: DataAnlApp provides a user interface that connects to the database and processes data, with two major functionalities: 1. a set of configurable graphs to understand the channel behavior; 2. an assistance to RadiaLE users to evaluate the performance of their estimators. Currently, DataAnlApp integrates a set of well-known LQEs, namely PRR (Packet Reception Ratio), WMEWMA (a smoothed PRR using EWMA filter), RNP(required number of packet retransmissions), ETX(Expected Transmission Count) and four-bit(TinyOS 2 default LQE), as well as our new LQE based on fuzzy logic [5]. Other LQEs can be easily integrated and compared to existing LQEs, due to the flexibility and completeness of the collected empirical data.

To illustrate the usefulness of RadiaLE, we intend to reproduce the simulation study conducted in [6], where five LQEs have been evaluated. The reliability of the LQEs can be evaluated by analyzing (i.) the distribution of their link quality estimates, illustrated by the empirical CDF (Fig. 3), and a scatter plot; and (*ii.*) their temporal behavior. The stability of LQEs is evaluated by the measure of the coefficient of variation of link quality estimates (Fig. 4).

## References

1. G. Werner-Allen, P. Swieskowski, and M. Welsh.: Motelab: A wireless sensor network testbed, in IPSN, 2005.
2. V. Handziski, A. Kopke, A. Willig, and A. Wolisz.: Twist: a scalable and reconfigurable testbed for wireless indoor experiments with sensor networks, in Proc. of the 2nd int. workshop on Multi-hop ad hoc networks: from theory to reality, 2006.
3. K. Srinivasan, M. A. Kazandjieva, M. Jain, E. Kim, and P. Levis.: Demo abstract: Swat: enabling wireless network measurements, in SenSys, 2008.
4. A. Cerpa, N. Busek, and D. Estrin.: Scale: A tool for simple connectivity assessment in lossy environments, Tech. Rep., 2003.
5. N. Baccour, A. Koubaa, H. Youssef, M. B. Jamaa, D. Rosario, L. B. Becker, and M. Alves.: F-LQE: A Fuzzy Link Quality Estimator for Wireless Sensor Networks. In EWSN, 2010.
6. N. Baccour, A. Koubaa, M. Ben Jamaa, H. Youssef, M. Zuniga, and M. Alves.: A comparative simulation study of link quality estimators in wireless sensor networks, in MASCOTS, 2009.