Demo: TRIDENT, Untethered Observation of Physical Communication Made to Share

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Abstract

Assessing the connectivity of Wireless Sensor Networks in the specific environment in which they are deployed is crucial to develop reliable system services and understand their behavior. In this demo, we introduce TRIDENT, a tool that measures communication with an untethered infrastructure. It enables the execution of connectivity experiments "in the wild", supporting also the sharing of the gathered results.

Categories and Subject Descriptors

C.4 [**Performance of Systems**]: Measurement techniques; C.2.1 [**Network Architecture and Design**]: Wireless communication

General Terms

Experimentation, Measurement, Performance

Keywords

802.15.4, Link quality, Connectivity assessment

1 Introduction

Wireless Sensor Networks (WSNs) are infrastructures able to monitor the environment in which they are immersed. As empirically demonstrated [6, 7], this environment deeply affects the behavior of the physical communication layer and, as a consequence, of the entire network stack. Therefore, information about the properties of the wireless links in the specific environment at hand is crucial to build reliable systems. The WSN community has recognized the relevance of the problem and built tools to empirically experiment with wireless links, e.g., SWAT [8], SCALE [5], and RadiaLE [3].

Our motivation comes from a wildlife monitoring project where biologists are interested in monitoring both animals and their environment. The aforementioned tools were not an option to study our target environment, as they all assume an infrastructure made by powered devices to which the motes are wired. Moreover, we needed a tool able to test links in a network composed also by mobile nodes.

To fulfill our requirements, we built TRIDENT, which allows experimenting with communication "in the wild" with nodes that are freely placed and moved. It has been used to collect connectivity traces in a primary cloud forest [4], where the tests were run directly by the biologists, and, during both winter and summer, in an open field and mountain forests. To uniformly store and access the results, we designed a single database, different from the CRAWDAD [1] and WISEBED [2] projects where traces are independent.

In this demo, we illustrate the versatility and effectiveness of our tool both with live experiments and by leveraging the data from our experimentation campaigns.

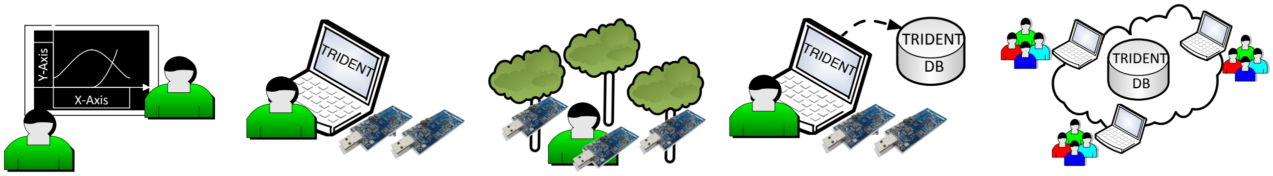
2 TRIDENT

TRIDENT is a tool enabling both the execution of communication tests without the need for a tethered infrastructure, and the sharing of results uniformly over different experiments. The steps involved in the usage of TRIDENT are shown in Figure 1. Once the tests have been designed, their description is input to TRIDENT and it produces the properly configured TinyOS code to be loaded on TelosB motes. Subsequently, the tests are run in the environment with only battery-powered devices (optionally a base station can supervise the tests online). Next, TRIDENT retrieves the results from the nodes, via multi-hop network forwarding or a direct USB connection. Finally, the results are uploaded on a repository and shared.

2.1 Assessing Connectivity

The goal of TRIDENT is to test communication links at the physical layer. This is done by having senders transmit

SenSys'11, November 1–4, 2011, Seattle, WA, USA.
ACM 978-1-4503-0718-5/11/11



(a) Test design (b) Test configuration (c) Test execution (d) Trace download (e) Trace sharing

Figure 1. Steps involved in the usage of TRIDENT**, from the design of the tests to the sharing of the traces.**

messages in round-robin, so as to avoid collisions, and listeners recording packet reception. We make use of broadcast communication, unless tests with acknowledgments are required. For each packet, the sender records the ambient noise before transmission and optionally the reception of the acknowledgement, whereas the receiver registers RSSI and LQI values. This data is stored in persistent memory, e.g., flash, either individually per packet or aggregated per test.

TRIDENT allows the configuration of an experiment as a series of tests, each characterized by a set of parameters. A test is described by the radio channel and power, the number of messages sent per sender, with the indication of how many must be sent in a single sequence, as well as the time interval between sequences. Additionally, each node can be chosen to behave as sender, listener, or both. Finally, TRIDENT can configure the sampling of environmental features, e.g., to assess the impact of temperature and humidity on connectivity.

After the code generated by TRIDENT has been loaded on the devices, the tests can be executed without constraints on the physical location of the nodes. Most importantly, this freedom enables testing wireless links with mobile devices. As a consequence, the information about the position of the nodes during the tests must be provided to permit the analysis of the results. Assuming the movements of the mobile nodes have been recorded with video cameras during the tests, TRIDENT provides an interface, shown in Figure 2, that replays the videos while showing a map where node movements can be drawn.

2.2 Handling the Results

Once the tests have been executed, the data downloaded from the nodes, and the movements of the mobile devices tracked, the results can be exported. Given the multiple possible uses of this information and the conceivable interest in running analyses spanning different environments and tests, TRIDENT makes use of a database where all data is stored in a uniform format. Our tool also offers a simple visualization of the results, as in Figure 3, either by showing

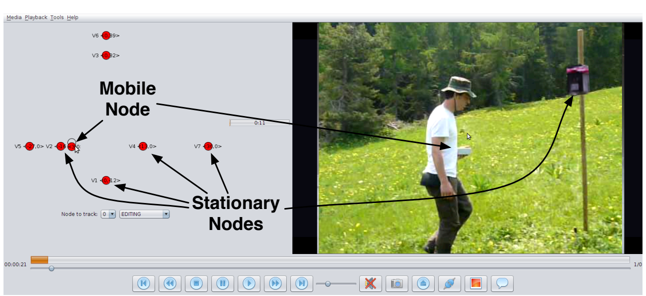


Figure 2. TRIDENT**, tracking mobile node positions.**

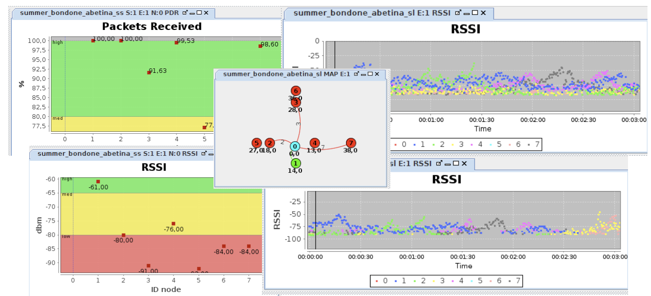


Figure 3. TRIDENT**, showing traces collected in our tests.**

aggregated information per link, or by enabling the replay of the transmission of the individual messages.

2.3 Sharing and Contributing

TRIDENT makes experimenting with wireless links easy in environments where previous solutions are impractical. Execution of the tests proved to be accessible to scientists without technical knowledge [4]. The ability to store the results in a database simplifies the sharing of the results and the comparison of experiments. By making TRIDENT public, we hope to build a public repository of communication traces from diverse environments. The instructions to download and use TRIDENT are available at the web page of the project: `http://d3s.disi.unitn.it/trident`

Acknowledgments. This work has been partially supported by the EU Cooperating Objects Network of Excellence (CONET: FP7-2007-2-224053).

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