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

Matteo Chini[1], Matteo Ceriotti[2], Ramona Marfievici[1,*], Amy L. Murphy[2], Gian Pietro Picco[1]

[1]Dip. di Ingegneria e Scienza dell'Informazione, University of Trento, Italy
[2]Bruno Kessler Foundation—IRST, Trento, Italy
*Contact author: marfievici@disi.unitn.it

Wireless Sensor Networks (WSNs) are infrastructures able to monitor the environment in which they are immersed. As empirically demonstrated [7, 6], 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. Asked to design a WSN working in the forest, we faced the question of how wireless communication behaves in such an environment. Not only are works reporting similar experiences not available, we also needed to consider factors such as trees and foliage, as well as intense weather conditions such as snow.

The aforementioned existing tools were not an option to study our target environment, as they all assume an infrastructure made by powered devices (e.g., embedded or standard computers) 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.

TRIDENT 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 multiple 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.

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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.

1 TRIDENT

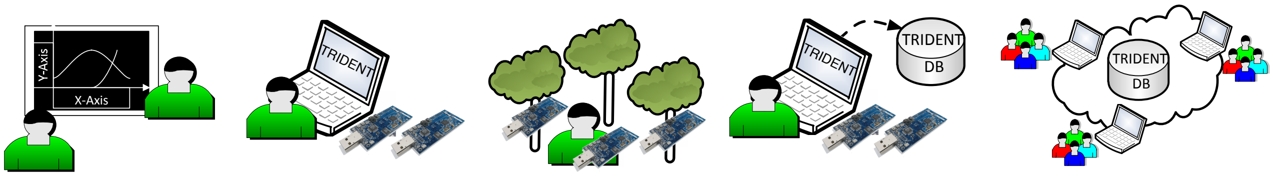
TRIDENT is a tool enabling both the execution of communication tests without the need for a tethered infrastructure, and the sharing of results uniformly over different experiments. The steps involved in the usage of TRIDENT are shown in Figure 1. Once the tests have been designed, their description 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.

1.1 Assessing Connectivity

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



(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.

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.

With the parameters available, we have configured and run a number of tests: *Mobile tests* used a single mobile node as the only sender, sending one message every 500 ms, for a total of 15 minutes; all other nodes were listeners, recording data for each packet received. In each test, the mobile node moved freely in the environment. Instead, in *stationary tests*, all nodes were both listeners and senders; a source in each test sent 215 packets with a single packet transmitted every 8 seconds. The nodes aggregated data per test, repeating the tests without intervention for several days.

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

1.3 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 will be available, before the SenSys conference, at the web page of the project: `http://d3s.disi.unitn.it/trident`

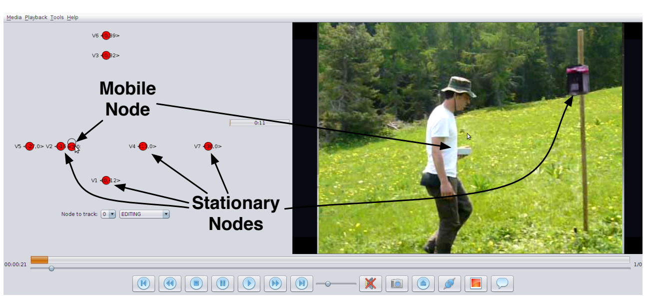


Figure 2. TRIDENT, tracking mobile node positions.

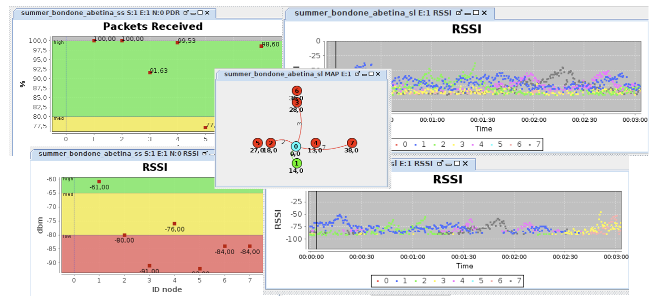


Figure 3. TRIDENT, showing traces collected in our tests.

2 Demonstration

The demonstration will be composed of two stations. In one, we show the steps involved in the usage of TRIDENT. With a few motes, we will configure small tests with people moving in the surrounding area according to predefined paths. We also plan to challenge the audience to "blindly" build links with different characteristics, e.g., with PDR in a given range, also investigating the impact of obstacles. In the second station, we will replay the tests we ran in our outdoor scenarios. Data traces in parallel with the video displaying the tests will be shown. We will discuss with the audience the challenges we faced in each scenario, showing the obtained results.

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3 References

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