Poster Abstract: A Site Properties Assessment Framework for Wireless Sensor Networks

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ABSTRACT

Comparing experimental results obtained on different wireless sensor network deployments is typically very cumbersome and in most cases unfeasible. This is due to the lack of a methodology to describe the properties of network deployments and the experimental conditions under which experiments have been run. Our work focuses on the design and development of a site properties assessment framework, called SiteWork, that aims at providing the means to quickly, automatically and accurately quantify their properties. This poster abstract describes the preliminary design and evaluation of the basic site properties assessment mechanisms provided by SiteWork.

Categories and Subject Descriptors

C.2.1 [**Network Architecture and Design**]: Wireless Communication

General Terms

Experimentation, Measurement, Performance

Keywords

802.15.4, Sites, Framework, Properties, Assessment

1. INTRODUCTION

As observed by several authors [7, 6, 5], it is usually unfeasible to compare the results obtained when evaluating the performance of wireless sensor network (WSN) protocols on different testbeds. This is mainly due to the fact that no standard methodology exists to describe the experimental conditions under which results have been obtained. The lack of such methodology also makes it hard for protocol designers to choose the more appropriate testbeds on which to test their approaches. Our work addresses this problem by providing a holistic framework to systematically assess the properties of WSN sites. A *site* indicates a generic WSN deployment, like an indoor or outdoor testbed or a real WSN working in the field. The *properties* of a site include both its high-level but also low-level network properties, topological characteristics (e.g., network diameter) as well as the hardware characteristics of the nodes available in the network.

This poster describes the prototypical architecture and initial implementation of our site properties assessment framework, called *SiteWork*. As depicted in Fig. 1, SiteWork consists of three main components dubbed SiteEval, SiteDB, and SiteViz. The SiteEval component is responsible for the actual assessment of the properties of a site by capturing detailed physical and network-level information. This information is then collected and stored centrally in the SiteDB database. The SiteViz component is finally used to further process and visualize the properties of the surveyed sites into aggregate-level statistics.

We envision two types of users to make use of SiteWork: site engineers and WSN protocol designers. The former can use SiteWork to iteratively verify the properties of their site and change it accordingly so as to achieve a desired configuration. The latter can instead use SiteWork to select the sites that guarantee for adequate (e.g., diverse enough) conditions over which to test their approaches. In the following, we first describe the preliminary design and evaluation of SiteWork's SiteEval and then briefly review related work.

2. ASSESSING WSN SITES PROPERTIES

The SiteEval component implements a two-stage protocol that is able to assess sites completely autonomously and collect the information at a central place. The only assumption that the assessment protocol makes is that the network is not partitioned. Node IDs should be unique, but can be arbitrary (i.e. they do not need to be contiguous). Data is collected wirelessly, not limiting its usage to testbeds with wired backchannel.

During the first stage, named CollectStaticProp (CSP), the properties of a site most likely to be `static` (e.g., number of nodes, average node density) are collected. To achieve this, every node in the network tries to register itself at a master node by sending `register request (RR)` messages to the master at random times. At the end of the stage, the master builds a list of slaves which will participate in the second stage. The master node needs to be connected to the SiteDB in order to store the received statistics.

In the second stage, CollectDynamicProp (CDP), the master passes a token to every slave in a round-robin fashion. The slave broadcasts a number p of probes and acknowledges this to the master, while receiver nodes generate statistics (PRR, RSSI, LQI, SNR, Seq. No.) for every received probe.

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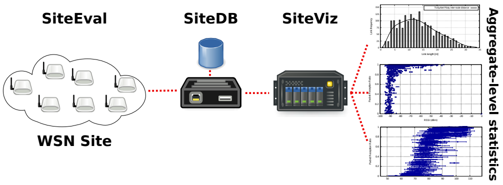

Figure 1: SiteWork Framework

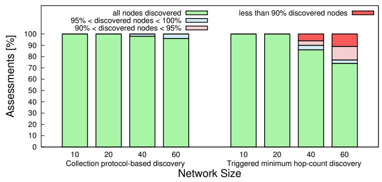

Figure 2: Nodes discovery in Piloty for different network sizes

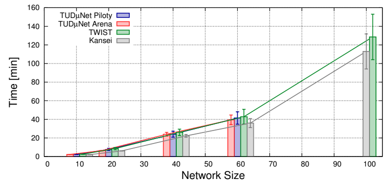

Figure 3: SiteEval assessment time across different sites

If an acknowledgment is not received within a given time frame, a timeout is triggered at the master and the token is sent again. After the master has the acknowledgement that a given node finished broadcasting its probes, it polls all other slaves requesting them to report their statistics.

We have implemented the assessment protocol on Contiki using the Rime communication stack. SiteEval automatically explores different frequencies and transmission power levels and allows to customize the number of probes p and the inter-packet interval. We encourage researchers to use the software, which is available to download under the BSD license at `https://github.com/igurov/SiteWork`.

3. EVALUATION

Failing to capture the exact number of nodes in the CSP leads to an inaccurate assessment. Two node discovery approaches were implemented: (i) a purely collection protocol-based discovery; (ii) a triggered minimum hop-count discovery in which the master triggers the registration by flooding the network and receiver nodes send `RRs` using a minimum hop-count routing protocol. The two approaches were evaluated in 4 different sites. The performance results from the evaluation in the TUDμNet Piloty site [4] are presented in Fig. 2. Across all sites the collection protocol-based discovery outperforms the triggered minimum hop-count approach in which sometimes nodes fail to register at the master as a result of choosing an unfavorable next-hop neighbor due to the link asymmetry resulting from the environment.

The autonomous network assessment is a time-costly operation because only one node is allowed to transmit at any given time, which, coupled with the centralized data collection, yields a quadratic run-time behavior. We evaluated the network assessment time for 5 different network sizes in 4 different sites - Piloty and Arena, part of the TUDμNet federation [4], TWIST, and Kansei [3] (cf. Fig. 3). It can be seen that the assessment of a middle-sized WSN ($\sim$60 nodes) is relatively quick ($\sim$40 minutes), which allows running the protocol several times per day (very important if ran on a time-shared site like a testbed).

The choice of master node has an impact on the measurement time. To examine this aspect, for every network configuration we set every second node as a master and repeated the test runs three times. As the network size grows, the standard deviation of the time needed to assess the network between all runs also grows. As expected, runs with centrally located master nodes were observed to be quicker than those where the master is at the edge of the network.

4. RELATED WORK

SiteWork is closely related to SCALE and SWAT, two other systems for fingerprinting wireless networks. SCALE [2] was an early effort to investigate packet delivery statistics in target environments. More recently proposed, SWAT [8] improves on SCALE by including more advanced metrics that correlate, e.g., packet reception. Conceptually, these two differ from our approach in their intent: while they can be used to understand a site, our goal is to enable consistent measurements across sites. Technically, our component SiteEval improves the former by not depending on a serial or Ethernet backchannel from a central entity towards the nodes, making it also appropriate for stand-alone sites.

In [1], Baccour et al. introduced RadiaLE, a framework for benchmarking link quality estimators (LQEs). In order to establish a rich set of links with various qualities, 49 nodes are wired to a central PC and placed in different circles around a central node. Then, a bidirectional data traffic over each link is created and packet-based link measurements are performed. Finally, the LQEs are evaluated using the collected statistics. In this way, RadiaLE provides a quantitative evaluation of LQEs accuracy, but falls short in its applicability to uniformly classify and compare sites.

Acknowledgments

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