

Chapter 7

Wireless Sensor Network Testbeds: A Survey

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ABSTRACT

The rapid increase in WSN-Testbed deployments alongside intra-academic and inter-industrial collaboration are two healthy signs which not only affirm but also confirm that it is a matter of time before WSN technology becomes a preferred industrial norm. In this chapter, the authors help in realizing this very fact through reflecting on different experiences pertinent to WSN-Testbed deployments. To put this objective into perspective, first, the authors adopt and describe a classification methodology for WSN-Testbeds. Second, the authors present a generic architecture for the different classes of WSN-Testbeds. Third, the authors pinpoint some design challenges and evaluation criteria/benchmarking scheme pertinent to WSN-Testbeds. Fourth, the authors examine the literature and opt for a variety of 30 WSN-Testbeds. The selection of these WSN-Testbeds is carefully made to cover the various spectra of WSN applications while avoiding redundancy. Fifth, selected WSN-Testbeds are comparatively analyzed with highlights of architecture and distinctive features. Sixth, the authors apply the benchmarking scheme and properly evaluate the selected WSN-Testbeds. Then, the authors shed light on some of the most relevant challenges and drawbacks. Finally, interesting discussion is introduced where among the issues discussed are: vitality of WSN-Testbeds, design trade-offs, network model, WSN's OS, topology control, power management, some real world deployment challenges, and confidentiality infringement. The authors believe that this chapter is a contribution towards realizing the important role that a WSN-Testbed plays in hastening the industrial adoption for the promising WSN technology.

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1. INTRODUCTION

A Wireless Sensor Network Testbed (WSN-Testbed) is a platform for experimentation of development projects. It allows rigorous, flexible, transparent and replicable testing of theories, computational tools and innovations. When compared to WSN simulators, WSN-Testbed enables more realistic and reliable experimentation in capturing the subtleties of the underlying hardware, software, and dynamics of the wireless sensor network. A quick look at the literature will reveal an overwhelming rapid increase in the deployments of such WSN-Testbeds. The momentum of WSN-Testbed deployment is further enhanced through an increasing collaboration between academia and industry.

Wireless Sensor Networks (WSNs) are rapidly gaining increasing attention on the experimentation level as well as the application-deployment level. Affordability, ease of deployment, and ability to monitor phenomena that were impossible to monitor using other solutions are just few among many other reasons that make WSN such a preferred choice. Thanks to recent advancements in wireless communications and MEMS technology, tiny low-cost and low-power devices known as sensor nodes or motes were developed. Motes can be spatially distributed and they are equipped with sensors that communicate over a wireless network and cooperate to monitor a physical or environmental phenomenon such as humidity, pressure, temperature, light, vibration, motion, sound, etc. (Haensel, ; Romer & Mattern, 2004).

The wide emergence of wireless sensor networks deployment was originally motivated by the military applications. Now, WSNs are deployed and being a fertile and active field of research for many military, industrial and civilian applications such as fire detection, habitat monitoring, health care, space, process monitoring, control, environmental, surveillance, security, etc. (Hadim & Mohamed, 2006).

As a result, this rapid growth enthruses universities and research institutes around the globe to set-up their own wireless sensor network testbeds (WSN-Testbeds). WSN-Testbeds enable researchers to gain hands-on experience and to investigate different kinds of scenarios. Additionally, WSN-Testbeds provide researchers with hands-on opportunity to experimentally investigate own innovation, and to test and evaluate its adaptability to real-world scenarios.

Accordingly, WSN-Testbeds are the basis for experimentation with wireless sensor networks in real-world settings; and they are also used by many researchers to evaluate specific applications pertaining to specific areas. A WSN-Testbed typically consists of sensor nodes deployed in a controlled environment. WSN-Testbeds provide researchers with an efficient way to examine and evaluate their algorithms, protocols, applications, etc. WSN-Testbed can be designed to support different features depending on the objective of the testbed. Among the important features of a WSN-Testbed is that it can be designed to remotely configure, run and monitor experiments. Another interesting feature is that the WSN-Testbed can be used for repeating experiments to produce similar results for analysis (Yick, Mukherjee, & Ghosal, 2008).

Since WSN simulators are available, why a researcher needs to use a WSN-Testbed which undeniably is a relatively costly solution? In fact, WSN simulators could be used for testing, evaluation and initial validation. For instance, they are used to test new protocols and to evaluate them. WSN simulator is based on mathematical models that attempt to model the underlying characteristics of its physical system probably taking current and potential ambient conditions into consideration. However, the fidelity of simulator is always a concern (J. Heidemann, N. Bulusu, J. Elson, C. Intanagonwiwat, K. Lan, Y. Xu, W. Ye, D. Estrin, and R. Govindan).

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