Deployment Support for Wireless Sensor Networks

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Abstract
Wireless Sensor Networks (WSNs) - networks of small resource-constrained devices that are able to sense their environment and communicate with each other - have received a growing interest by academia and industry in the past years. However, the number of actually deployed sensor networks is rather small and those are in the order of tens of nodes instead of thousands. The focus of this thesis lies on the analysis of real-world WSN deployment issues and on the provision of concepts and tools to facilitate the implementation of WSN applications, to monitor deployed networks and to allow for efficient identification and solving of WSN problems.

Keywords
Wireless sensor networks, deployment, monitoring, maintenance, debugging, testing, distributed systems.

Problem Statement and Research Question
So far, deploying a WSN is considered an *art,* performed by a WSN system programmer and not by an application domain expert. This thesis aims at bridging this gap by identifying main real-world deployment issues and providing concepts and tools to cope with these, based on the availability of an additional deployment-support network (DSN)[1],

which is temporarily installed next to the main WSN. More specifically, this thesis will focus on the media access and routing layers, as these are required for most of the WSN applications and are a common cause for failures. We will address the questions of what kind of problems can be identified and solved by eavesdropping on exchanged radio messages and how well distributed debugging techniques, such as deterministic replay and unit testing, can be applied in WSNs.

Approach and Methodology

Researchers deploying wireless sensor networks in real applications face various problems not seen in simulation or lab tests. The thesis will start by surveying existing WSN deployments and their reported issues. As sensor networks are optimized to fulfill their task with a minimal energy-consumption, it is hard to collect enough information to understand and solve such problems. Gathering exhaustive information from the sensor network for debugging purposes would require changes to the distributed application itself and might lead to additional bugs. Therefore, in this thesis, the usefulness of an additional deployment-support network will be evaluated. This DSN can be used in two ways: First, in an unobtrusive way to observe exchanged radio messages, and second, as a way to directly control WSN nodes from a central node to allow for distributed debugging and to introduce distributed unit tests. As an example application, the newly developed BitLMAC media access protocol based on BitMAC[2] will be implemented using the proposed DSN approaches.

Related Work

Existing works in the area of deployment support for WSNs follow different approaches. Real-world deployments are conducted to gain experience. Indoor testbeds consisting of wired sensor nodes, which provide power and a direct communication backchannel, are used to test applications before they are deployed on real sensor nodes outdoors. Two recent projects aim at providing insight into single sensor nodes such as the Nucleus network management system (NNMS)[3], or collecting additional statistics of the whole network to detect and identify failures like Sympathy[4]. Both approaches require to run additional program code on the sensor node and create additional network traffic. A deployment support network provides the benefits of a wired testbed to a deployed WSN. This thesis builds upon on the availability of a DSN, which will be used in the two proposed ways. Both the metrics described in the Sympathy paper as well as the data accessible by Nucleus can be used as a test case for the abilities of the DSN.

Future Steps

The next steps will be to further investigate papers on WSN deployments in more detail and to analyse conditions on which these problems could be solved with a DSN. Then, a tool to aid in development and debugging of the MAC layer will be built. As a real-world test, BitLMAC will be implemented using this tool.

Potential Collaboration

To gain a better insight into real-world problems, reports and feedback from groups deploying large WSN are highly appreciated. Also, it would be beneficiary to test and evaluate the developed tools in such settings.

As WSNs are a specific instance of distributed systems, expertise on available techniques for debugging and distributed (unit) testing and their applicability for WSN would be helpful.

References

[1] Jan Beutel et al. Scalable topology control for deployment-sensor networks. Proceedings of 4th Int'l Conf. Information Processing in Sensor Networks (IPSN '05), pp. 359–363, 2005.

[2] Matthias Ringwald and Kay Römer. BitMAC: A Deterministic, Collision-Free, and Robust MAC Protocol for Sensor Networks. Proceedings of 2nd European Workshop on Wireless Sensor Networks (EWSN 2005), pp. 57-69, Istanbul, Turkey, January 2005

[3] Gilman Tolle and David Culler. Design of an application-cooperative management system for wireless sensor networks. Proceedings of 2nd European Workshop on Wireless Sensor Networks (EWSN 2005), pp. 121-132, Istanbul, Turkey, Jan 2005.

[4] Ramanathan et al. Sympathy for the Sensor Network Debugger. Proceedings of 3rd ACM Conf. Embedded Networked Sensor Systems (SenSys 2005), pp. 255-267, San Diego, California, 2005.