Programming Abstractions for Large Scale Deployment of Wireless Sensor Networks

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Abstract
Wireless sensor networks have been an active area of research in the past years. This research has fostered the development of a multitude of different hardware and software platforms as well as several potential application scenarios. Unfortunately, a functional large-scale, non-academic deployment of a wireless sensor network is hitherto unknown. Currently, expert knowledge is required to implement even simple, functionally limited wireless sensor networks. We envision a programming application framework that simplifies deployment by abstracting from the low level implementation of individual nodes and focusing instead on the objectives of the entire network.

Keywords
wireless sensor networks, programming abstractions

Problem Statement and Research Question
At present, programming wireless sensor network devices is a very low-level task that requires intimate knowledge of the underlying hardware and software technologies. Furthermore, applications for wireless sensor networks are largely tailored to the particular target platform and can not be ported easily. In addition, the designer usually imposes functionality and capability statically at compile-time, which means that

each node fulfils one specific task throughout its lifetime, and this task needs to be determined in advance. As a result, deploying large wireless sensor networks is a time-consuming task that can not be executed by the typical envisioned user. These limitations currently inhibit wireless sensor networks as an enabling technology.

Wireless sensor nodes should be dynamic entities with the ability to adapt to the changing environment, in order to serve a common goal. Hence, we would like to suggest a shift of paradigm in programming wireless sensor networks. Instead of focusing on the implementation of individual nodes and their respective responsibilities, we would like to program the network as a whole by specifying more abstract goals. This requires developing appropriate tools that can transform a higher level sensor network specification into low level code for deployment on individual nodes. Together, the nodes then perform the specific task at hand, including coordinating and changing responsibilities automatically when necessary. Ideally, the user should not need to worry about the tasks of individual nodes (unless he has a specific interest in doing so) because the network as a whole achieves the desired goal.

Approach and Methodology

We will first identify the exact requirements of a suitable programming application framework based on the desires and capabilities of our typical envisioned user, as well as typical sensor network application scenarios. Ongoing research in the areas of MAC protocols, energy efficient data acquisition, storage and retrieval, and dynamic ad-hoc networking will be scrutinised in order to assess suitability for inclusion into the framework. A programming application framework will be designed, prototyped and analysed.

Related Work

There are various research activities that address individual aspects of the problem described. TinyDB [1] is an implementation of a distributed database that runs on sensor nodes. TinyDB allows the user to formulate queries concerning the network as a whole, abstracting from individual nodes. Barr et al developed MagnetOS [2], a distributed Java virtual machine for sensor nodes. Applications are written as if they were executed on a single machine and the sensor network automatically partitions the resulting program into components that are migrated to the most suitable node for execution. SensorWare [3] and Agilla [5] are mobile agent based sensor network frameworks. SensorWare provides a higher level language to express distributed algorithms that abstracts from low-level details and provides resource sharing among nodes. In Agilla, the network can react to changing circumstances by migrating agents between nodes, and as with MagnetOS, code is written as for a single machine. Finally, DSWare [4] operates between the network and application layers of a sensor network and provides a database-like abstraction to applications. Lower-level characteristics such as unreliability of sensor or communication devices are hidden from the user.

Conclusions and Future Steps

Considering their huge potential in a large number of application scenarios, wireless sensor networks are not as widespread as they could be. Current research offers the vision that application experts are able to deploy wireless sensor networks in their field of expertise with

little to no support from technology experts. In order to bridge this gap, a number of programming abstractions have evolved with the goal of making the technology more accessible. Nonetheless, work in this field is far from complete and provides plenty of further challenges.

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