SomSeD: An Interdisciplinary Approach for Developing Wireless Sensor Networks

Sebastian Georgi[1], Christoph Weyer[2], Martin Stemick[1], Christian Renner[2], Felix Hackbarth[3], Ulf Pilz[4], Jens Eichmann[5], Tobias Pilsak[5], Harald Sauff[6], Luis Torres[7], Klaus Dembowski[8], Fabian Wagner[9]

Hamburg University of Technology

georgi@tu-harburg.de, c.weyer@tu-harburg.de

ABSTRACT

The research field "Self organized mobile Sensor and Datanetworks" (SomSeD) is introduced. Its purpose is the investigation of Wireless Sensor Networks (WSN). It benefits from interdisciplinary exchange between various institutes of the Hamburg University of Technology (TUHH). Due to different design constraints (such as energy-efficiency and package size) compared to well known classical computer networks, all aspects of the development of WSNs must be reconsidered. This paper describes the advantage of having experts of various faculties both in computer science and electrical engineering in a single research field. In addition to the introduction of the participating institutes, the deployment of a WSN on the TUHH campus will be outlined.

1. SOMSED

Since the foundation of the Hamburg University of Technology a unique organization structure has been applied. On the one hand teaching is distinguished in classical deaneries. Research on the other hand is performed over boundaries of faculties in distinct research fields. Thus, teaching and research are related to each other in a matrix organization structure.

One of these research fields is "Self organized mobile Sensor and Data networks" (SomSeD). Its benefits, goals and challenges will be described in this paper. Besides the coordination on the level of the university teachers, the cooperation of undergraduate and Ph.D students is encouraged. Within SomSeD the so called "Junior" group has been created, in which Ph.D candidates design and develop a WSN. The degree of freedom is high, all decisions regarding the system design are made by the participants themselves. Thus the launch of SomSeD-Junior leads to a great motivation and an appreciable progress.

Deploying a WSN for long-term measurements is one objective of SomSeD. This network is intended to be a platform to integrate all results from research. The TUHH campus is well suited to sustain a WSN due to its continuous area. A permanent installation will support practical demonstrations for various applications and technological concepts of WSNs. This encourages the interest in SomSeD.

2. INSTITUTE COOPERATION

Developing WSNs demands contributions from all experts in the field of electrical engineering and computer science, because all components in both hardware and software have to be aligned to each other. While Quality of Service criteria such as goodput and latency of classical networks can be loosened, energy-efficiency, reliability in adverse conditions, low complexity and the size of single sensor nodes are the most important challenges. Classical models such as the OSI-reference model are given up to allow a crosslayer design: The application has a very strong influence on all layers of abstraction, e.g., routing and media access control (MAC) must be considered together when energy-efficiency shall be achieved [2].

To fulfill these demands, a strong cooperation between different faculties is necessary to define interfaces and redesign all components. Although the individual nodes are very small, the overall complexity of WSNs and the bandwidth of research topics is still high; beginning with hardware aspects such as sensor design and autonomous energy supply and reaching to software methods like data-gathering and visualization. The following institutes participating in SomSeD represent a unique aggregation of competence in WSN development.

The Institute of Telematics has been active in research of WSNs since 2004 [3]. It is obvious, that Telematics is the best choice to supervise the research field and to build the bridge between communication and information engineers.

The Institute of Telecommunications has its traditional research activities in radar development and broadband communications. While the radar technique already performed

[1]Institute of Telecommunications
[2]Institute of Telematics
[3]Institute of Automation
[4]Institute of Control Systems
[5]Institute of Measurement Technology
[6]Institute for Security in Distributed Applications
[7]Institute of Communication Networks
[8]Institute of Microsystem Technology
[9]Institute of Nanoelectronics

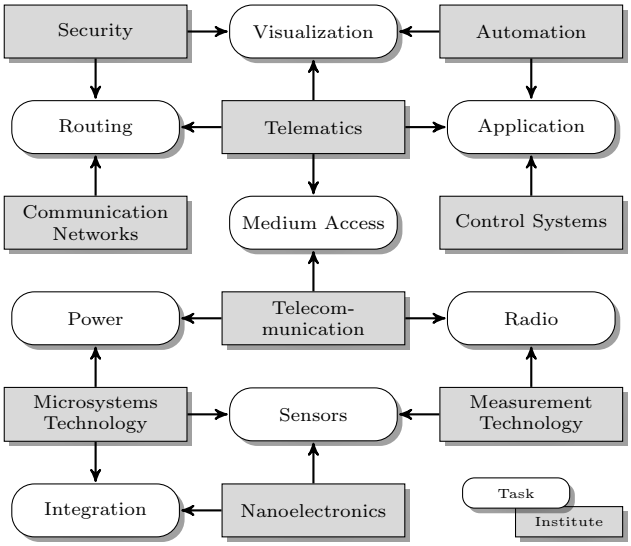

Figure 1: Hardware Overview

the transformation from large rotating antennas with huge transmit power into small and cheap automotive equipment, the communications section is also gaining more and more interest in wireless sensor networks.

Sensors are a major component of WSNs. Hence, it is natural to include the Institute of Measurement Technology into the research field. Besides a profound knowledge about various sensors, the Institute offers a great experience in field testing.

Another crucial point is Networking. The Institute of Communication Networks plays an important role in developing suitable routing and networking algorithms. Careful design of these algorithms helps to decrease protocol overhead and retransmissions and thus improves energy-efficiency.

Cheap and small sensor nodes can only be realized, if a high integration can be achieved. The Institute of Nanoelectronics offers the complete competence in the design of integrated circuits in up-to-date process technology.

The Institute of Microsystem Technology is capable of building very complex and sensitive sensors with small size. A focus lies on the design of medical sensors that are distributed all over the human body. An obvious application for a WSN.

The robustness against malicious network influences is investigated by the Institute for Security in Distributed Applications. Operating mostly in ISM frequency bands and using only low transmission power, WSNs are sensitive to all kinds of interferers, but a wilful disturbance of the network must also be inhibited.

Many decisions depend on the chosen network application. Long-term stability, autonomous operation of the network, and maximum tolerable delays to establish stable control loops are necessary investigations performed by the Institute of Automation and the Institute of Control Systems.

3. CAMPUS NETWORK

One important goal of the research field SomSeD is the deployment of a WSN on the TUHH campus. An entire network of sensor nodes will be installed permanently at the buildings to cover the whole main campus. The density will be chosen to guarantee a connected network, even if some nodes experience permanent failure. The well known IRIS platform is utilized and TinyOS 2.x [1] forms the basis for the software development. This demonstration system gives the opportunity to gather long-term measurements of the behavior of WSNs. It will fulfill two major tasks:

Collecting status information of the network itself, such as neighborhood link quality, successful packet transmission rates, and power-supply monitoring. Running for several months, a good estimation on stability and reliability of such a WSN can be achieved.

Besides status monitoring, convenient applications will be demonstrated. All nodes are regularly measuring the temperature, which is graphically displayed. The network will also be able to forward position information of mobile nodes that are equipped with GPS-receivers.

The architecture is based on a routing tree with one distinct data sink. All acquired data is stored inside a database and visualized using Google Maps. In a first version most nodes are battery-equipped, and a few nodes are powered by an autonomous supply unit developed at the TUHH. This unit uses a solar cell that is dimensioned to guarantee a stable power supply of the backbone routing network even under unfavorable weather conditions.

3.1 Applications

Hardware and software development for WSNs will be validated by performing long-term tests on the campus network. Gathering statistics about the network topology, link qualities, and power consumption is an important application of the experimental system. Once a stable network is established, the WSN can support the facility management of the TUHH by automatically forwarding meter readings and monitoring temperature, humidity, and carbon dioxide in lecture rooms. Thus, a green campus will be realized.

For a university of technology it is extremely important to fascinate visitors for technical study paths. The GPS application offers a convincing show case which will encourage pupils to choose the career of an engineer.

4. REFERENCES

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