

DES-Testbed

A Wireless Multi-Hop Network Testbed for future mobile networks

Mesut Güneş Oliver Hahm Kaspar Schleiser
{guenes,hahm,schleiser}@inf.fu-berlin.de

Distributed Embedded Systems
Computer Systems and Telematics
Institute of Computer Science
Freie Universität Berlin, Germany

06.05.2010

1 Introduction

The *DES-Testbed*[1][2][3] is a Wireless Multi-hop Network testbed located on the campus of *Freie Universität Berlin*. Used by multiple projects, it provides the necessary infrastructure to research and develop next-generation multi-hop network algorithms and protocols. In combination with the *DES-Framework*, a sophisticated testing and evaluation framework, it is possible to define, schedule, run, monitor and evaluate Wireless Multi-hop Wireless network and Wireless Sensor Network experiments.

The *DES-Testbed* consists of 110 *DES-Nodes* spread over three buildings. Each *DES-Node* consists of a wireless router equipped with three IEEE 802.11a/b/g transceivers and a wireless sensor node. While the wireless transceivers form the Wireless Mesh Network *DES-Mesh*, the sensor nodes establish a Wireless Sensor Network called *DES-WSN*. Thus a Wireless Mesh and Wireless Sensor Network are operated in parallel, making the testbed one of the largest hybrid networks world-wide. The *DES-Nodes* are deployed in an irregular topology across several buildings on the campus. To design, manage, run and evaluate experiments on the *DES-Testbed* a

software framework was developed. This enables the examination of new protocols on all layers and their interactions. For the integration of the *Internet of Things* into the *Future Internet* several challenges have to be met. In this presentation we will show how topics like quality of service, route-redistribution or energy efficiency for wireless multi-hop networks can be studied using the *DES-Testbed* in combination with the *DES-Framework*.

2 Quality of Service in Wireless Multi-hop Networks

In the *Future Internet*, there will be an increased amount of realtime applications. The network core has to offer some support to make these applications feasible. The algorithms and protocols on the transport and network layer play a particular role in this area.

In the *DES-Testbed* we can consider the impact of these layers to the network performance. In order to have accurate information about the testbed's characteristics, several monitoring and data collecting services are being used. The formal experiment speci-

fication and execution via *DES-Cript*[4] and *DES-Exp*[5] allows the repetition of experiments, generating results that are comparable to each other. This enables the researchers to compare different routing metrics as well as transport layer protocols and their inter-dependencies.

DES-SERT[6] provides an easy way to implement routing protocols independently from the underlying operating system. Thereby the relationship between routing and transport layer can be studied.

3 Route-Redistribution

Wireless Sensor Networks, Wireless Mesh Networks and wired networks have different requirements for routing protocols. To connect, e.g., Mobile Ad-Hoc Networks (MANET) to traditional Internet topologies mediation between these networks is inevitable. Different routing protocols and varying address schemes require the usage of gateways or translators at the edges of the subnets.

The protocols used in wired networks can be mapped at service access points to semantically equivalent representations that are adapted to the requirements of Wireless Sensor Networks and Wireless Mesh Networks. Alternatively, Wireless Sensor Networks, Wireless Mesh Networks, and wired networks can be considered as autonomous systems, which communicate via gateways. This will result in the route-redistribution problem in which routes have to be exchanged among autonomous systems that use different routing protocols.

Moreover, integrating Wireless Sensor Networks into conventional networks is a nontrivial challenge as the requirements are partially orthogonal to the requirements of Wireless Mesh Networks and fixed networks. For sensor networks the energy consumption is prevailing whereas for other networks the throughput and delay are primary concerns. Nevertheless these networks have to interact with each other. There are different approaches like 6LoWPAN[7] to accomplish this goal.

4 The Internet of Things

Every mesh router in the *DES-Testbed* contains one MSB-A2[8] wireless sensor node. We are in the process of implementing a 6LoWPAN stack for the used sensor node operating system which will enable the nodes to be accessed using any IPv6 connected system. One of our fridges is also equipped with a MSB-A2, connecting it to the rest of the testbed. We are planning to integrate more devices into this sensor network, enabling interaction over the Internet.

One of the most useful features of our MSB-A2 sensor node is its integrated coulomb meter. It offers exact measurement of energy usage with nearly function-level granularity. Energy consumption can be accessed in real-time from within the sensor node operating system, allowing the implementation of energy aware routing protocol. Together with the routing framework this enables the researcher to do comparisons of the energy consumption of different routing protocols in real-world scenarios.

5 Conclusion

The *DES-Testbed* in combination with the *DES-Framework* offer researchers a real-world testing and experimentation environment for future mobile network technologies. Requirements for Wireless Multi-hop Networks like quality of service, route-redistribution, and energy efficiency can be studied comfortably. This allows the development and evaluation of new protocols for the integration of the *Internet of Things* into the *Future Internet*.

References

- [1] M. Günes, B. Blywis, and F. Juraschek, "Concept and Design of the Hybrid Distributed Embedded Systems Testbed," Freie Universität Berlin, Tech. Rep. TR-B-08-10, 2008.
- [2] M. Günes, B. Blywis, F. Juraschek, and P. Schmidt, "Practical Issues of Implementing a Hybrid Multi-NIC Wireless Mesh-Network," Freie Universität Berlin, Tech. Rep. TR-B-08-11, 2008.

- [3] B. Blywis, M. Günes, F. Juraschek, and J. Schiller, "Trends, advances, and challenges in testbed-based wireless mesh network research," *ACM/Springer Mobile Networks and Applications (MONET)*, February 2010, special Issue on Advances In Wireless Testbeds and Research Infrastructures. [Online]. Available: <http://www.springerlink.com/content/hk25051135m36571/>
- [4] M. Günes, F. Juraschek, B. Blywis, and O. Watteroth, "DES-CRIPT - A Domain Specific Language for Network Experiment Descriptions," in *Inproceedings of the International Conference on Next Generation Wireless Systems (NGWS) 2009*, Melbourne, Australia, 12-14, October 2009.
- [5] M. Günes, B. Blywis, F. Juraschek, and O. Watteroth, "Experimentation Made Easy," in *Inproceedings of the First International Conference on Ad Hoc Networks*, ICST, Ed., Ontario, Canada, September 2009.
- [6] B. Blywis, M. Günes, F. Juraschek, P. Schmidt, and P. Kumar, "Des-sert: A framework for structured routing protocol implementation," in *IFIP Wireless Days 2009*, 2009.
- [7] Z. Shelby and C. Bormann, *6LowPAN: The Wireless Embedded Internet*. Wiley, 2009.
- [8] M. Baar, H. Will, B. Blywis, T. Hillebrandt, A. Liers, G. Wittenburg, and J. Schiller, "The ScatterWeb msb-a2 platform for wireless sensor networks," Freie Universität Berlin, Department of Mathematics and Computer Science, Institute for Computer Science, Telematics and Computer Systems group, Takustraße 9, 14195 Berlin, Germany, Tech. Rep. TR-B-08-15, 09 2008. [Online]. Available: <http://www.inf.fu-berlin.de/publications/techreports/tr2008/B-08-15/index.html>