
Evaluation of a lightweight debugging platform for mobile sensor networks

Bachelorarbeit im Studiengang Angewandte Informatik - Systems Engineering am Institut für Informatik und Wirtschaftsinformatik der Universität Duisburg-Essen

Michael Krane

2233018

Essen, July 20, 2015

Supervisor: Hugues Smeets

1. Examiner: Prof. Dr. Pedro José Marrón

2. Examiner: Prof. Dr. Gregor Schiele

Eidesstattliche Erklärung

Hiermit versichere ich, dass ich die vorliegende Arbeit ohne Hilfe Dritter und nur mit den angegebenen Quellen und Hilfsmitteln angefertigt habe. Ich habe alle Stellen, die ich aus den Quellen wörtlich oder inhaltlich entnommen habe, als solche kenntlich gemacht. Diese Arbeit hat in gleicher oder ähnlicher Form noch keiner Prüfungsbehörde vorgelegen.

Essen, am July 20, 2015

Abstract

TODO

List of Figures

1	Overview of the SHAMPU Framework	2
2	OSI-Layer vs. ANT Protocol	2
3	Example ANT Topologies	3

List of Tables

Contents

Eidesstattliche Erklärung	I
Abstract	II
List of Figures	III
List of Tables	IV
1 Introduction	1
1.1 Related work	1
2 Technical Background	2
2.1 SHAMPU	2
2.2 ANT	2
2.2.1 ANT Topology	3
2.2.2 ANT Channels	3
2.2.3 ANT Communication	3
2.3 ANTAP1MxIB RF	4
3 Evaluation of SHAMPU	5
3.1 Experiment 1: Delay calculations between two nodes	5
3.2 Experiment 2: Delay calculations between multiple nodes	5
3.3 Experiment 3: Maximal communication Range	5
3.4 Experiment 4: Data Transfer between two nodes	5
3.5 Experiment 5: Reflash of a wireless sensor network	5
4 Conclusion	6
4.1 Summary	6
4.2 Future Work	6
Bibliography	7

1 Introduction

TODO

- Explain Context in which SHAMPU was designed
- Explain Problem SHAMPU tries to fix
- Explain "Problem" of this thesis "ANT as an addition to SHAMPU, need to know how good ANT is"
- Explain how problem was solved, e.g. Different experiments which try to evaluate ANT in the context of SHAMPU

In this thesis we evaluate the WSN testbed: SHAMPU (Single chip Host for Autonomous Mote Programming over USB).

1.1 Related work

There are already several different WSN testbeds available. These testbeds all fulfil certain roles, but ultimately fail to provide all the necessary features for a small, mobiles and low power WSN testbed.

There are some testbeds which need a fixed infrastructure, like FlockLab [1] or Minverva [2]. The nature of a fixed infrastructure has certain problems. For once it might only be viable to test inside the lab and not in the target environment since the needed infrastructure is often only available inside a lab or not easily transportable.

Other technologies aim to detach the testbed from the infrastructure itself and rely on wireless communication instead. Sensei-UU [3] for example uses a wireless 802.11 network for communication between the nodes and the sensor host. The problem here is the power requirements for the communication, which makes it hard to run the nodes without an external power source.

BTNodes [4] or Smart-Its [5] use Bluetooth to address the power issue. But Bluetooth introduces different problems, such as size limitations for the network and a difficult set-up and use of more complex network topologies. The newest version of Bluetooth tries to address this with the introduction of ScatterNets, but the setup and maintenance of the network still remains challenging.

2 Technical Background

2.1 SHAMPU

SHAMPU (Single chip Host for Autonomous Mote Programming over USB) [6] is a WSN testbed, which allows the remote debugging and reprogramming of sensor nodes. The main advantages over other testbeds (see section 1.1) are the low cost, small size and low energy consumption. SHAMPU can be used as an extension to an already existing sensor node. The node only needs to provide an USB-Interface, SHAMPU is thus completely OS independent. The SHAMPU framework (see Figure 1) itself is split into multiple modules. The Code

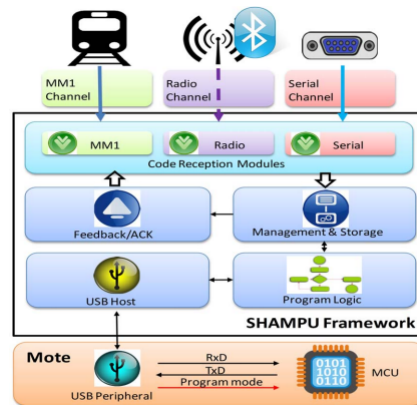


Figure 1: Overview of the SHAMPU Framework

Reception Module allows the use of different protocols to connect to and communicate with other SHAMPU enabled devices. For wireless communication SHAMPU uses an ANTAP1MxIB RF Transceiver Module, which supports the ANT protocol. The USB Host module is used to connect to the sensor node, which SHAMPU is attached to.

2.2 ANT

ANT [7] is a wireless protocol which operates in the 2.4 GHz ISM Band. Originally developed in 2003 by Dynastream Innovations Inc. for the use wireless sensors. The ANT protocol is designed for the use in low power WSNs and puts a focus on scalability and ease of use. One

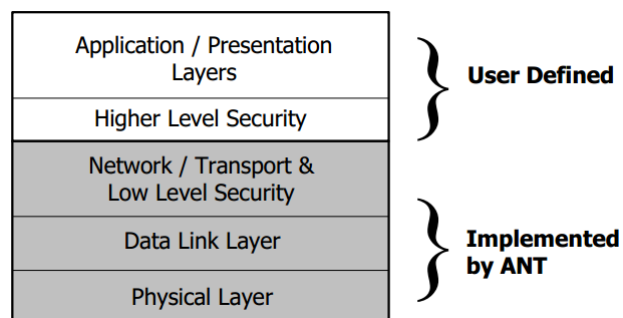


Figure 2: OSI-Layer vs. ANT Protocol

of the advantages ANT has over other protocols, like Bluetooth or ZigBee is the high level of abstraction the ANT Protocol provides. This is achieved by the incorporation the first 4 OSI-layer (see Figure 2) into the ANT protocol and thus allowing even low-cost MCU to setup and maintain complex wireless networks.

2.2.1 ANT Topology

In order for ANT-Nodes to communicate with each other, they have to be part of a network. This is done by creating a channel and connection between two or more different ANT nodes together.

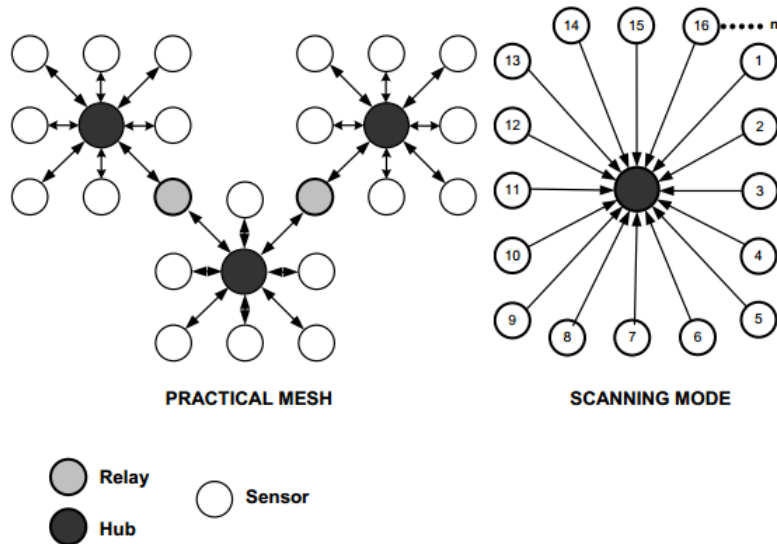


Figure 3: Example ANT Topologies

TODO

- Explains what ANT nodes are
- Explain what channels are (for now in section ANT Channels)

2.2.2 ANT Channels

Most of the available channel types are bidirectional, but the ANT protocol still differentiates between master and slave nodes. While a master node mostly sends data and a slave node mostly receives data, the slave still has the ability to respond to the incoming data.

The ANT protocol knows 125 different channels, each 1 MHz wide. Each Channel supports a data rate of 1 Mbps and up to 65533 nodes. To avoid interference between the channels, isochronous self-adjusting TDMA technology is used; this allows the ANT nodes to change the transmit timings and even the frequency that is being used for the current channel.

Picture Process to establish a channel between master and slave nodes.

The ANT protocol distinguishes between 2 different Channel types:

Independent Channels

Independent Channels are used if there is only one ANT node, which is transmitting data. This allows 1:1 transmission, but also broadcasts.

Shared Channels

Shared Channels are used if a single ANT node needs to receive data from many nodes. This type of channel is made possible by the use of Shared Channel Address, however this reduces the amount of data that can be transmitted at a time.

2.2.3 ANT Communication

TODO

- Explain how each msg is structured
- Explain extended msg

2.3 ANTAP1MxIB RF

In order to use the ANT protocol each SHAMPU-mote is equipped with an ANTAP1MxIB RF Transceiver Module. The module was chosen because of its small form factor (20mm x 20mm) and very low power draw. The ANTAP1M can handle up to 4 ANT channels and a 1Mbps RF data rate, which is enough to setup and use the desired network topology.

TODO

- Explain how the Chip communicates with the SHAMPU node
- Explain how the Chip communicates with the host PC

3 Evaluation of SHAMPU

In order to assess the capabilities of SHAMPU we plan and run experiments designed to evaluate the SHAMPU framework in the following three categories:

- **Communication Range**
- **Communication Delay**
- **Data Throughput**

For this we designed different scenarios, which test one or more of the described categories. The following section describes the experiments according to the following template:

Name

The name of the experiment.

Description

A description of the experiment and the the category being evaluated.

Network Topology

A diagram of the network topology in which the experiment is run.

Result

The results of the experiment and any additional collected data.

3.1 Experiment 1: Delay calculations between two nodes

3.2 Experiment 2: Delay calculations between multiple nodes

3.3 Experiment 3: Maximal communication Range

Diagram for the experiment: 2 nodes x meter apart. with distances from 0.5 m to 30m (floor in SM 3xx is 27m long) In this experiment we propose to test this theoretical limit, we set up two ANT radios next to each other. We then start moving the nodes away from each other until the connection breaks. We then start moving the nodes back together until a new connection is established.

3.4 Experiment 4: Data Transfer between two nodes

The ANT protocol promises a speed of up to 1 Mbps, 20 kbps of which are available for the application itself. In this experiment we try to determining the speed with which it is possible to move data to and from a SHAMPU device. We also try to determinate what effect the size of the payload and the number of the nodes in the network have on the transmission speed.

3.5 Experiment 5: Reflash of a wireless sensor network

4.1 Summary

4 Conclusion

TODO

4.1 Summary

TODO

4.2 Future Work

TODO

Bibliography

- [1] R. Lim, F. Ferrari, and M. Zimmerling, "FlockLab: A testbed for distributed, synchronized tracing and profiling of wireless embedded systems," *Proceedings of the 12th ...*, pp. 153–165, 2013. [Online]. Available: <http://dl.acm.org/citation.cfm?id=2461402>
- [2] P. Sommer, "Minerva : Distributed Tracing and Debugging in Wireless Sensor Networks."
- [3] O. Rensfelt, F. Hermans, C. Ferm, P. Gunningberg, and L. Larzon, "Sensei-UU: A Nomadic Sensor Network Testbed Supporting Mobile Nodes," 2009. [Online]. Available: <http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Sensei-UU+:+A+Nomadic+Sensor+Network+Testbed+Supporting+Mobile+Nodes#0>
- [4] T. Moser and L. Karrer, "The EventCollector Concept," *Topology*.
- [5] O. Kasten and M. Langheinrich, "First Experiences with Bluetooth in the Smart-Its Distributed Sensor Network The Smart-Its Prototype," *System*, no. 00, 2000.
- [6] H. Smeets, C.-Y. Shih, T. Meurer, and P. J. Marrón, "Demonstration Abstract: A Lightweight, Portable Device with Integrated USB-host Support for Reprogramming Wireless Sensor Nodes," in *Proceedings of the 13th International Symposium on Information Processing in Sensor Networks*, ser. IPSN '14. Piscataway, NJ, USA: IEEE Press, 2014, pp. 333–334. [Online]. Available: <http://dl.acm.org/citation.cfm?id=2602339.2602401>
- [7] Dynastream Innovations Inc., "ANT Message Protocol and Usage," pp. 1–134, 2013.