

## Peer Observations of Observation Units

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# **Abstract**

What is wrong with the world? Motivation 1-3 sentences, Arch, Des, Imp, Exp  
1,2-3 sentences, results and main conclusion.



# **Acknowledgements**



# Contents

<b>Abstract</b>	<b>i</b>
<b>Acknowledgements</b>	<b>iii</b>
<b>List of Figures</b>	<b>vii</b>
<b>List of Tables</b>	<b>ix</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Motivation . . . . .	2
1.2 Contributions . . . . .	2
1.3 Assumptions . . . . .	2
1.4 Limitations . . . . .	2
1.5 Outline . . . . .	2
<b>2 Routing Techniques in WSNs?</b>	<b>5</b>
<b>3 Related Work</b>	<b>7</b>
3.1 Routing Protocols in WSNs . . . . .	7
3.2 Data Collection/Aggregation in WSNs . . . . .	8
<b>4 Architecture</b>	<b>9</b>
4.1 Discovery Of Other Nodes . . . . .	9
4.1.1 Node Lookup Service . . . . .	9
4.2 Incoming Network Requests . . . . .	10
4.3 Data Transmission . . . . .	10
4.3.1 Connect To Neighbours . . . . .	10
4.3.2 Cluster-Head Election Request . . . . .	10
4.3.3 Data Collection . . . . .	10
4.4 Base Station Access . . . . .	10
<b>5 Design</b>	<b>11</b>
5.1 Broadcasting . . . . .	11
5.2 Cluster-Head Election . . . . .	11

5.3	Accumulate Data/Forwarding . . . . .	11
5.4	Base Station Access? . . . . .	12
<b>6</b>	<b>Implementation</b>	<b>13</b>
6.1	Distance To Other Nodes In The Network . . . . .	13
6.2	Data Transmission . . . . .	14
6.2.1	Cluster-Head Election . . . . .	14
6.3	Data Accumulation . . . . .	14
<b>7</b>	<b>Evaluation</b>	<b>15</b>
7.1	Experimental Setup . . . . .	15
7.2	Experimental Design . . . . .	16
7.2.1	CPU Measurements . . . . .	16
7.2.2	Memory Measurements . . . . .	16
7.2.3	Network (Socket) Usage . . . . .	16
7.2.4	Network Lifetime? . . . . .	16
7.3	Results . . . . .	16
7.3.1	CPU Usage . . . . .	16
7.3.2	Memory Usage . . . . .	16
7.3.3	Network Usage . . . . .	16
7.3.4	Network Lifetime? . . . . .	16
<b>8</b>	<b>Discussion</b>	<b>17</b>
8.1	Availability of nodes in the system? . . . . .	17
8.2	Cluster-head Election? . . . . .	17
8.3	Data Transmission? . . . . .	17
<b>9</b>	<b>Conclusion</b>	<b>19</b>
<b>10</b>	<b>Future Work</b>	<b>21</b>
<b>11</b>	<b>Appendix</b>	<b>23</b>
	<b>Bibliography</b>	<b>25</b>

# **List of Figures**

5.1	Figure show broadcast range of a OU . . . . .	12
6.1	Broadcast simulation . . . . .	14



# **List of Tables**

5.1 My caption . . . . .	12
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# / 1

## Introduction

**FRA CAPSTONE:** *The Arctic tundra in the far northern hemisphere is challenged by climate changes in the world today and is one of the ecosystems that are most affected by these changes[10]. The Climate-ecological Observatory for Arctic Tundra (COAT) is a long-term research project developed by five Fram Center<sup>1</sup> institutions. Their goal is to create robust observation systems which enable documentation and understanding of climate change impacts on the Arctic tundra ecosystems. COAT was in autumn 2015 granted substantial funding to establish research infrastructure which allowed them to start up a research infrastructure during 2016-2020[10].*

Wireless Sensor Network (WSN) is a system that consists of hundreds or thousands of low-cost micro-sensor nodes. These nodes monitor and collect physical and environmental conditions. The various activities in the sensor nodes consume lots of energy and the battery of the sensor node is difficult to recharge in wireless scenarios and also because the sensor nodes are located at remote areas in the Arctic tundra.

*This thesis presents the architecture, design and implementation of a peer observation that can observe and accumulate data from in-situ observation units.*

<sup>1</sup>. <http://www.framsenteret.no/english>

## 1.1 Motivation

The motivation behind this project is...

The purpose is to fetch and accumulate data observed by observation units for further use.

The observation units to be used for the prototype comprises Observation Unit Processes executing on PCs and/or Raspberry Pi.

## 1.2 Contributions

The dissertation makes the following contributions:

- A
- B

## 1.3 Assumptions

Avgrense viktig!

## 1.4 Limitations

Avgrense viktig!

## 1.5 Outline

This thesis is structured into X chapters including the introduction.

**Chapter 2** describes ..

**Chapter 3**

**Chapter 4**

**Chapter 5**

**Chapter 6**

**Chapter X**



# /2

## **Routing Techniques in WSNs?**

Som eget kapittel eller ha det under Related Work? Si noe om routing protocols som hierarchical (evt flat-based og location-based) og si noe om routing protocol operations som multipath (evt. query-based, QoS-based, coherent-based etc..)?

Har også fra WSN-bok ("Protocols and Architectures for Wireless Sensor Networks, Holger Karl, Andreas Willig) kap. 11 som heter "Routing Protocols" som sier noe om gossiping, energ-efficient unicast, broadcast/multicast, geographic routing og mobile nodes..



# /3

## Related Work

### 3.1 Routing Protocols in WSNs

Wireless sensor networks main task is to periodically collect information of the interested area and broadcast the information to a Base Station (BS). An easy approach to achieve this task is to make each sensor node transmit their data directly to the BS. But the problem is that the BS can be far away from the sensor node and the sensor node will die due to energy consumption. LEACH, PEGASIS, TEEN and APTEEN are different hierarchical protocols that has been proposed as solutions to this problem [3][4].

LEACH [1] introduce a hierarchical clustering algorithm for sensor networks. It is self-organized and use randomization to distribute the energy load evenly among the sensors in the network. The sensor nodes organize themselves into local clusters where one node is the local BS or Cluster Head (CH). The CH are not fixed to avoid nodes to drain their battery and to spread the energy usage over multiple nodes. The nodes self-elect a new CH depending on the amount of energy left at the nodes at different time-intervals. LEACH is divided into different rounds where each round include a setup phase and a steady-state phase [4]. In the setup phase will each node decide whether to become a CH or not. When a CH is chosen, each node will select its own CH based on the distance between the node and the CH and join the cluster. In the steady-state phase will the CH fuse the received data from the node members in the cluster and send it to BS.

PEGASIS is a chain-based protocol with the idea to form a chain among the sensor nodes so each node will receive from and transmit to a close neighbor. The sensor nodes will also take turns on being the leader for transmitting data to the BS and therefore distribute the energy load evenly among the sensor nodes. The chain can be organized by the nodes themselves using a greedy algorithm starting from some node or the BS can compute the chain and broadcast it to all the nodes in the network [6].

Fuzzy logic is also a suitable problem-solving control system methodology [8].

CH were elected by the BS in each round by calculating the change each node has to become the CH using three fuzzy descriptors [9].

## 3.2 Data Collection/Aggregation in WSNs

# / 4

## Architecture

This chapter describes the architecture of the system.

The main functionality can be divided into X sub-sections: x,x,x,x.. The architecture of the system is presented in Figure X..

### 4.1 Discovery Of Other Nodes

Each node can only discover nodes within a possible range. Figure 5.1 shows how a possible range of a node may be discovered. When a new node in the network has been discovered will meta-data about the node such as address be stored on locally on the device in the cluster.

#### 4.1.1 Node Lookup Service

The lookup service is responsible for storing a list of all previous discovered nodes and their address.

## **4.2 Incoming Network Requests**

## **4.3 Data Transmission**

### **4.3.1 Connect To Neighbours**

### **4.3.2 Cluster-Head Election Request**

### **4.3.3 Data Collection**

## **4.4 Base Station Access**

CH should access BS..?

# / 5

## Design

In this chapter we will look at the design of the system and present the design of each component of the architecture. Figure XX shows how the cluster network may appear (in the system). Nodes are connected to other nearby nodes represented by arrows and together they form a cluster network.

### 5.1 Broadcasting

Nodes discover other nodes in the network, initiate a broadcast.. Broadcast is limited due to a radio range limitations where only nodes that are within this range will receive the broadcast, shown in Figure 5.1.

### 5.2 Cluster-Head Election

### 5.3 Accumulate Data/Forwarding

A node may at times forward data to another node in the cluster.

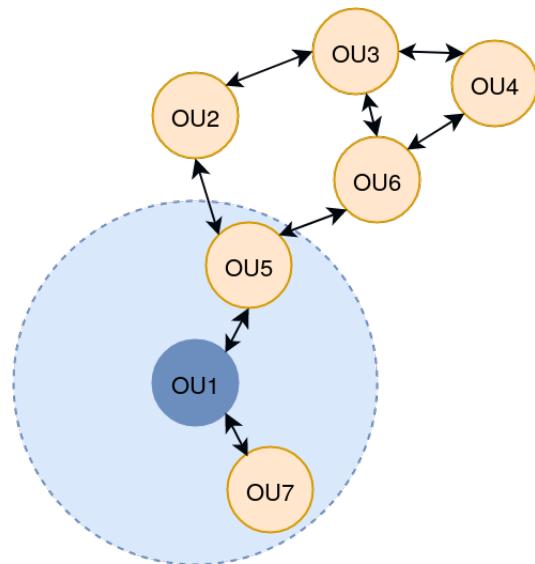


Figure 5.1: Figure show broadcast range of a OU.

Parameter	Value
No. of nodes	100
Network size	500 x 500
Node broadcast width	100

Table 5.1: My caption

## 5.4 Base Station Access?

# / 6

## Implementation

This chapter will elaborate on how we implemented the system, general implementation requirements, issues and choices.

The system is implemented in the open source programming language GO 1.9.3<sup>1</sup>.

### 6.1 Distance To Other Nodes In The Network

The formula 6.1 is used to calculate the range between two points in a two-dimensional coordinate map and is used to see if a node is within a range or not.

$$d = \sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2} \quad (6.1)$$

Figure 6.1 shows ...

<sup>1</sup>. <https://golang.org/>

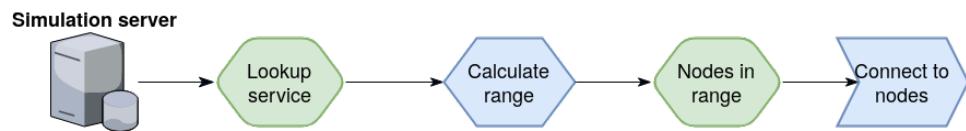


Figure 6.1: Broadcast simulation

## 6.2 Data Transmission

### 6.2.1 Cluster-Head Election

## 6.3 Data Accumulation

The collected data is stored in a map and maps in Go are not safe for concurrent use. If a map is read from and wrote to from concurrent goroutines, the access must be compromised by a synchronization mechanism. One of the most common ways to protect maps is by using mutexes.

**Listing 6.1:** Small Go program showing how mutexes are used when updating a map

```

/*DBStation is data stored at leader*/
var DBStation struct {
    sync.Mutex
    BSdatamap map[uint32][]byte
}

func sendDataToLeaderHandler() {
    DBStation.Lock()
    defer DataBaseStation.Unlock()

    DBStation.BSdatamap[sData.FP] = receivedData
}
  
```



# 7

# Evaluation

This chapter describes the experimental setup and metrics used to evaluate the implemented system.

## 7.1 Experimental Setup

All experiments were done on a Lenovo ThinkCenter with the following specifications:

- Intel® Core™ i5-6400T CPU @ 2.20GHz × 4
- Intel® HD Graphics 530 (Skylake GT2)
- 15,6 GiB memory and 503 GB disk
- Ubuntu 17.04 64-bit with gcc V6.3.0 compiler and GO 1.9.3

## 7.2 Experimental Design

### 7.2.1 CPU Measurements

### 7.2.2 Memory Measurements

### 7.2.3 Network (Socket) Usage

### 7.2.4 Network Lifetime?

## 7.3 Results

### 7.3.1 CPU Usage

### 7.3.2 Memory Usage

### 7.3.3 Network Usage

### 7.3.4 Network Lifetime?

# / 8

## **Discussion**

This chapter discusses our approach, experience, how we solved the problem and why we chose the solution we ended up with..

### **8.1 Availability of nodes in the system?**

### **8.2 Cluster-head Election?**

### **8.3 Data Transmission?**





# 9

## Conclusion

In this thesis, we have implemented a system/prototype...

Our experiments showed that the system ...





**10**

## **Future Work**





# 11

## Appendix



# Bibliography

- [1] W. R. Heinzelman and A. Chandrakasan and H. Balakrishnan, *Energy-efficient communication protocol for wireless microsensor networks*, 2000, in *Proceedings of the 33rd Annual Hawaii International Conference on System Sciences*, 10 pp. vol.2-.
- [2] K. Latif and M. Jaffar and N. Javaid and M. N. Saqib and U. Qasim and Z. A. Khan, *Performance Analysis of Hierarchical Routing Protocols in Wireless Sensor Networks*, 2012, in *2012 Seventh International Conference on Broadband, Wireless Computing, Communication and Applications*, pp. 620-625.
- [3] K. Gotefode and K. Kolhe, *Energy efficiency in wireless sensor network using Fuzzy rule and tree based routing protocol*, 2015, in *2015 International Conference on Energy Systems and Applications*, pp. 712-717.
- [4] Z. Han and J. Wu and J. Zhang and L. Liu and K. Tian, *A General Self-Organized Tree-Based Energy-Balance Routing Protocol for Wireless Sensor Network*, 2014, in *IEEE Transactions on Nuclear Science Vol.61, Nr.2*, pp. 732-740.
- [5] J. N. Al-Karaki and A. E. Kamal, *Routing techniques in wireless sensor networks: a survey*, 2004, in *IEEE Wireless Communications Vol.11, Nr.6*, pp. 6-28.
- [6] S. Lindsey and C. S. Raghavendra, *PEGASIS: Power-efficient gathering in sensor information systems*, 2002, in *Proceedings, IEEE Aerospace Conference Vol.3*, pp. 3-1125-3-1130.
- [7] X. Liu, *Atypical Hierarchical Routing Protocols for Wireless Sensor Networks: A Review*, 2015, in *IEEE Sensors Journal Vol.15, Nr.10*, pp. 5372-5383.
- [8] A. K. Mishra and R. Kumar and J. Singh, *A review on fuzzy logic based clustering algorithms for wireless sensor networks*, 2015, in *2015 International Conference on Futuristic Trends on Computational Analysis and Knowledge*

*Management (ABLAZE), pp. 489-494.*

- [9] Indranil Gupta and D. Riordan and Srinivas Sampalli, *Cluster-head election using fuzzy logic for wireless sensor networks*, 2005, in *3rd Annual Communication Networks and Services Research Conference (CNSR'05)*, pp. 255-260.
- [10] Maryam Sabet and Hamid Reza Naji, *A decentralized energy efficient hierarchical cluster-based routing algorithm for wireless sensor networks*, 2015, in *AEU - International Journal of Electronics and Communications Vol.69, Nr.5*, pp. 790 - 799.
- [11] Shio Kumar Singh, M P Singh and D K Singh, *Routing Protocols in Wireless Sensor Networks – A Survey* , 2010, in *International Journal of Computer Science & Engineering Survey (IJCSES) Vol. 1, No.2, November 2010*, pp. 63-83.
- [12] W. B. Heinzelman and A. P. Chandrakasan and H. Balakrishnan, *An application-specific protocol architecture for wireless microsensor networks*, in *IEEE Transactions on Wireless Communications Vol.1, No.4, October 2002*, pp. 660-670.
- [13] Demers, Alan and Greene, Dan and Hauser, Carl and Irish, Wes and Larson, John and Shenker, Scott and Sturgis, Howard and Swinehart, Dan and Terry, Doug, *Epidemic algorithms for replicated database maintenance*, in *ACM: Proceedings of the Sixth Annual ACM Symposium on Principles of Distributed Computing, 1987*, pp. 1-12.