Thesis Title

Bachelor Thesis

Natural Science Faculty of the University of Basel
Department of Mathematics and Computer Science
Computer Networks Group
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Abstract

In a wireless sensor network with intermittent connectivity, continuous operation requires unsupervised resource management. This project builds a demonstrator for sampling-rate adaption and data thinning that is dependend on memory availability and data drainage progress. The distributed system will consist of constrained devices running on solar power.

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1 Introduction

A network built of small, solar powered devices can be used for a wide variety of different applications. Some possible use-cases could be monitoring agricultural sites, recording weather data for scientific purposes or serve as an independent network for communication. For those devices (network nodes) to be autonomous, it is essential to reduce their energy consumption as much as possible. To transmit data between network nodes, we therefore need wireless technology that has a low power consumption. In this project we use LORA (Long Range) wireless technology which fulfils this requirement. Additionally to having a very small energy consumption, it is also capable of transmitting signals over distances greater than 15 kilometres under optimal conditions. [1] The tradeoff is a smaller data transmission rate.

To manage and propagate data through the network, we use a protocol called 'TinySSB'. It is heavily influenced by the Secure Scuttlebutt Protocol which is an 'event-sharing protocol and architecture for social apps.' [3] TinySSB is optimised for small microcontroller devices by omitting data that is not essential while still guaranteeing authenticity [Later More]. Both protocols use so-called 'append-only-logs' or 'feeds' to append new packets to. Once a network node trusts the head packet of a feed, it can autonomously verify if a new incoming packet is the correct continuation of the last received packet. With this practical feature it is even possible to receive packets that have been propagated via a number of different nodes and still guarantee that no middle man could have altered the data. However the drawback of this method is limited flexibility in changing or deleting old data. Since the devices that are used for this project have only limited storage capability we need to find a way to be able to remove old data while still keeping the secure properties of the append-only-logs.

In this thesis we will have a look at two different approaches of achieving this goal for two different use-cases. We will explore how we can use multiple different feeds and combine them to bigger constructs (feed-trees) using packets that serve as pointers to other feeds. These pointers help us to create a link between different feeds that can be differently interpreted depending on the type of the feed-tree. Those feed constructs use simple feeds and pointers as building blocks but can get quite complex when interacting with each other. We want to hide this complexity from the user and present him with only an abstraction of the feed-tree that can be used like a normal feed with additional functionality.

Furthermore we want to have a look at how we can improve resource management in general. This includes sorting incoming and outgoing packets according to priorities to reduce the number of sent packets. Some feeds have to be given more computing time than others depending on how critical they are for either a specific feed construct or for the system as a whole.
While the focus of this project is not the real-life implementation of the device with solar cells, it should be as well prepared as possible for this scenario. Therefore the system needs to be able to withstand unexpected shutdowns due to power outages and recover later once enough power is available again.

2
Background

2.1 Long Range (LoRa) Wireless Technology

In recent years the number of devices connected to the Internet of Things (IoT) has been increasing rapidly. Since a lot of those devices do not need to transfer high amounts of data and rather focus on using as little energy as possible, LoRa and similar technologies have been developed to serve those use-cases. In this section we will give a short overview of how LoRa works and how we can adjust its parameters.

LoRa promises long battery life, far-reaching communication distances (10 to 15 kilometres if devices are in line-of-sight) and high node density (nodes in close proximity can operate at the same time if configured correctly). The downside of having all those practical features is a lower data rate. To achieve this, it uses chirp spread spectrum modulation. Data that has to be sent is converted into *upchirps* and *downchirps*. Chirping up or down refers to a signal that is sent with constantly increasing or decreasing frequency. To adjust the transmission settings optimally to specific environments, different parameters that alter the chirps can be configured individually. One of those parameter is the **bandwidth**. The bandwidth is the difference in frequency of the start and end of one chirp and is typically set to 125, 250 or 500kHz. A higher bandwidth increases the acceptable transmission distance. Another parameter is the **spreading factor**. It determines the angle of one chirp. The higher the spreading factor, the longer it takes to complete one chirp. This can increase the transmission distance but reduces the data rate. Additionally to the physical settings we can set different **coding rates** which determine the forward error correction. A higher coding rate leads to a more reliable reception of packets and a lower data rate. For our project we use a spreading factor of 7, bandwidth of 250kHz and a coding rate of 4/7. These settings have worked well to test the software but need to be reconsidered once the devices get deployed depending on the surrounding conditions.

In Fig. 2.1 we can see ten upchirps (preamble) and two downchirps (start frame delimiter) followed by modulated chirps that contain the actual data.

(Sources for Section 2.1 are [1] and [2])

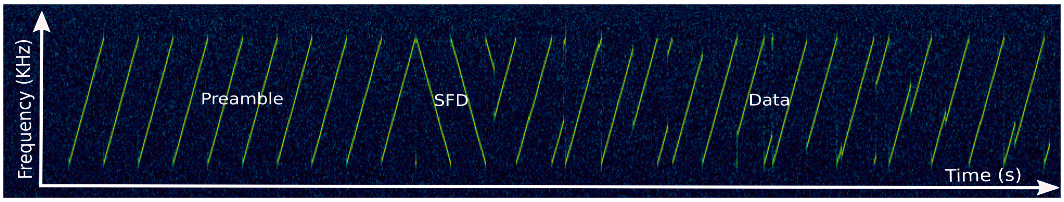

Figure 2.1: A visualized lora packet transmission. Source: [2]

2.2 Comparing SSB and TinySSB

2.2.1 SSB

2.2.2 TinySSB

2.3 Pycom 4

2.4 Packages

These packages might be helpful for writing your thesis:

`caption` to adjust the look of your captions

`glossaries` for creating glossaries (also list of symbols)

`makeidx` for indexes and the back of your document

`algorithm`, `algorithmicx`, `algpseudocode` for adding algorithms to your document

3 Conclusion

This is a short conclusion on the thesis template documentation. If you have any comments or suggestions for improving the template, if you find any bugs or problems, please contact me.

Good luck with your thesis!

Bibliography

[1] Anders Carlsson, Ievgeniia Kuzminykh, Robin Franksson, and Alexander Liljegren. Measuring a lora network: Performance, possibilities and limitations. In Olga Galinina, Sergey Andreev, Sergey Balandin, and Yevgeni Koucheryavy, editors, *Internet of Things, Smart Spaces, and Next Generation Networks and Systems*, pages 116–128, Cham, 2018. Springer International Publishing. ISBN 978-3-030-01168-0.

[2] Jansen C. Liando, Amalinda Gamage, Agustinus W. Tengourtius, and Mo Li. Known and unknown facts of lora: Experiences from a large-scale measurement study. *ACM Trans. Sen. Netw.*, 15(2), feb 2019. ISSN 1550-4859. doi: 10.1145/3293534. URL https://doi.org/10.1145/3293534.

[3] Dominic Tarr, Erick Lavoie, Aljoscha Meyer, and Christian Tschudin. Secure scuttlebutt: An identity-centric protocol for subjective and decentralized applications. In *Proceedings of the 6th ACM Conference on Information-Centric Networking*, ICN '19, page 1–11, New York, NY, USA, 2019. Association for Computing Machinery. ISBN 9781450369701. doi: 10.1145/3357150.3357396. URL https://doi.org/10.1145/3357150.3357396.

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Appendix

University of Basel

Faculty of Science

Declaration on Scientific Integrity
(including a Declaration on Plagiarism and Fraud)
Translation from German original

Title of Thesis:

Name Assesor: ____________________

Name Student: ____________________

Matriculation No.: ____________________

With my signature I declare that this submission is my own work and that I have fully acknowledged the assistance received in completing this work and that it contains no material that has not been formally acknowledged. I have mentioned all source materials used and have cited these in accordance with recognised scientific rules.

Place, Date: ____________________ Student: ____________________

Will this work be published?

☐ No

☐ Yes. With my signature I confirm that I agree to a publication of the work (print/digital) in the library, on the research database of the University of Basel and/or on the document server of the department. Likewise, I agree to the bibliographic reference in the catalog SLSP (Swiss Library Service Platform). (cross out as applicable)

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Please enclose a completed and signed copy of this declaration in your Bachelor's or Master's thesis .