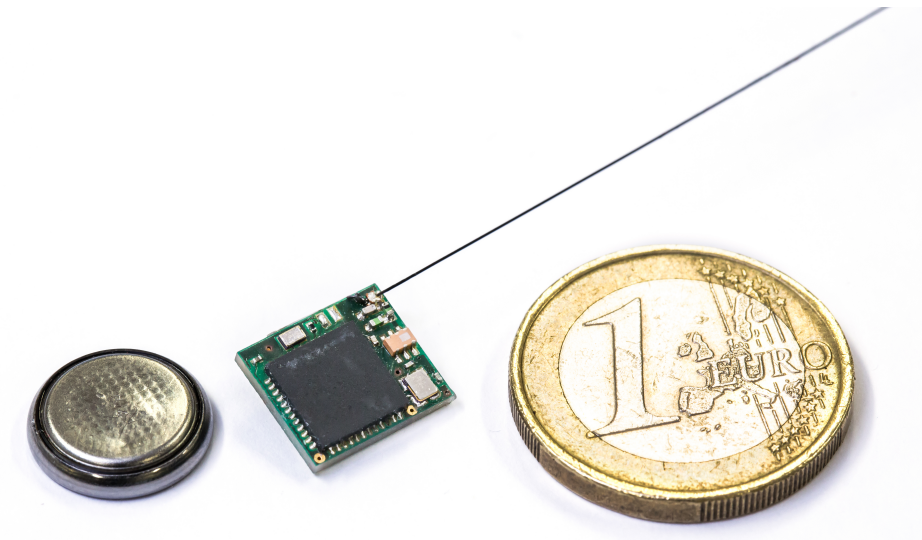


# DFG FOR BATS - a Broadly Applicable Tracking System

## TP4: Energy Efficient Management and Operation

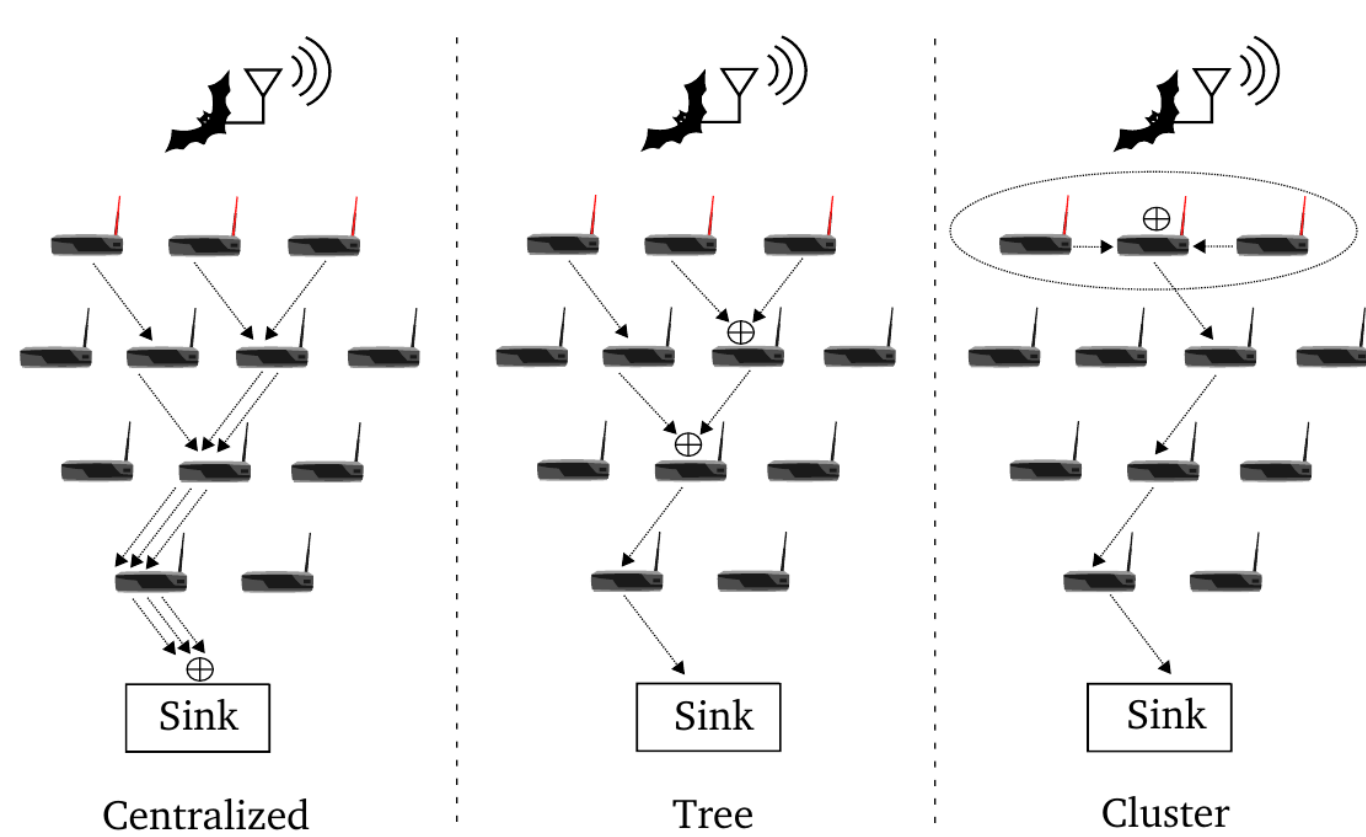
### Abstract

The overall objective of the project is to research wireless communication protocol options between the mobile nodes and to improve the reliability of the entire communication system while maintaining the already tight energy budget. Given the small dimension of the mobile bat nodes, new communication techniques are needed for connecting the mobile nodes to the stationary ground network. First, the communication among the mobile nodes needs to be designed keeping the energy budget and the hardware constraints into account. It is planned to develop a novel wake-up system in order to exchange node IDs as well as complete bat encounter information. In the best way, the node ID can already be encoded in the wake-up signal. Secondly, the robustness and reliability of the entire communication system needs to be improved without increasing the energy consumption. One approach is to exploit the spatial diversity of the radio signals from the mobile nodes that are received by multiple ground stations simultaneously. The aim is to use the ground network as a distributed and dynamic multi-antenna system that needs to be configured and maintained in a self-organizing manner.



### Diversity Combining

- Multiple base stations receive a copy of the signal
- Combination of signals to increase packet reception rate
- Different combination strategies and levels of detail
- Real World experiments and simulation studies



Forwarding Data as	Single Node (Mbit/s)	64 Nodes (Mbit/s)	Diversity Gain
Complete signal	64	4096	Highest
Signal samples	3.07	196.6	High
Soft-Bits	0.31	19.66	Medium
Hard-Bits	0.01	0.61	Very low

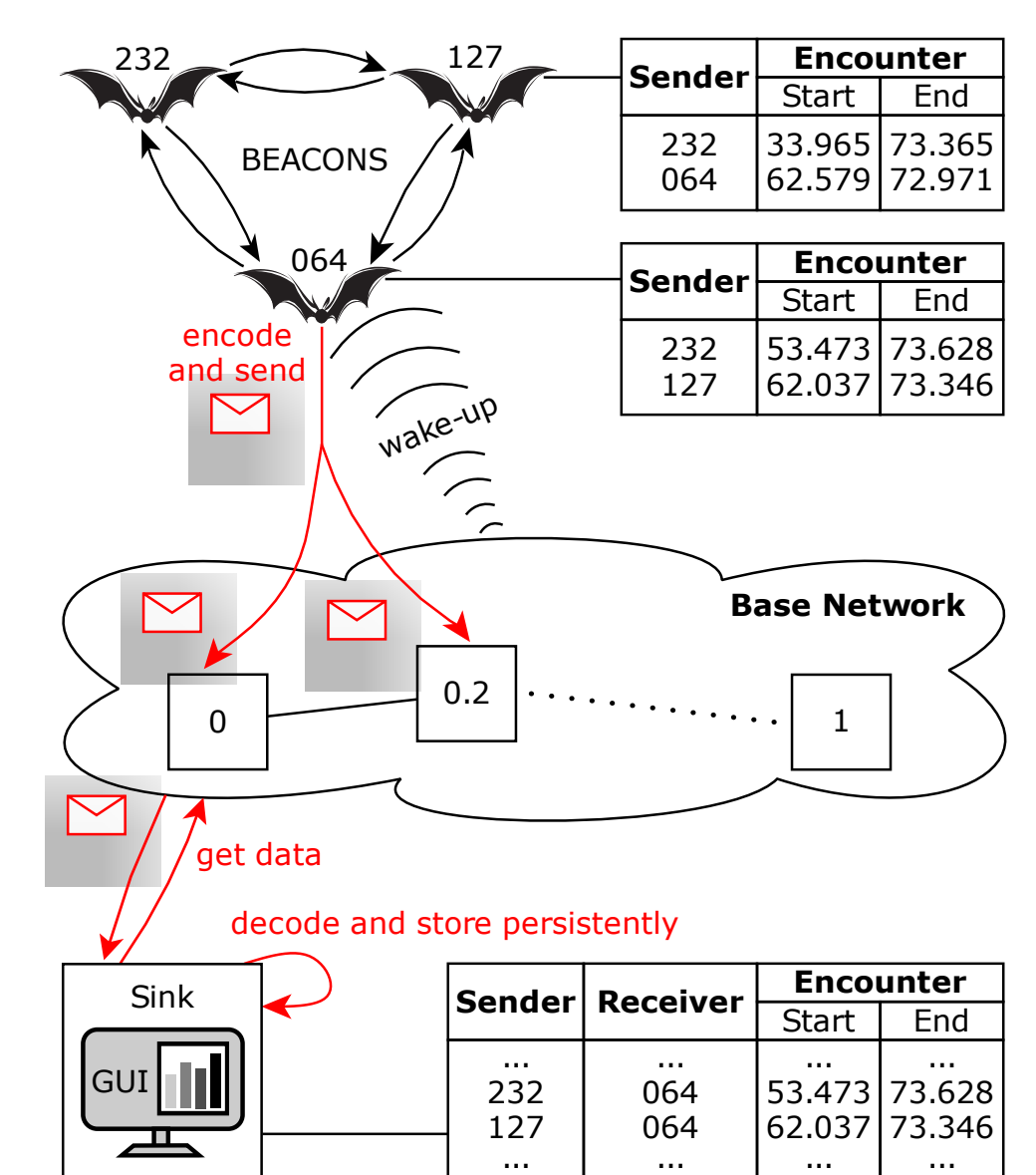
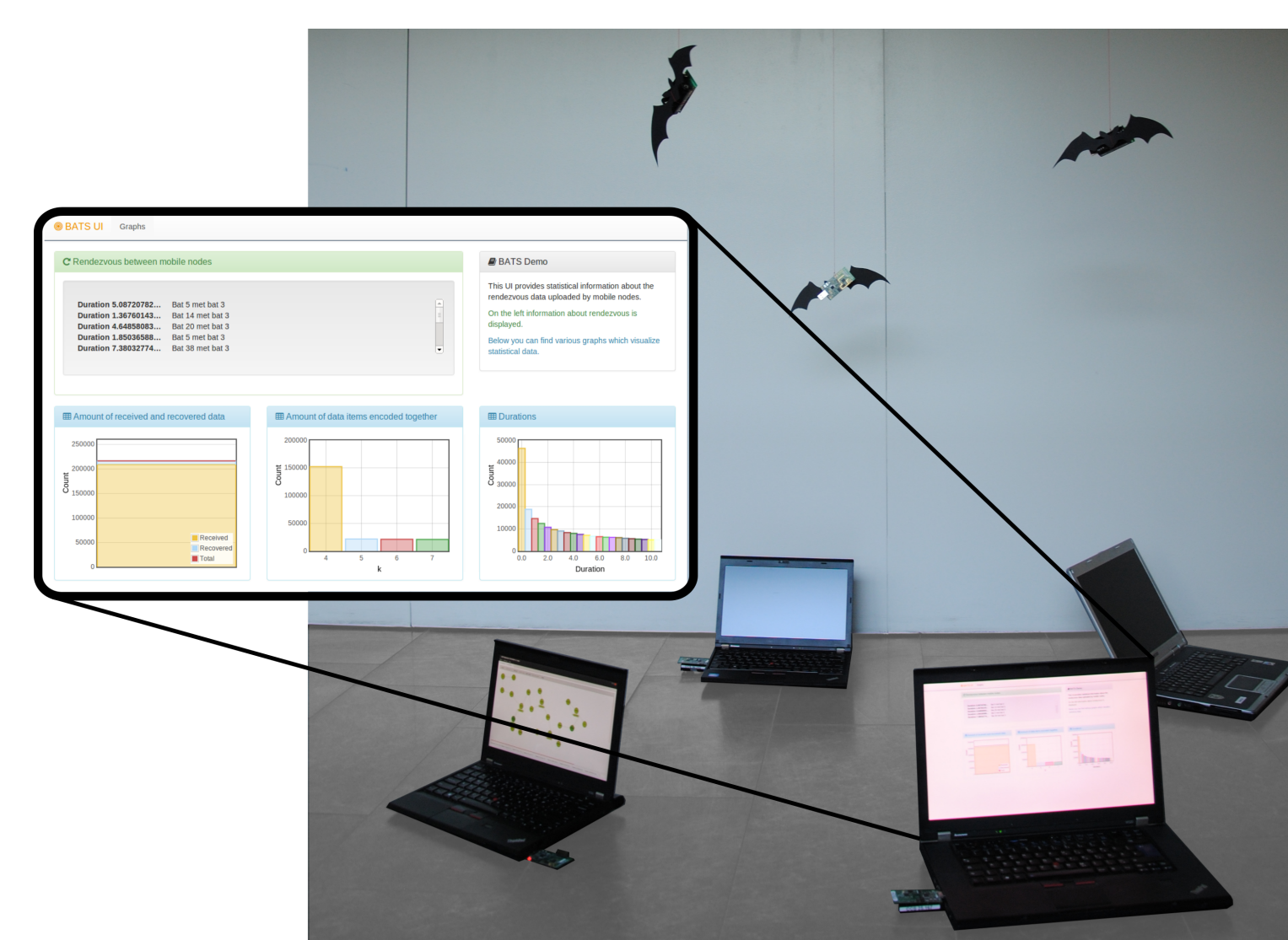
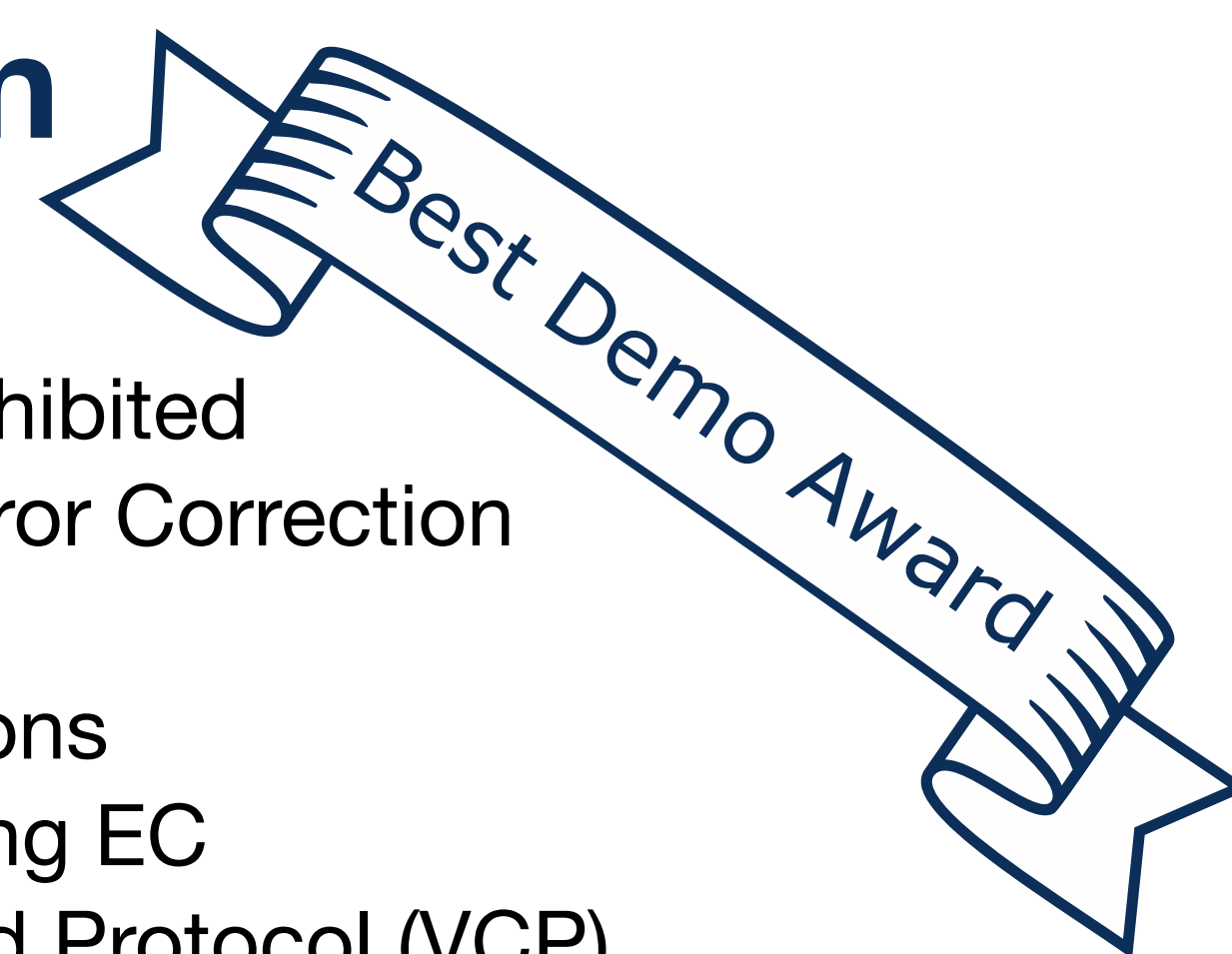
### Reliable Communication

#### Erasure Codes (EC)

- Communication using retransmissions prohibited
- Reliable Communication using Forward Error Correction

#### Demo

- 3 mobile nodes (TelosB) exchanging beacons
- Transmission of neighbour information using EC
- Distributed Data Storage using Virtual Cord Protocol (VCP)



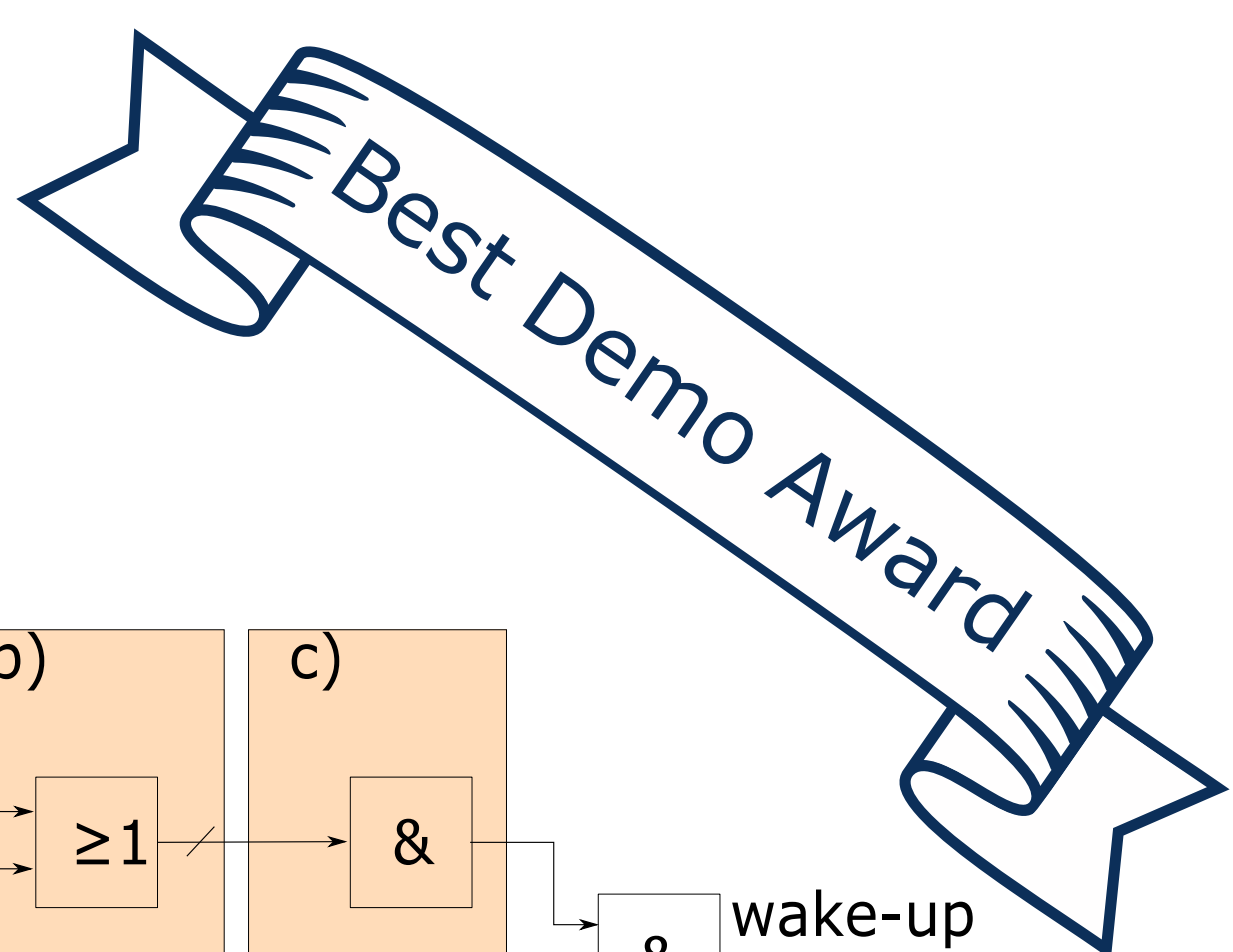
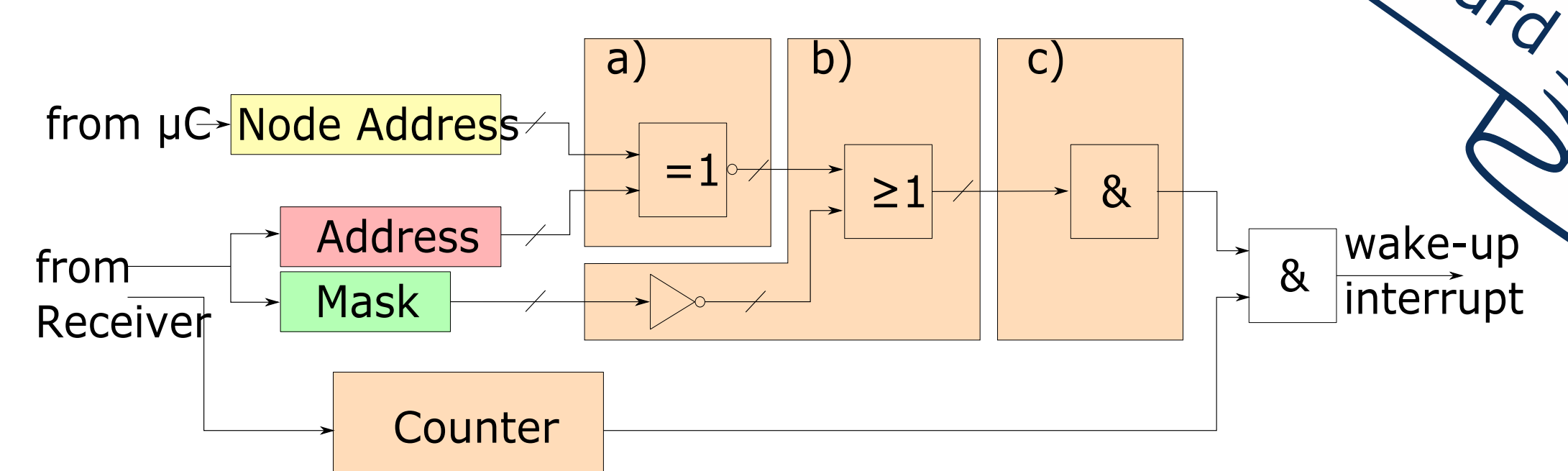
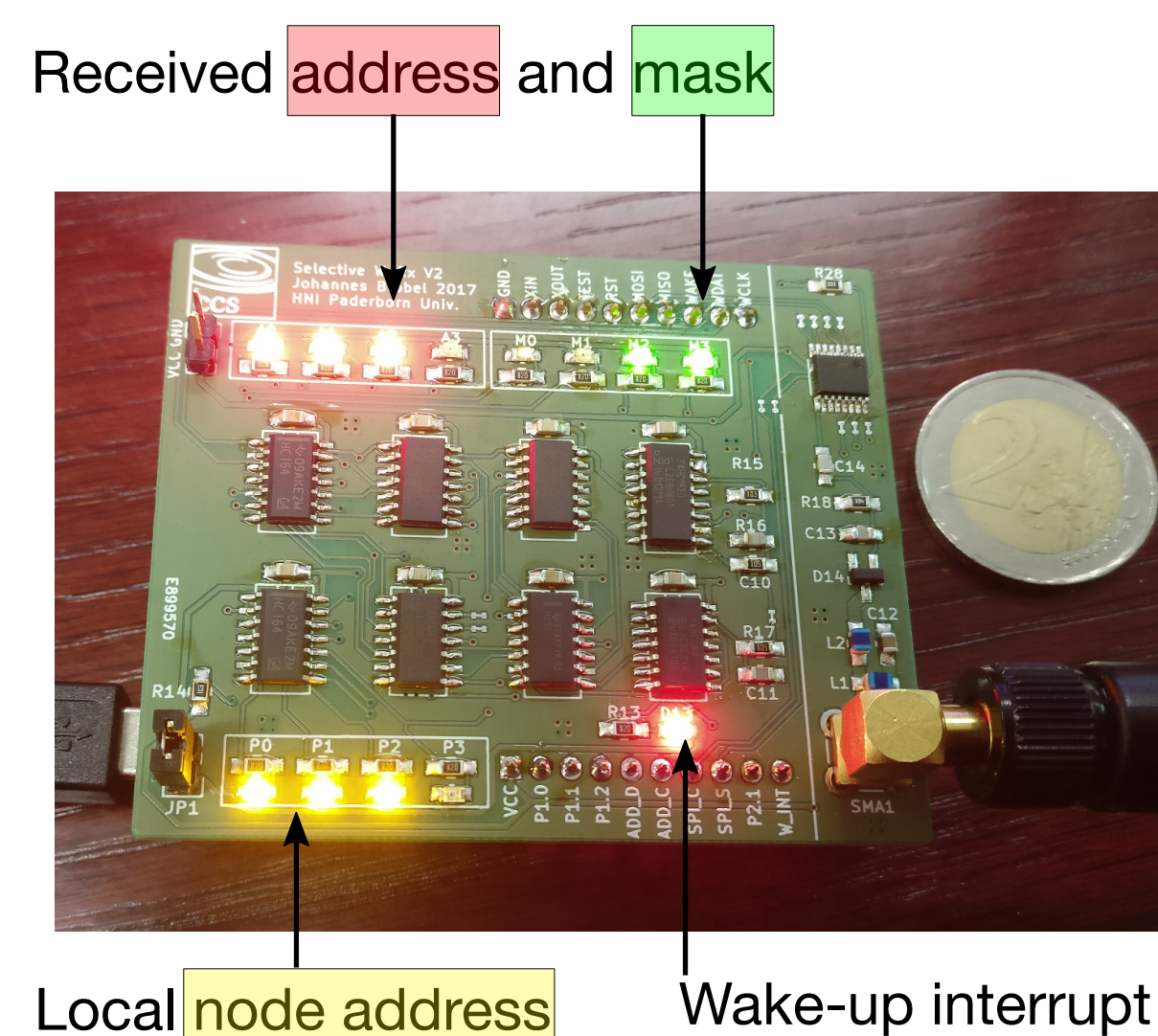
### Wake-Up Receiver

#### Energy Efficient Communication

- Asynchronous low-power communication
- Applications in WSNs and IoT devices
- New matching circuit for dynamic addressing schemes
- Hardware prototypes and simulation studies

#### Demo

- SDR based Sender with GUI to determine wake-up mode
- Broadcast, Multicast and Unicast wake-ups
- Wake-up receiver prototypes indicating status via LEDs



### Selected Publications

◆ **IEEE** Margit Mutschlechner, Florian Klingler, Felix Erlacher, Florian Hagenauer, Marcel Kiessling and Falko Dressler, **"Reliable Communication using Erasure Codes for Monitoring Bats in the Wild,"** Proceedings of 33rd IEEE Conference on Computer Communications (INFOCOM 2014), Student Activities, Toronto, Canada, April 2014, pp. 189–190. **(Best Student Poster)**

◆ **IEEE** Falko Dressler, Simon Ripperger, Martin Hierold, Thorsten Nowak, Christopher Eibel, Björn Cassens, Frieder Mayer, Klaus Meyer-Wegener and Alexander Koelpin, **"From Radio Telemetry to Ultra-Low-Power Sensor Networks: Tracking Bats in the Wild,"** *IEEE Communications Magazine*, vol. 54 (1), pp. 129–135, January 2016.

◆ Falko Dressler, Margit Mutschlechner, Bijun Li, Rüdiger Kapitza, Simon Ripperger, Christopher Eibel, Benedict Herzog, Timo Hönig and Wolfgang Schröder-Preikschat, **"Monitoring Bats in the Wild: On Using Erasure Codes for Energy-Efficient Wireless Sensor Networks,"** *ACM Transactions on Sensor Networks*, vol. 12 (1), February 2016.

◆ **IEEE** Muhammad Nabeel, Bastian Bloessl and Falko Dressler, **"Efficient Receive Diversity in Distributed Sensor Networks using Selective Sample Forwarding,"** *IEEE Transactions on Green Communications and Networking*, vol. 2 (2), pp. 336–345, June 2018.

◆ **IEEE** Bastian Bloessl and Falko Dressler, **"mSync: Physical Layer Frame Synchronization Without Preamble Symbols,"** *IEEE Transactions on Mobile Computing*, vol. 17 (10), pp. 2321–2333, October 2018.

◆ **IEEE** Muhammad Nabeel and Falko Dressler, **"Turning Sensor Networks into Distributed Antenna Arrays for Improved Communication Performance,"** *IEEE Communications Magazine*, vol. 57 (9), pp. 100–105, September 2019.

◆ **IEEE** Johannes Blobel and Falko Dressler, **"Sender-Triggered Selective Wake-Up Receiver for Low-Power Sensor Networks,"** Proceedings of 36th IEEE Conference on Computer Communications (INFOCOM 2017), Demo Session, Atlanta, GA, May 2017. **(Best Demo Award)**