

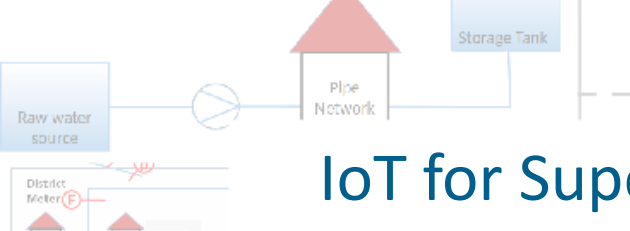
IoT.H2O

IoT for Supervision and Control of Water Systems



Influence on antenna design on range of LoraWAN devices – a practical test

Harald Roclawski, Thomas Krätzig, Laura Sterle , Martin Böhle



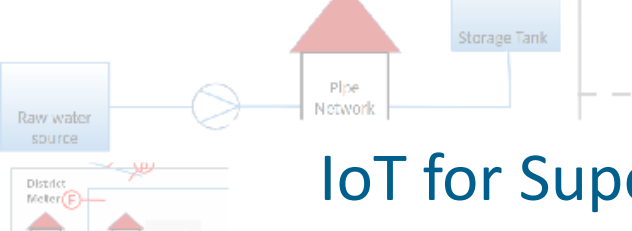
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Outline

- Objective of IoT.H2O
- IoT-concept
- IoT.H2O LoRaWAN technology
- LoRaWAN Antennas
- Setup of LoRaWAN range test
- Results



Introduction

- This work is part of the project: IoT.H2O - IoT for Supervision and Control of Water Systems funded by Water JPI
- Objective: Explore the potential of the Internet of Things (IoT) model for monitoring and operating small water utilities
- In this presentation our experience with LoRaWAN devices is presented
- Project consortium:
 - Technical University of Kaiserslautern (Germany),
Institute for Fluid Mechanics and Fluid Machinery (SAM)
 - Dr. Krätzig Ingenieurgesellschaft mbH (KI), Aachen, Germany
 - Federal University of Minas Gerais, Brazil (CPH), Centro de Pesquisas Hidráulicas e Recursos Hídricos
 - Liege University, Research group Hydraulics in Environmental and Civil Engineering (HECE), Belgium
 - Institut national des sciences appliquées de Rouen, LITIS LAB, MIND Group, France



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IoT.H2O - Concept Internet of Things (IoT)

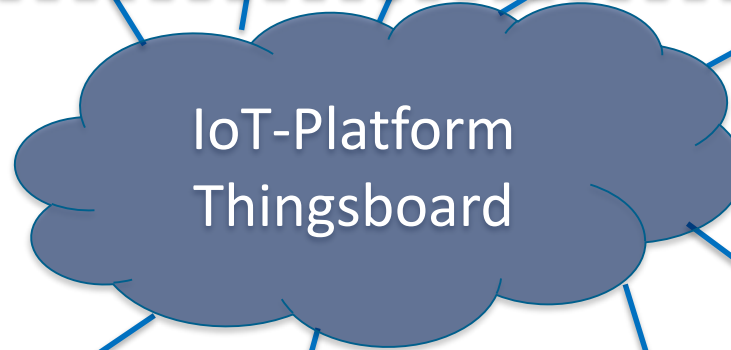
Application level:

User Interface,
Software, Digital Twin



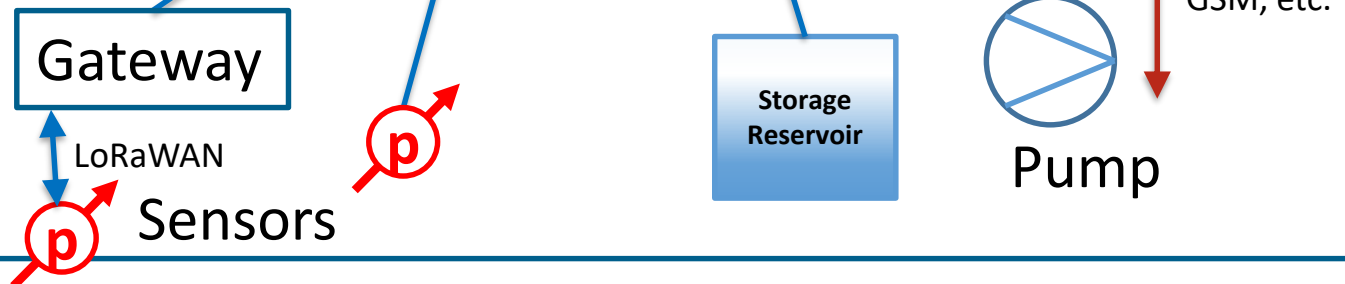
Transport level:

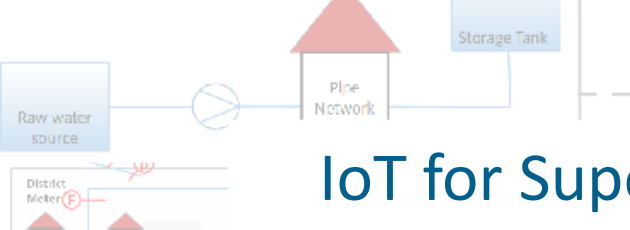
Cloud / Server



Field Level:

Smart Devices





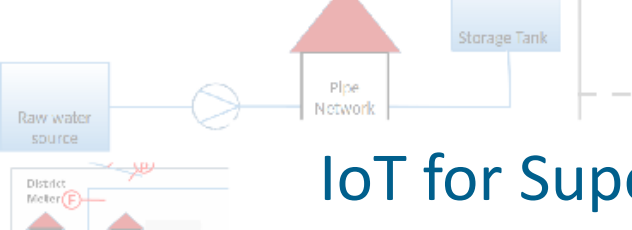
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IoT.H2O - Concept Internet of Things (IoT)

- For monitoring and control of devices, the open-source IoT-platform Thingsboard is used
- Devices are connected directly via WiFi or LAN network
- In case there is no internet available at the device location, the signals are transmitted via LoRaWAN to a gateway which is located in a place with internet connection
- IoT.H2O LoRaWAN technology is based on open-source software and a combination of commercially available and self-developed hardware



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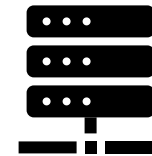
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IoT.H2O – LoRaWAN setup



LoRaWAN Server



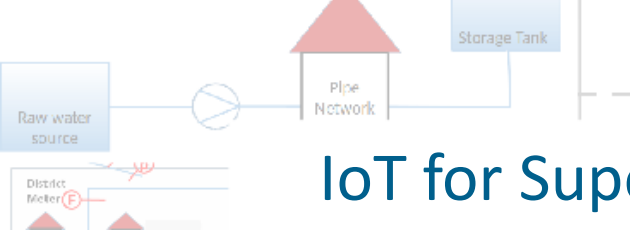
Field Unit for devices:

- Microcontroller Heltec ESP32 Wifi Lora(V2)
- Analogue digital converter (ADC)
- Designed for sensors with a voltage (0-5V) or current of (4-20 mA), e.g. pressure sensor, flow meter
- Communication: LoRaWAN, Wifi, Bluetooth

LoRaWAN Gateway:

- Raspberry Pi4
- iC880A-SPI LoRa® Concentrator

Open-Source Software:
The Things Stack



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IoT.H2O – Antennas under investigation

Antenna A1:

Specification unknown

Delivered with 2nd batch of Heltec ESP32 LoRaWiFi V2

Directly connected to antenna output of microcontroller

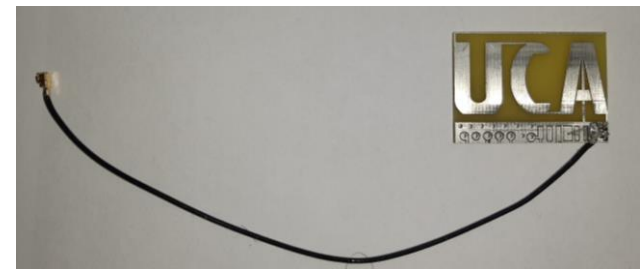


Antenna A2:

Printed on PCB based on design of Fabien Ferrero

Available at https://github.com/FabienFerrero/UCA_Board

Antenna part of PCB was cut and directly connected to antenna output of microcontroller



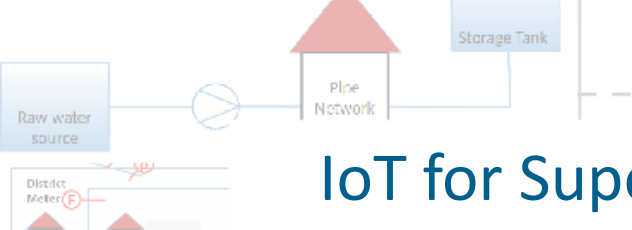
Antenna A3:

Printed on PCB based on design of Fabien Ferrero

Available at https://github.com/FabienFerrero/UCA_Board

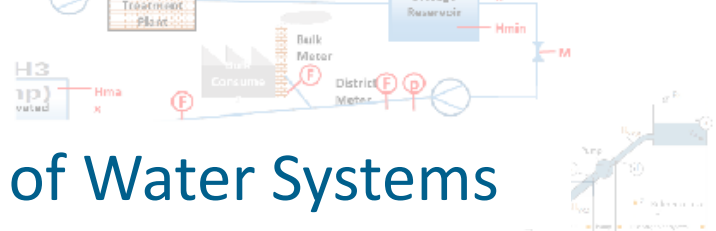
Antenna with complete PCB was directly connected to antenna output of microcontroller





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IoT.H2O – Antennas under investigation

Antenna A4:

MA Antenna for iC880A-SPI, WSA01-iM880B and Lite Gateway.

Frequency range: 824-896 MHz, Impedance: 50 Ω , Gain: 2 dBi, Polarization: linear, vertical, RF power handling: 50 W.

Antenna connected with pigtail to output of microcontroller



Antenna A5:

Wittenberg Antenna WB 16

Frequency range: 2G/3G/4G 698-960 / 1710-2700 Mhz

Gain:4dBi

Antenna connected with pigtail to output of microcontroller



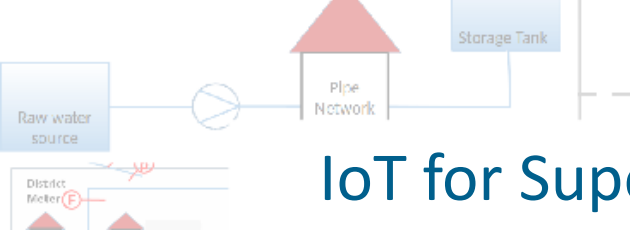
Antenna A6:

Aurel GP 868 Ground Plane Antenna

Frequency 868 MHz

Antenna connected with pigtail to output of microcontroller





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IoT.H2O – Antennas under investigation

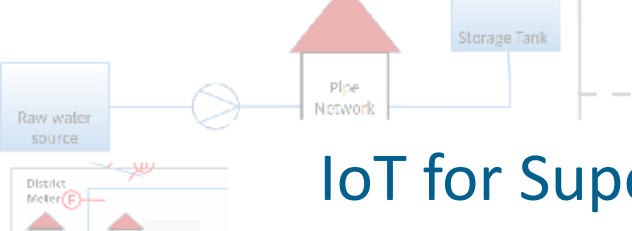
Gateway antenna:

MikroTik LoRa® Antennen Kit - TOF-0809-7V-S1

Frequency range 824-960 MHz, Gain: 6.5 dBi

Antenna connected with pigtail to iC880A-SPI concentrator board





LoRaWAN Range test setup

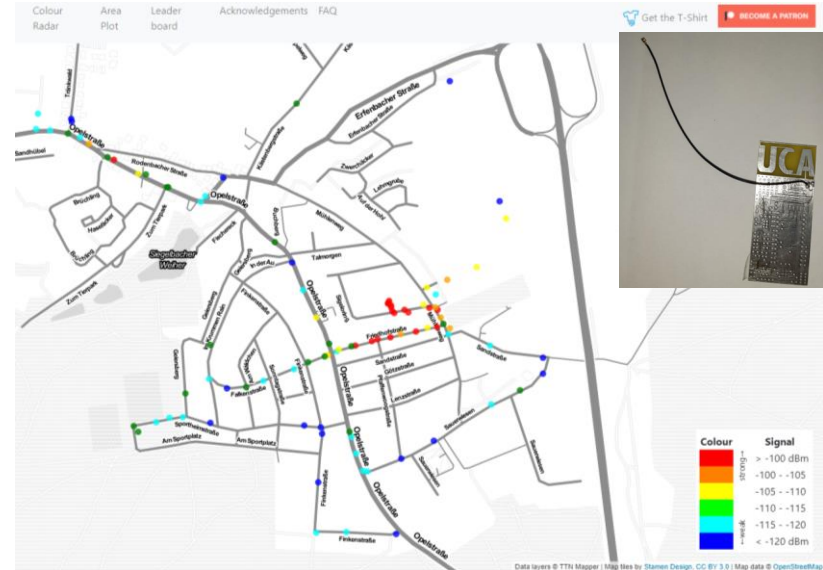
- Gateway antenna is mounted on roof top of a house in an elevated position
- LoRaWAN device is mounted on dashboard of car
- TTN Mapper app installed on smartphone:
 - LoRaWAN server and device is defined in app settings
 - App used GPS signal of smart phone for identifying the position of the device
 - all signals transmitted by the device which are received by the gateway are recorded by the map
 - Results can be downloaded on TTN Mapper website
<https://ttnmapper.org/>

Results test 1: A1



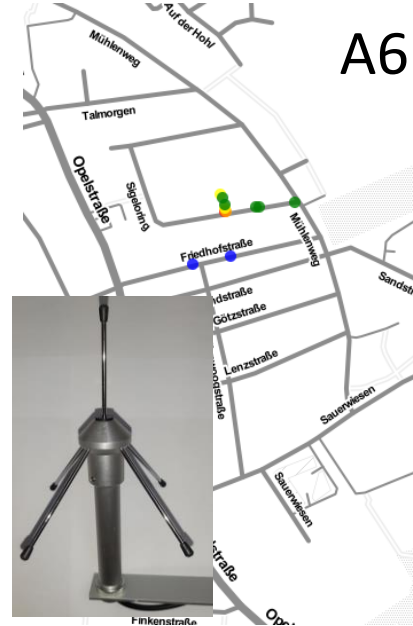
- A1 showed the best results
- Good coverage in a range of 1.4 km
- Signal passes through several buildings

Results test 1: A2 and A3



- PCB antennas A2 and A3 showed also good results
- A3 is slightly better than A2 -> influence of metall mass?
- Compared to A1 signal strength is decreased

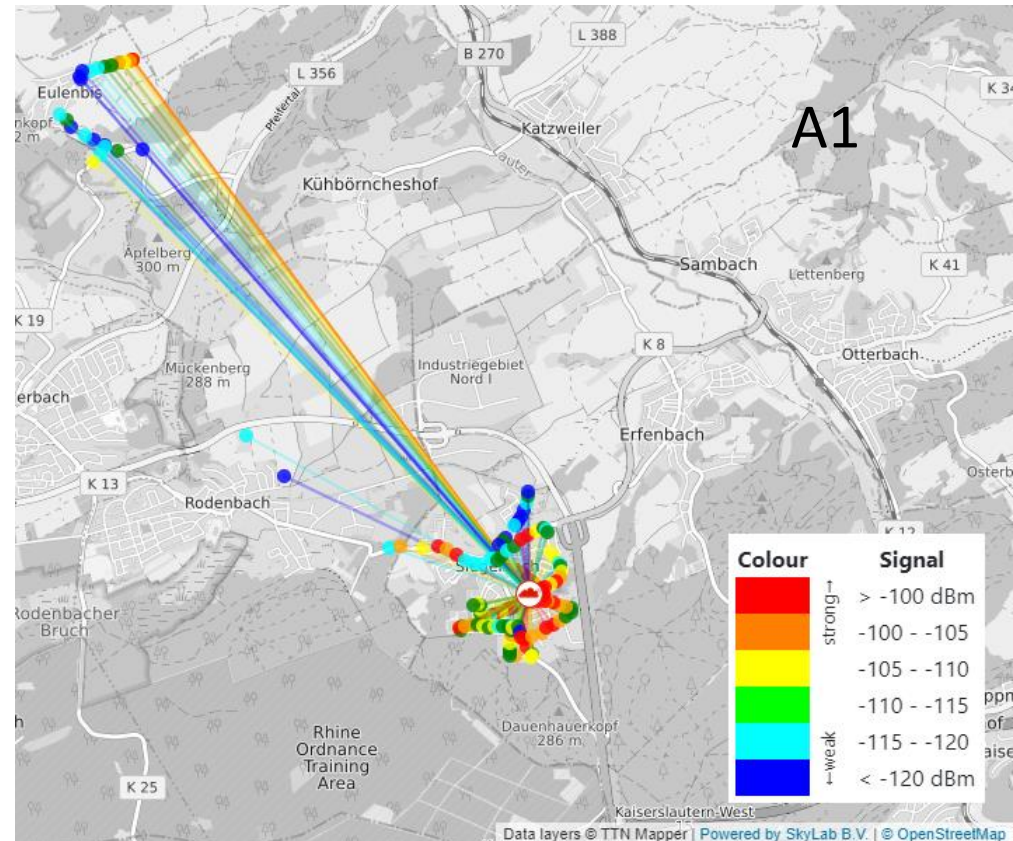
Results test 1: A4, A5 and A3

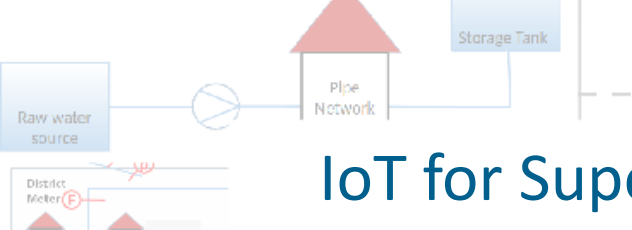


- Very poor performance of A4, A5 and A6
- Signaly can just be received in distance of ~120m from the gateway

Results Test 2: Long range, direct line of sight

- Although test 1 showed very different results in case of a direct line of sight all antennas were able to transmit signals over a distance of 6km
- Because of the hilly landscape signals were not received in valley
- A higher position for the gateway is necessary for better coverage in valleys





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Results Test 3: water utility installations

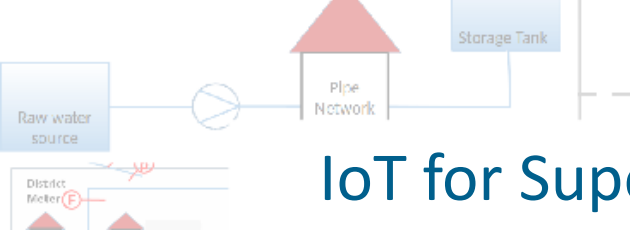
- Initially it was planned to also present tests of the coverage of all antennas in installations at the water utility Jockgrim, Germany -> not possible because of COVID19
- So far the following installations were possible with A4 as gateway antenna and A1 as antenna for the devices:
 - Well pump with plastic cover -> very good signal transmission
 - Distribution pump in basement of water utility -> good signal transmission
 - Well pump in steel container, no signal transmission -> mount antenna outside





Summary and future work

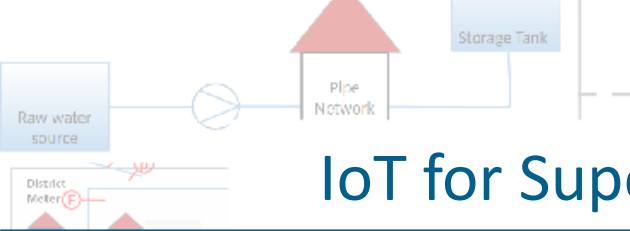
- The quality of the LoRaWAN signal transmission strongly depends on the antennas used, the topology of the landscape, the number and type of buildings between gateway and device and whether the antennas are installed outside or inside of buildings
- Although commercially available antennas are specified for LoRaWAN a good signal transmission was possible in a direct line of sight only
- PCB antennas provide good results and are a cheap solution, no additional holes have to be introduced into the device casing
- Next steps
 - Test all antennas in water utility installations
 - Check combinations of gateway and device antenna
 - Measure power spectrum of antennas to get a better understanding of the test results
 - Integrate PCB antenna design in PCB of IoT.H2O field device



Acknowledgement

We would like to thank the following funding organisations:

- Agence nationale de la recherche (ANR), France
 - Fundação de Amparo à Pesquisa do Estado de Minas Gerais – FAPEMIG, Brasil
 - Federal Ministry of Education and Research (BMBF), Germany
 - Fund for Scientific Research (F.R.S.–FNRS), Belgium
- and the Zweckverband Wasserversorgung Germersheimer Südgruppe, Germany for their support



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Thank you very much for your attention!
<https://www.mv.uni-kl.de/IoTDotH2O>