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für Wirtschaft
und Energie
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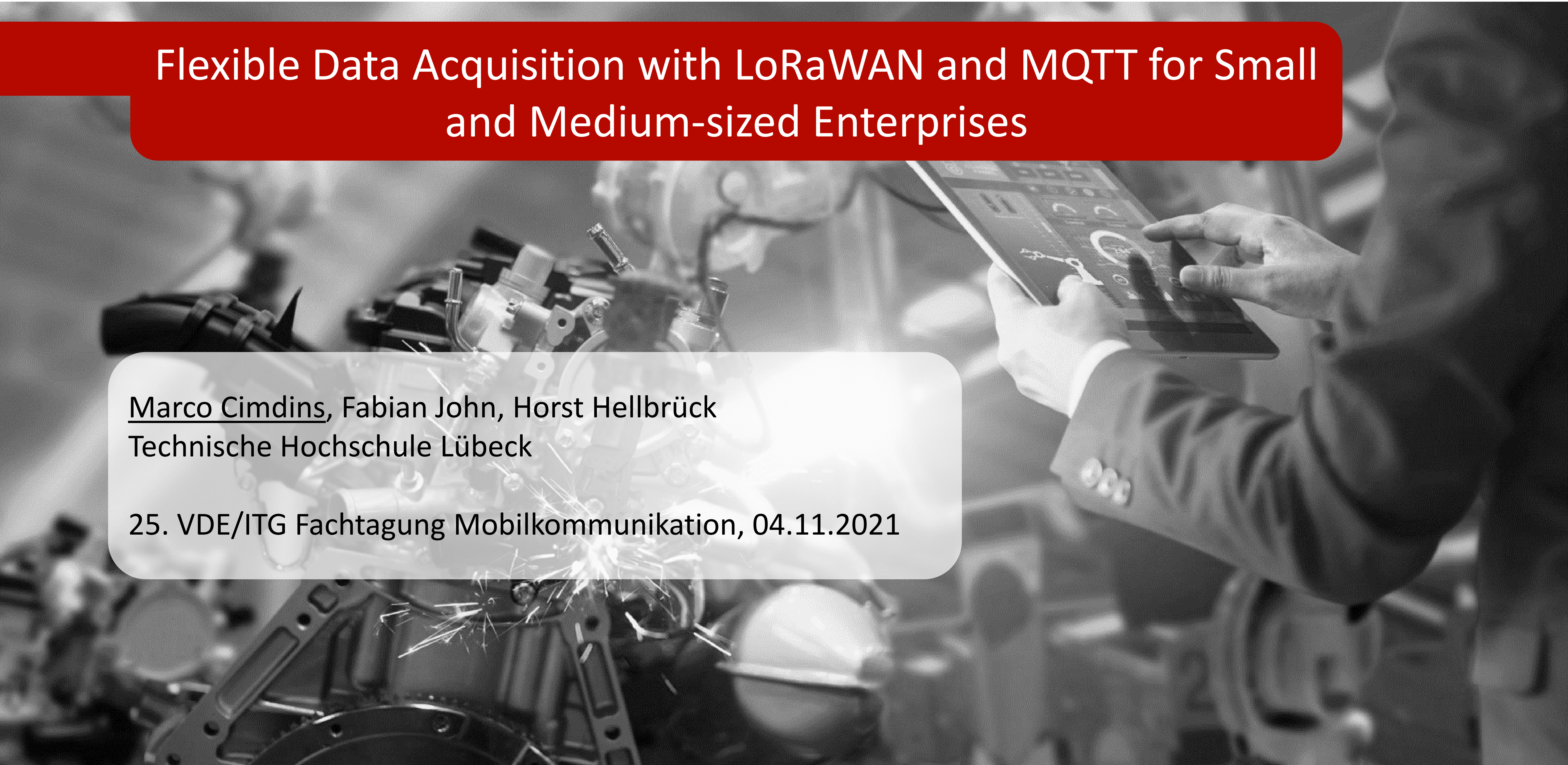
des Deutschen Bundestages

Flexible Data Acquisition with LoRaWAN and MQTT for Small and Medium-sized Enterprises



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25. VDE/ITG Fachtagung Mobilkommunikation, 04.11.2021

Introduction

- Data acquisition, aggregation, and visualization is the first step towards digital transformation.

- Small and medium-sized enterprises (SME) have to choose from a variety of technologies that promise to provide a solution for their respective problem.

- We explain the theoretical principles behind data acquisition and transfer and give practical examples and suitable technologies for applications

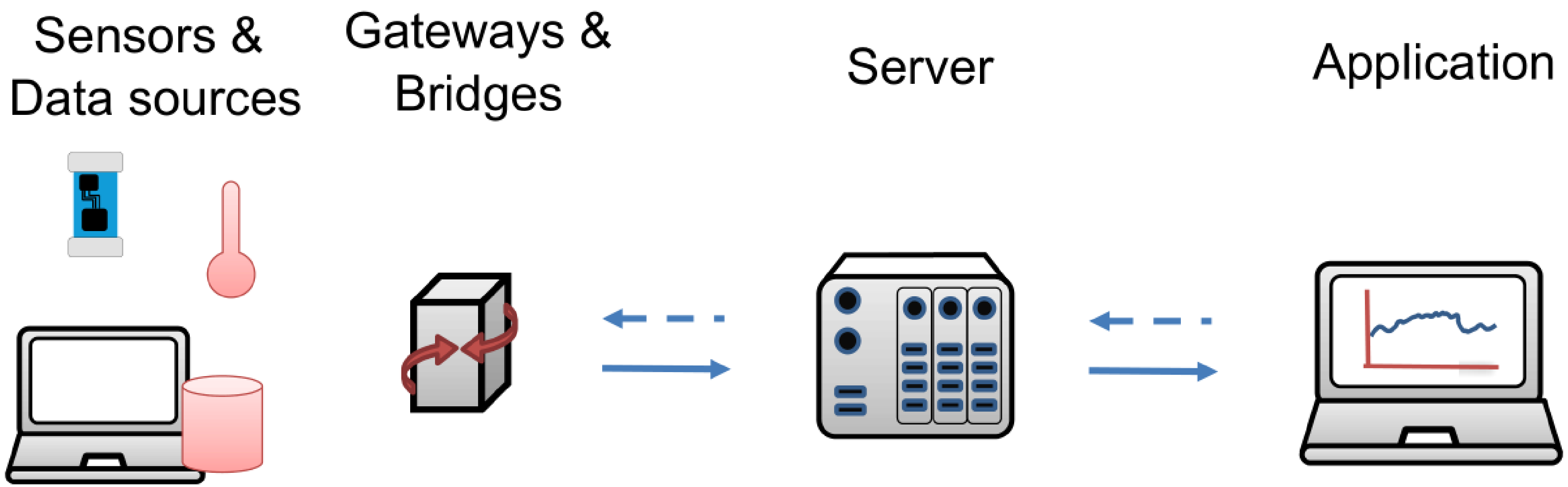
Introduction II

- Propose a uniform approach that can be applied to SMEs
  - Digitize the respective application in a low-threshold way
    - avoiding high investment costs
    - seeing the data within a short period

- Solution based on open-source solutions

- Data stays within the solution to circumvent data privacy concerns

Proposed Approach

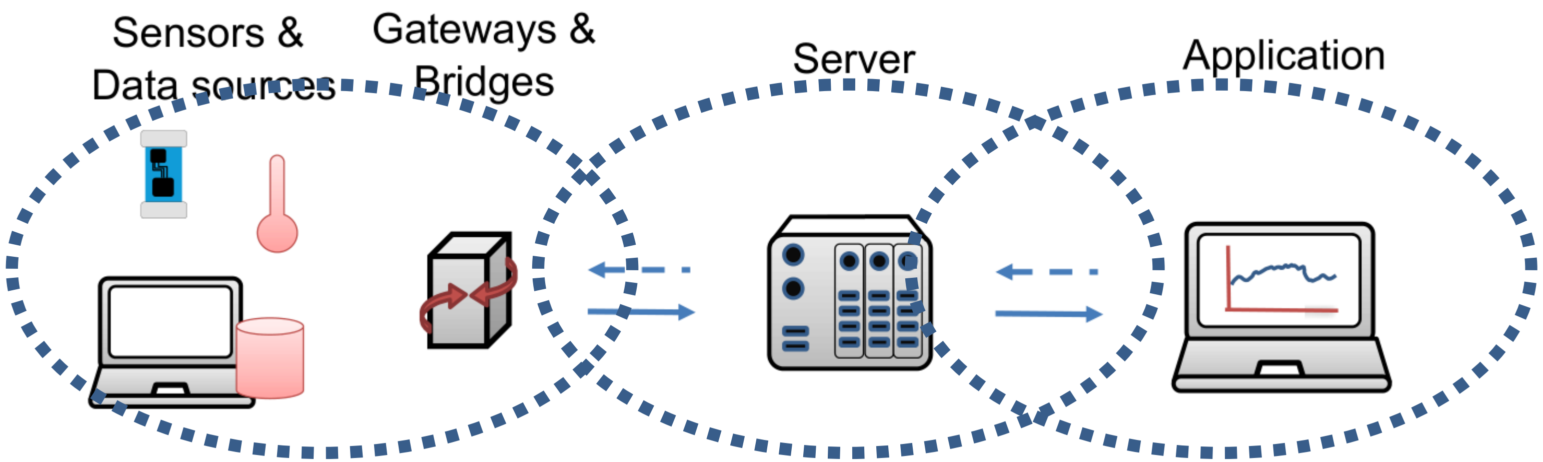


Contributions of this Paper

- Propose a flexible, simple infrastructure for data acquisition designed for use in small and medium-sized enterprises (SMEs)
  - LoRaWAN for sensor network data acquisition
  - Visualization provided by an Internet of Things (IoT) platform
- MQTT broker connects the LoRaWAN and server architecture
  - Enables data transfer from other sources
- Present and applications of LoRaWAN sensors
- Investigate throughput for applications that communicate via MQTT

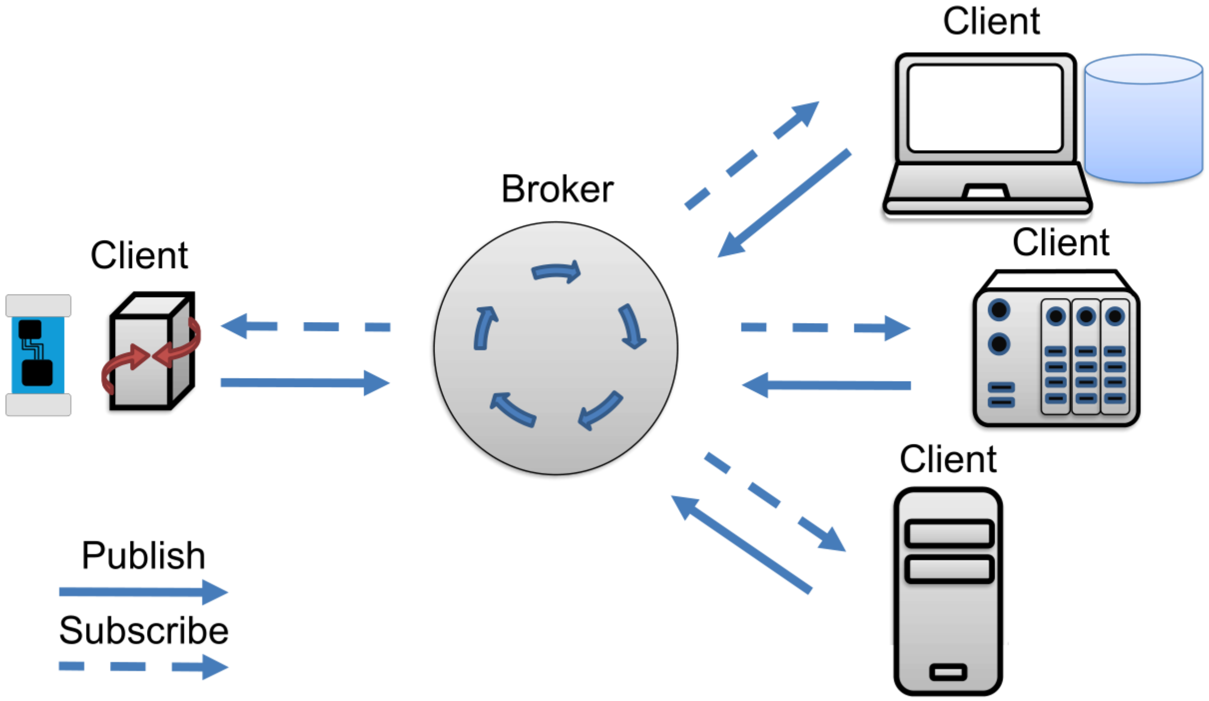
Concept

- Proposed solution is based on three main components
  - Data Hub
  - Data Acquisition with LoRaWAN
  - IoT Platform



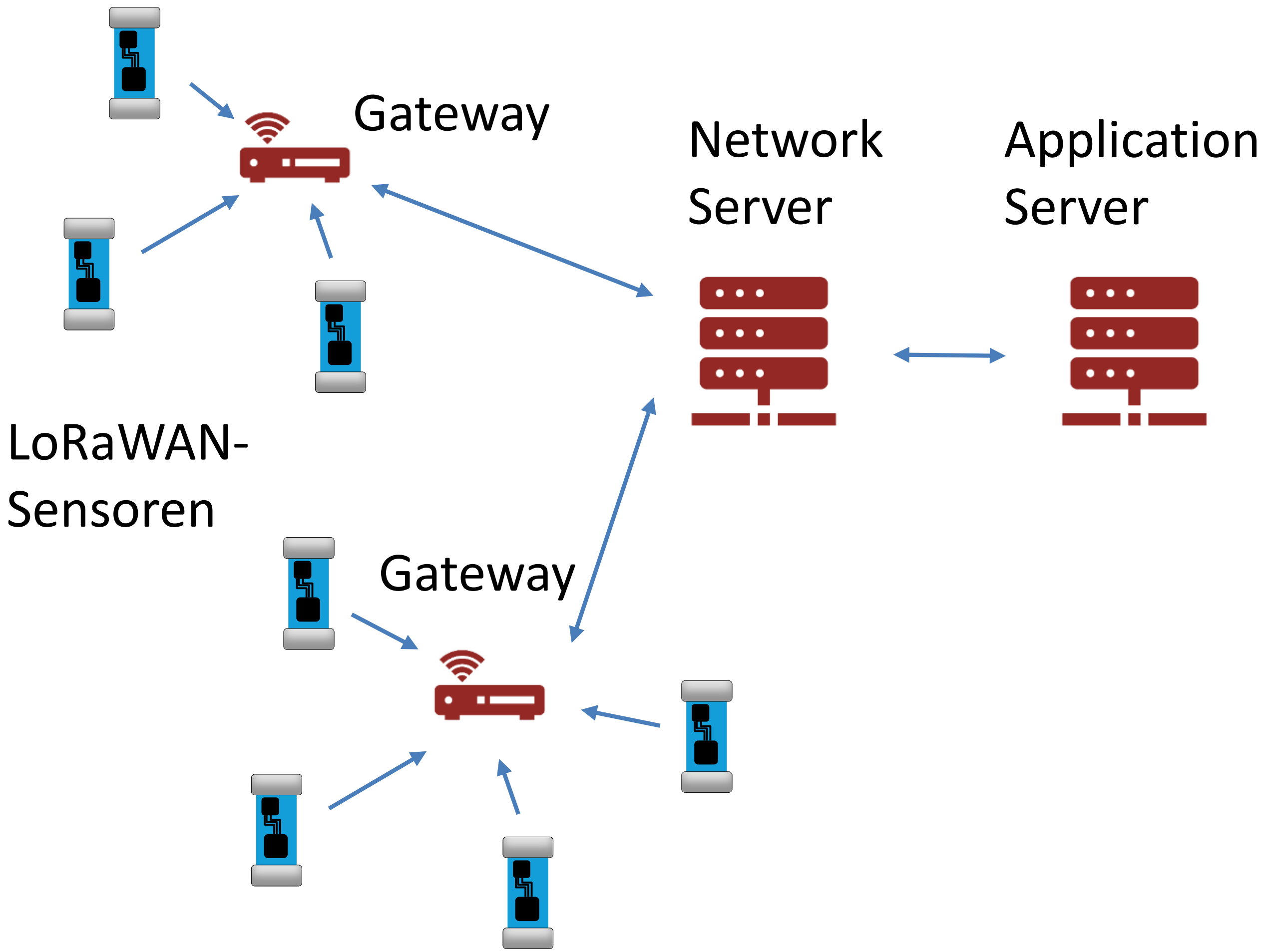
Concept – Data Hub

- MQTT Broker as data hub
  - Designed for connection of resource-constrained devices
    - Low code footprint and bandwidth
  - Enables cross-system communication with publish & subscribe pattern
    - Clients publish data to a broker
    - Clients subscribe data from a broker
    - Topics for filtering messages of clients



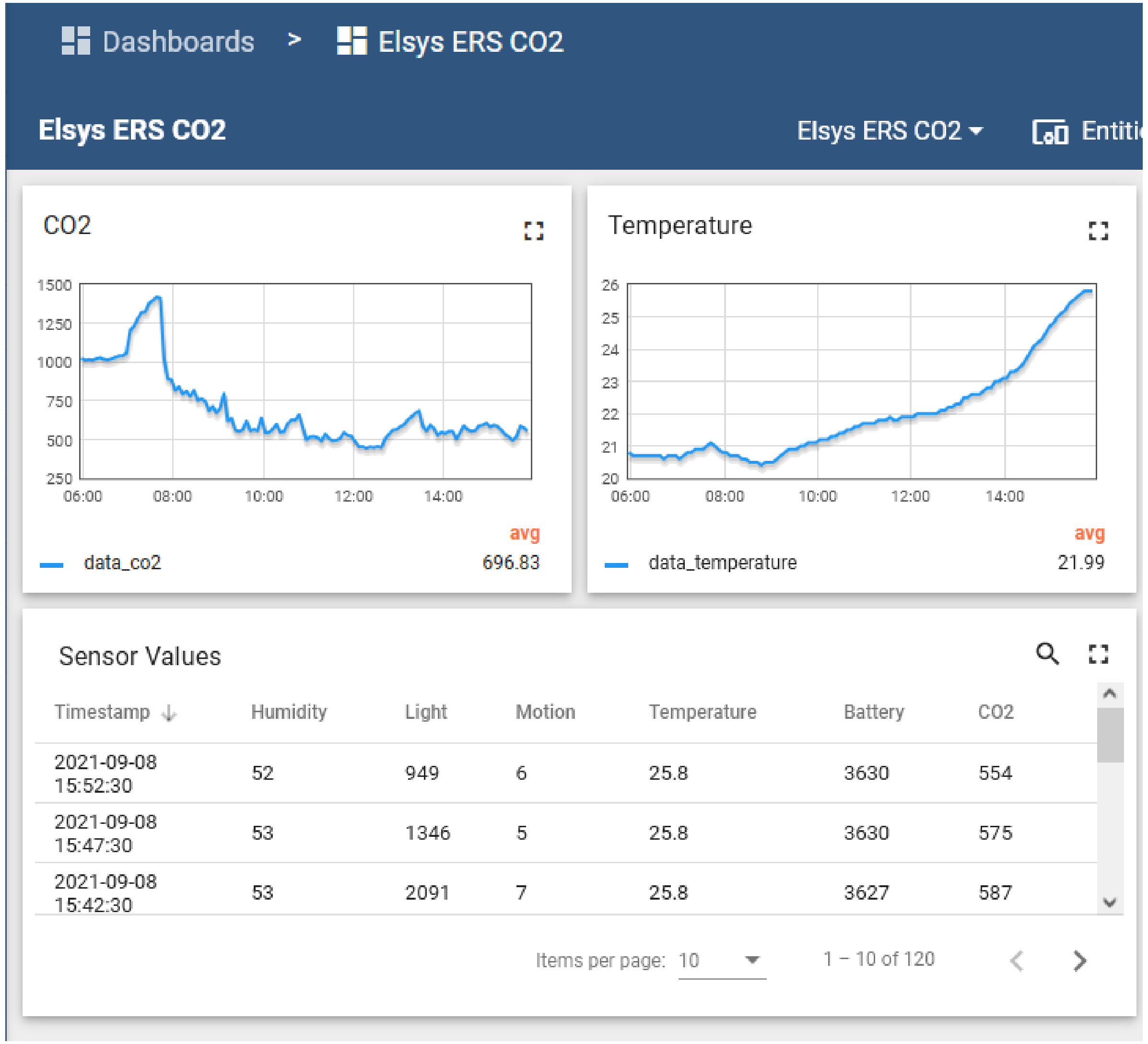
Concept – LoRaWAN

- LoRaWAN for wireless sensor network
  - Easy deployment of battery operated sensors
  - Long range data transmission
    - Single gateway covers a campus of an SME
  - Integration of sensors via web interface
    - No further programming knowledge is required
  - Many ready-made LoRaWAN sensors available



Concept – IoT Platform

- Deploy IoT platform to visualize measured data in dashboards
- SME monitor status of devices and visualize measurements with little effort
- Within IoT platform
  - Aggregate data from several sources
  - Further interfaces such as MQTT/REST for system integration



Sensor Values

Timestamp ↓	Humidity	Light	Motion	Temperature	Battery	CO2
2021-09-08 15:52:30	52	949	6	25.8	3630	554
2021-09-08 15:47:30	53	1346	5	25.8	3630	575
2021-09-08 15:42:30	53	2091	7	25.8	3627	587

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Implementation – Hardware I

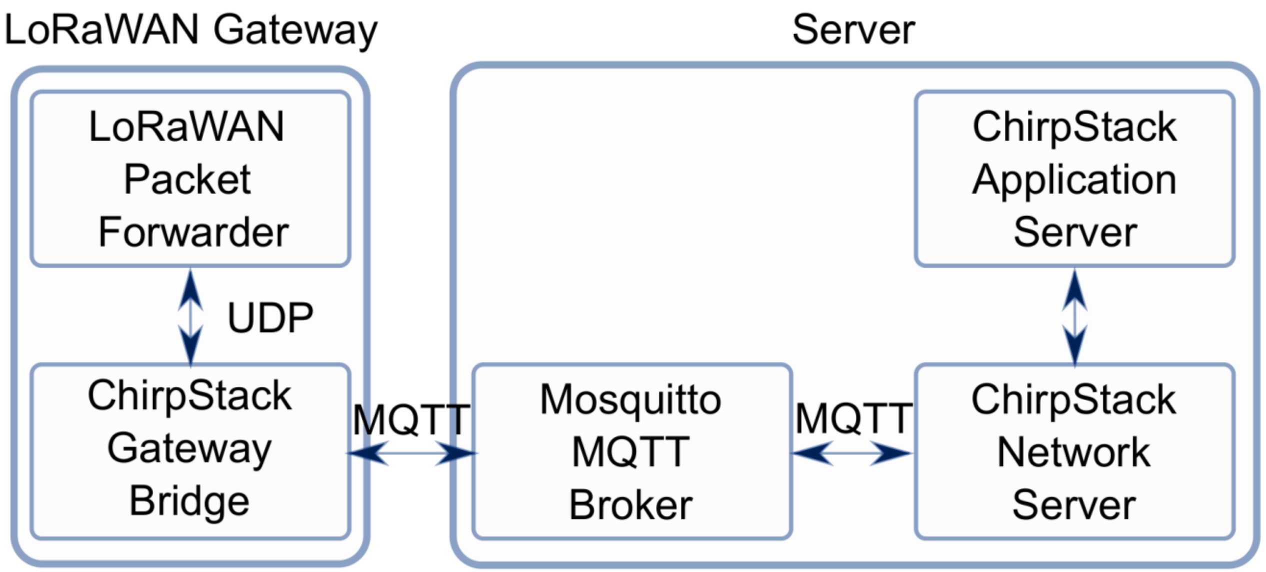
- Server
  - Synology DiskStation 718+
- LoRaWAN Gateway
  - Dragino LG308
    - SX1301 LoRa concentrator
    - Two SX1257 transceivers
- Network Setup
  - AVM FRITZ!Box 6820 LTE
  - TP-Link TL-SG105 5-Ports Gigabit network switch

Implementation – Hardware II

- LoRaWAN Sensors
  - Elsys ERS CO2
  - Elsys ELT-2
  - Elsys ERS Sound
  - Elsys EMS Door
- Physical Sensor Nodes
  - RedPitayas
    - Embedded signal generator and oscilloscope with 2 analog input und output channels

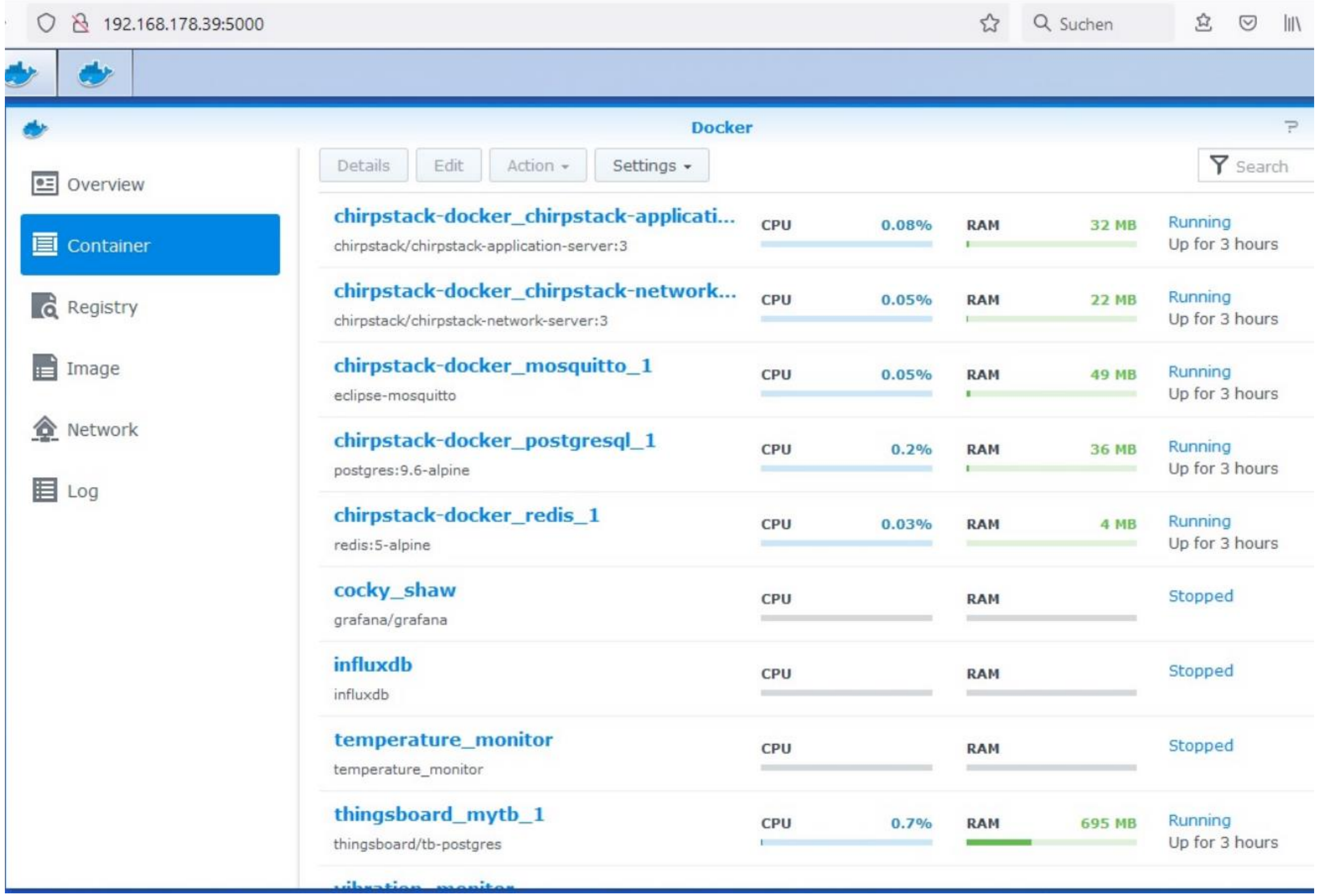
Implementation – Software I

- Mosquitto MQTT broker as a data hub
- ChirpStack (CS) as an open source LoRaWAN stack
  - CS Gateway bridge is installed on the LoRaWAN gateway
  - CS Network and Application Server on the NAS


LoRaWAN Gateway
Server
LoRaWAN Packet Forwarder
UDP
ChirpStack Gateway Bridge
MQTT
Mosquitto MQTT Broker
MQTT
ChirpStack Network Server
ChirpStack Application Server

Implementation – Software II

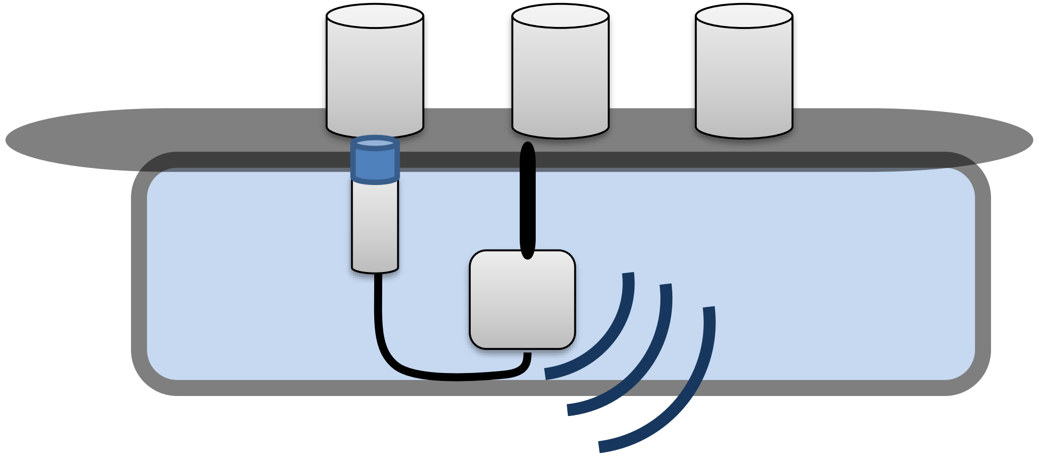
- We run software components on the NAS using Docker



chirpstack-docker_chirpstack-applicati... chirpstack/chirpstack-application-server:3	CPU	0.08%	RAM	32 MB	Running Up for 3 hours
chirpstack-docker_chirpstack-network... chirpstack/chirpstack-network-server:3	CPU	0.05%	RAM	22 MB	Running Up for 3 hours
chirpstack-docker_mosquitto_1 eclipse-mosquitto	CPU	0.05%	RAM	49 MB	Running Up for 3 hours
chirpstack-docker_postgresql_1 postgres:9.6-alpine	CPU	0.2%	RAM	36 MB	Running Up for 3 hours
chirpstack-docker_redis_1 redis:5-alpine	CPU	0.03%	RAM	4 MB	Running Up for 3 hours
cocky_shaw grafana/grafana	CPU		RAM		Stopped
influxdb influxdb	CPU		RAM		Stopped
temperature_monitor temperature_monitor	CPU		RAM		Stopped
thingsboard_mytb_1 thingsboard/tb-postgres	CPU	0.7%	RAM	695 MB	Running Up for 3 hours
vibration_monitor					

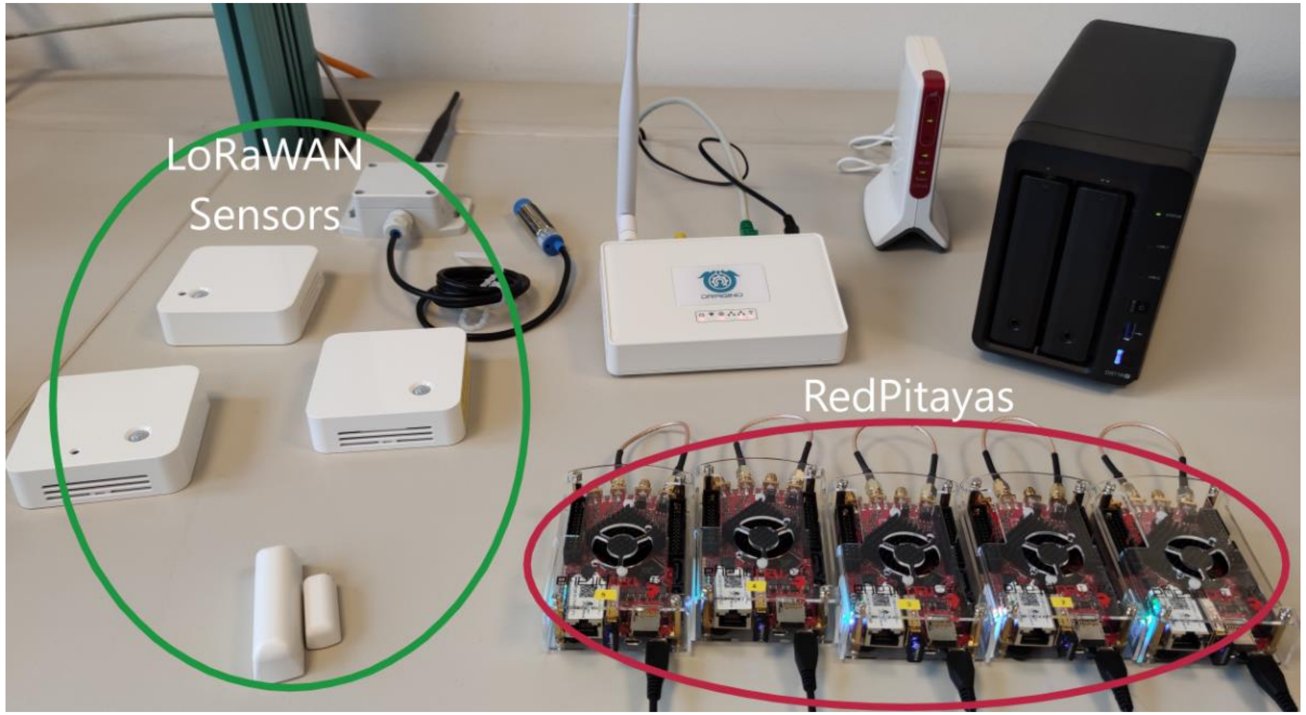
Applications in SMEs

- We deployed the system for smaller projects in SMEs
  - 1. Elsys ERS CO2 LoRaWAN sensor to monitor CO2 in the room.
    - Employees monitored the air quality and ventilate the premises accordingly
  - 2. Elsys ELT-2 with inductive proximity sensor
    - Sensor counts metallic object that are transported on a conveyer belt during production



System Evaluation I

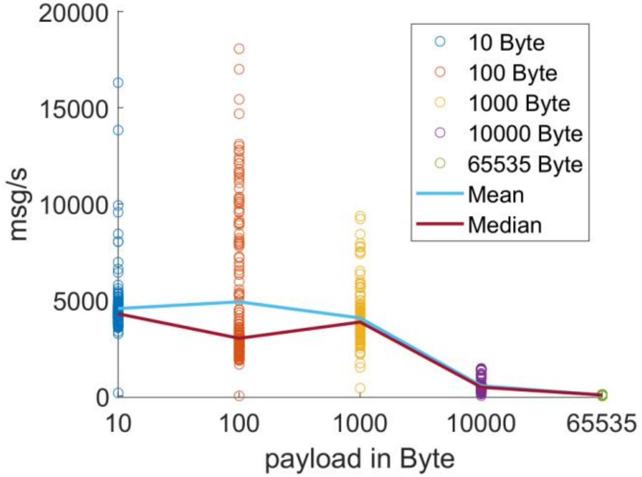
- With only a few LoRaWAN sensors the system is idle
- We determined the performance of our system empirically with two experiments
  - MQTTLoader to determine the maximum message rates
  - Maximum user data rate with RedPitayas



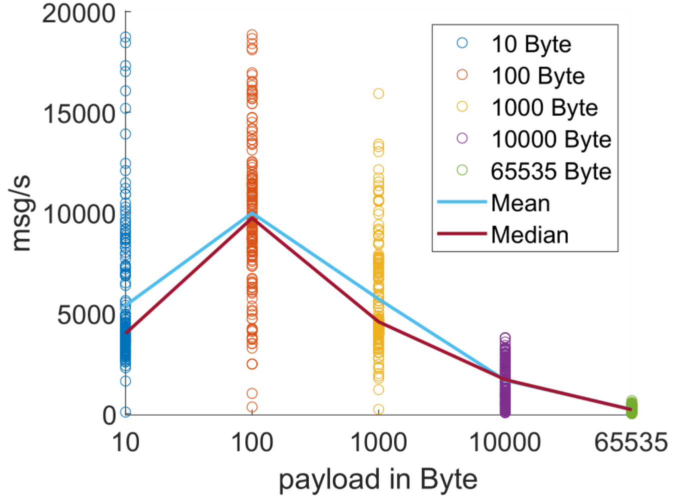
System Evaluation II

- Measure the maximum message rates with MQTTLoader [1]
  - MQTTLoader v.0.8.1 is running within a virtual machine running Ubuntu 20.04 on a Windows PC that is connected either via the local WLAN or via Ethernet
  - Configured with increasing payload
  - Timeout after 180 s

- For payloads up to 1000 Bytes, we conclude that we are able to send up to 5000 msg/s



(a) Connection with WLAN

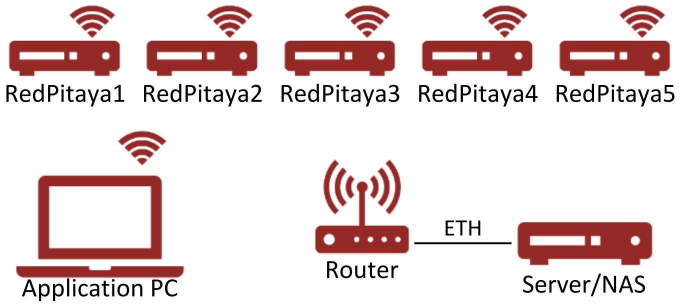


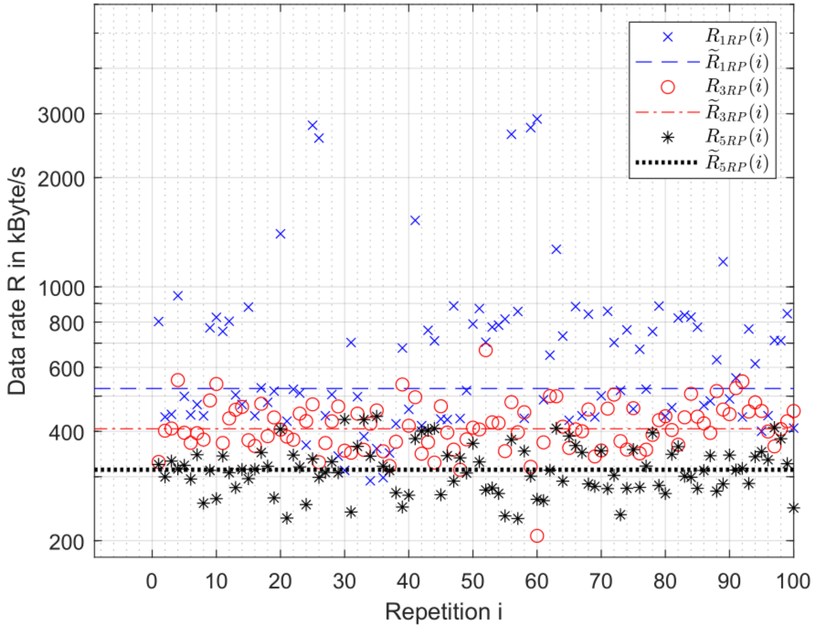
(b) Connection with Ethernet

[1] R. Banno, K. Ohsawa, Y. Kitagawa, T. Takada, and T. Yoshizawa, "Measuring Performance of MQTT v5. 0 Brokers with MQTTLoader," in 2021 IEEE 18th Annual Consumer Communications & Networking Conference (CCNC). IEEE, 2021, pp. 1–2.

System Evaluation III

- To measure the maximum achievable user data rate with 1, 3, and 5 RedPitayas [2]
  - Collect analog raw data and send via MQTT with a payload of 65535 Byte per channel
  - Data is stored in a MATLAB script on the application PC
  - The results of the measurements performed with 1, 3, and 5 RedPitaya devices, publishing ≈ 50 messages per second
  - Determine Data rate R from processed data D and run time t





[2] F. John, S. O. Schmidt, and H. Hellbrück, "Flexible Arbitrary Signal Generation and Acquisition System for Compact Underwater Measurement Systems and Data Fusion," in Global Oceans 2021: San Diego Porto, Sep 2021, pp. 1–6

Conclusion

- We propose a flexible, simple, and portable infrastructure for data acquisition designed for use in SMEs
- Tested empirically the performance of the MQTT broker
  - The broker and local network is able to handle additional 5000 MQTT messages per second
- The components such as the MQTT broker and ThingsBoard are a good start for SMEs and are a framework for further process optimization

Future Work

- Currently, we investigate an automated deployment process and getting started guide
- Investigate max. number of LoRaWAN sensors that the system is able to handle

Thank you for you attention!
Feel free to ask questions.