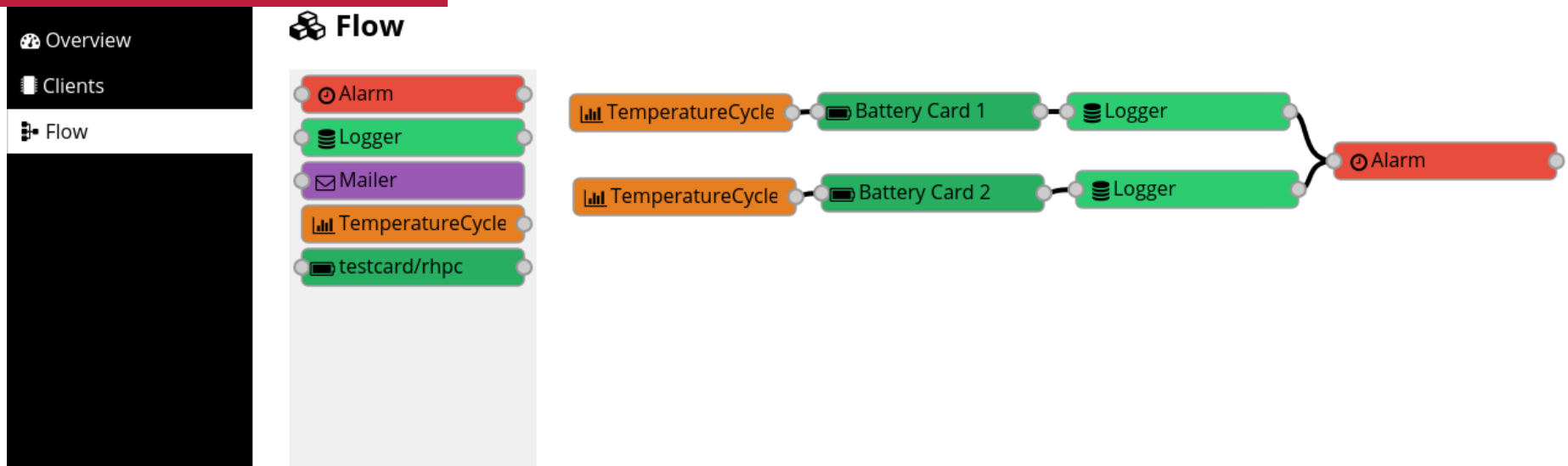
Technische Universität Braunschweig

Institute of Operating Systems and Computer Networks



A Flexible Software Framework for Testbeds

In Real-World Experiments and Temperature-Controlled Environments

Robert Hartung, Ulf Kulau, Niels Lichtblau, Lars Wolf, 2018-11-02

Motivation

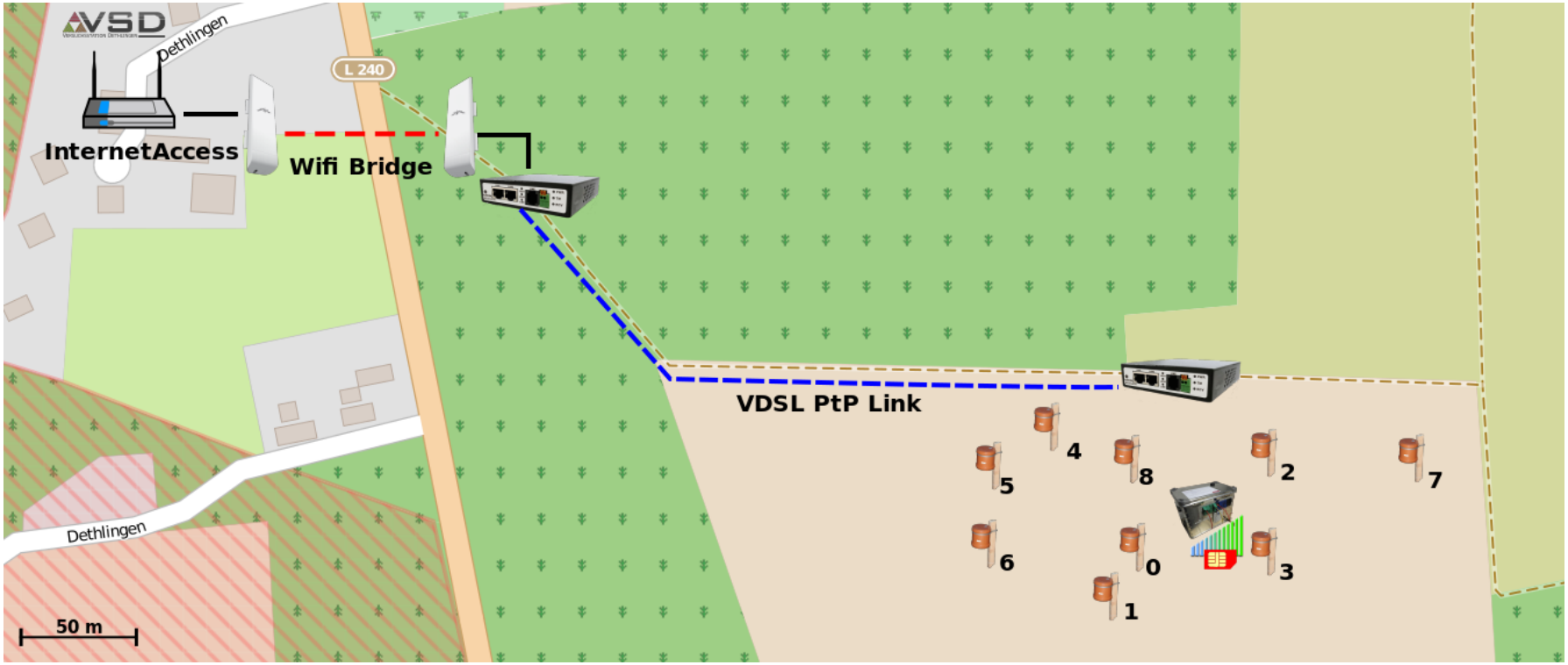
- Gap between simulations and real-world deployments
- Testbeds can help filling the gap, but...
  - require significant amount of time
    - setup
    - maintenance
  - often tailored to a specific use case
  - can fail![1]
- Ultimate goal: Provide repeatability under realistic conditions

[1] FAILSAFE'17: On the Experiences with Testbeds and Applications in Precision Farming

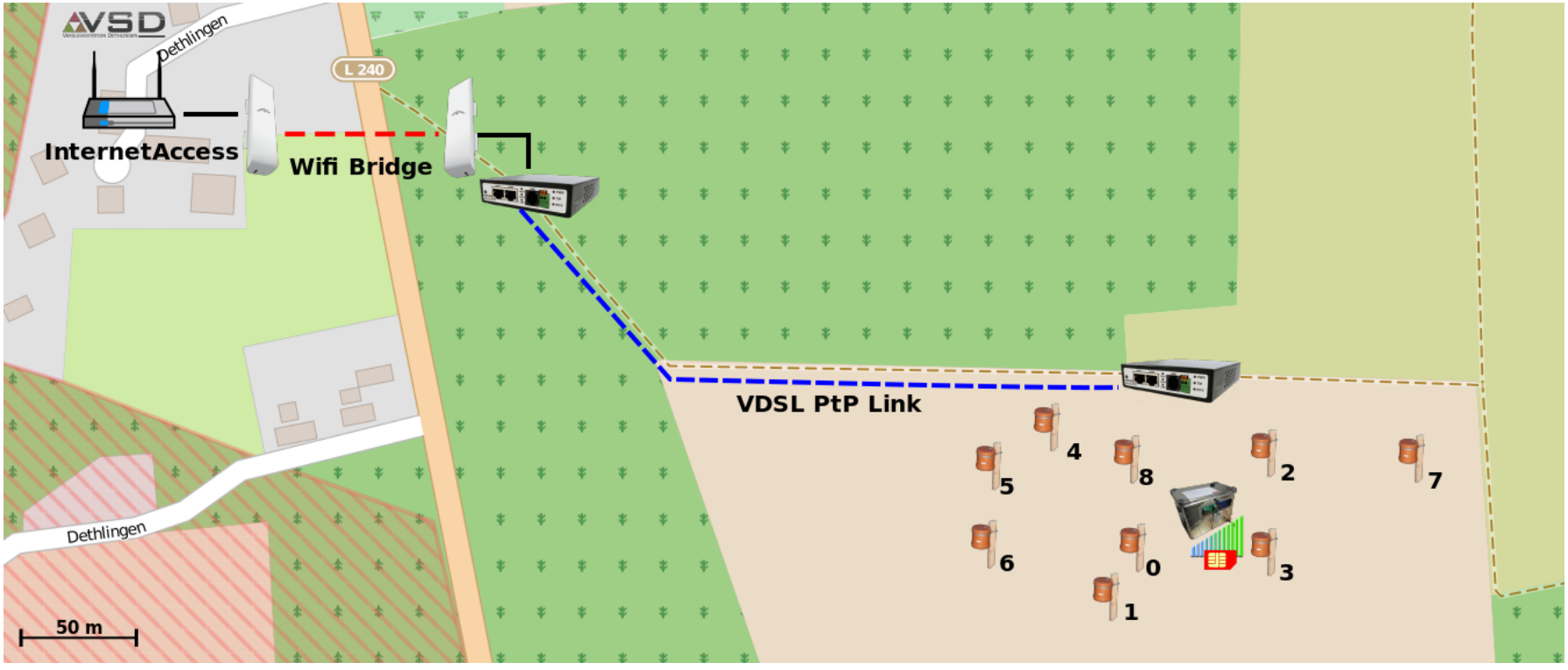
PotatoNet: Goals

- Sensor network to measure dry stress of potato plants
  - soil temperature, air temperature, ...
- ... but also use as testbed for other WSN applications
- Remotely accessible

PotatoNet: Architecture



PotatoNet: Architecture



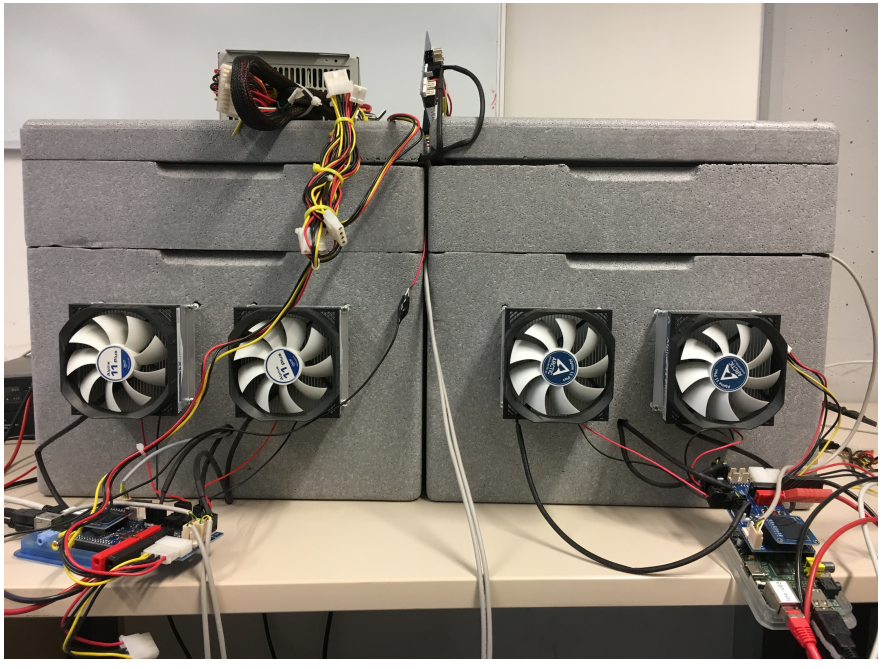
Challenges: Failing nodes, environment, farming activities

Temperature testbed

- Polystyrene box
- Peltier elements for temperature control
- −15 °C to 80 °C @ 0.12 °C accuracy

Temperature testbed

- Polystyrene box
- Peltier elements for temperature control
- −15 °C to 80 °C @ 0.12 °C accuracy
- Use cases:
  - Effects of temperature on hardware
  - Energy harvesting experiments
  - Temperature effects on batteries and super capacitors



Requirements

PotatoNet

- Read sensor node's data
- Re-program nodes
- Handle connection errors

Temperature-controlled chamber

- Quick setup
- Long-term experiments
- Flexibility

High Level Architecture

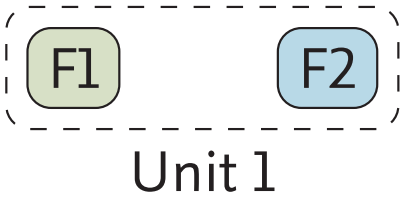
High Level Architecture

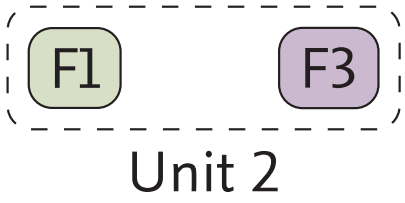
Unit 1

Unit 2

e.g. chamber, energy platform, sensor node

High Level Architecture





High Level Architecture

High Level Architecture

Software

- Written in python
- Small modules (F1,F2,F3)
  - Serial
  - Temperature Chamber

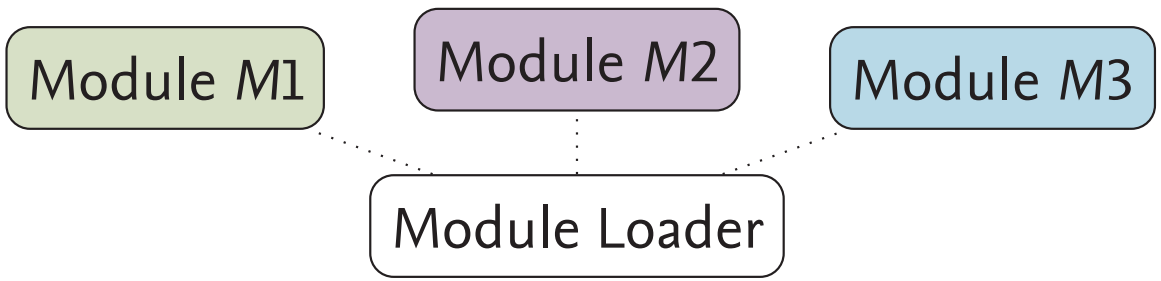
MQTT

- QoS
- Message buffering

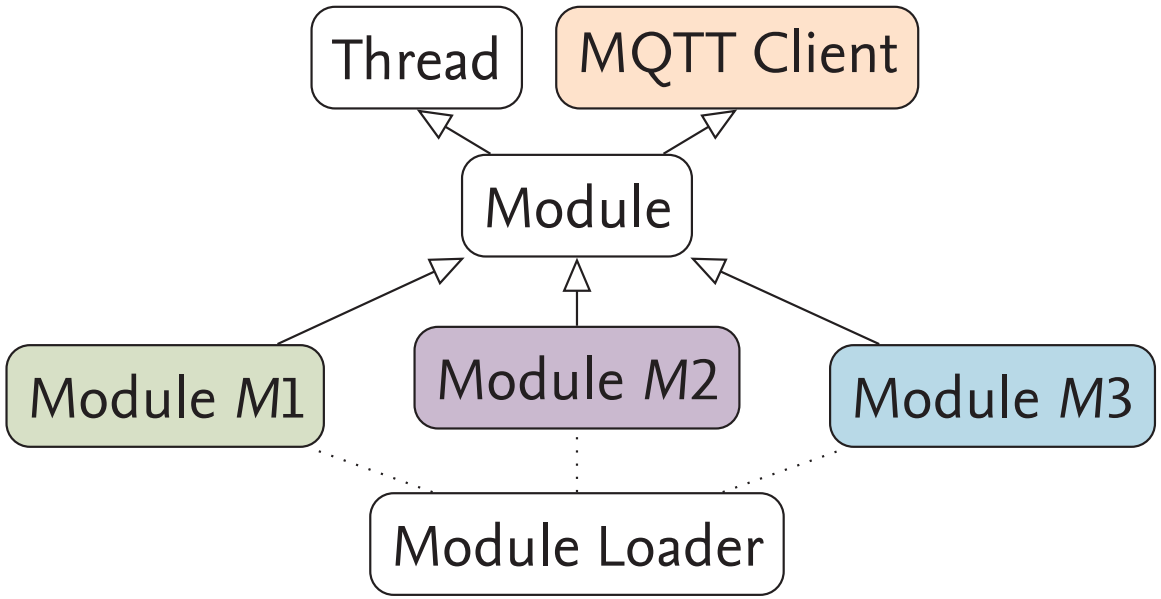
Software Architecture

Module Loader

Software Architecture



Software Architecture



Communication

- Topics for communication, e.g.
  - `module/host/state`
  - `module/host/config`
  - `module/host/temp/[target|current]`
  - `module/host/<id>/tx`

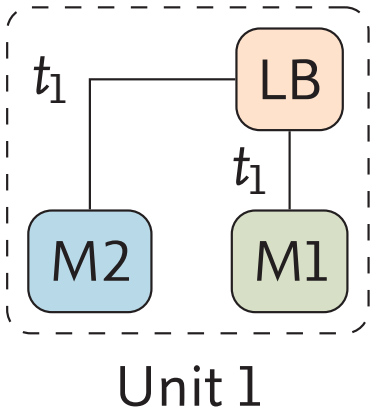
Communication

- Topics for communication, e.g.
  - `module/host/state`
  - `module/host/config`
  - `module/host/temp/[target|current]`
  - `module/host/<id>/tx`

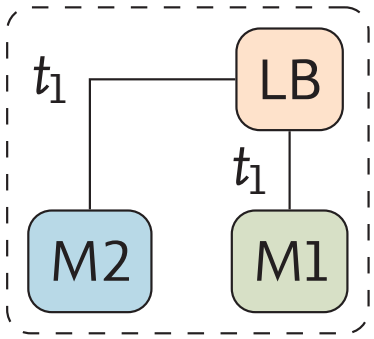
Problem: Communication

- Idea: Use chamber without network
- Inter-module communication based on MQTT
- Hence we use multiple brokers in our architecture

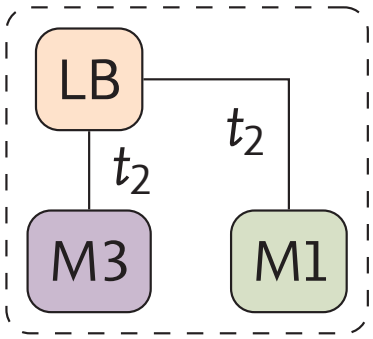
Communication (2)



Communication (2)

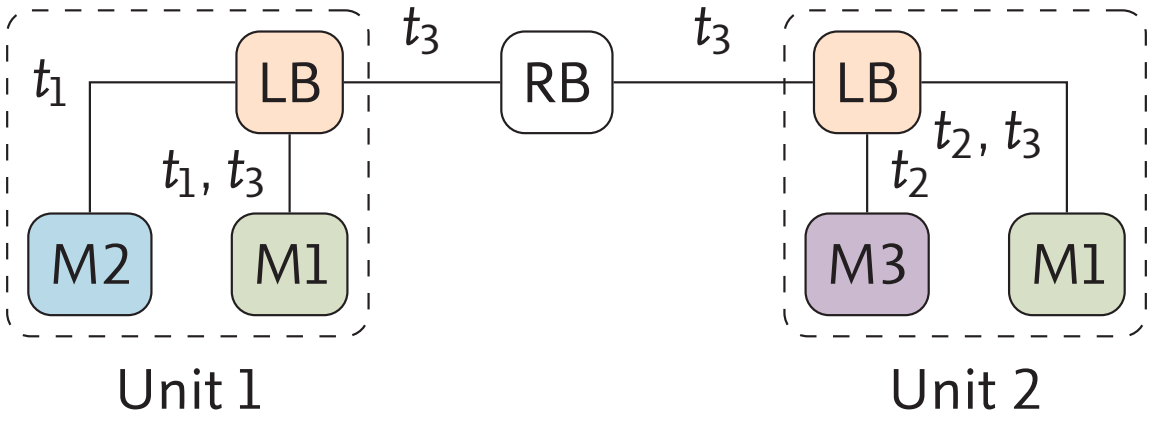


Unit 1



Unit 2

Communication (2)



GUI: Motivation

Configuration

- How to configure modules and their interactions?
- Config files can be used, but not user-friendly!

GUI: Motivation

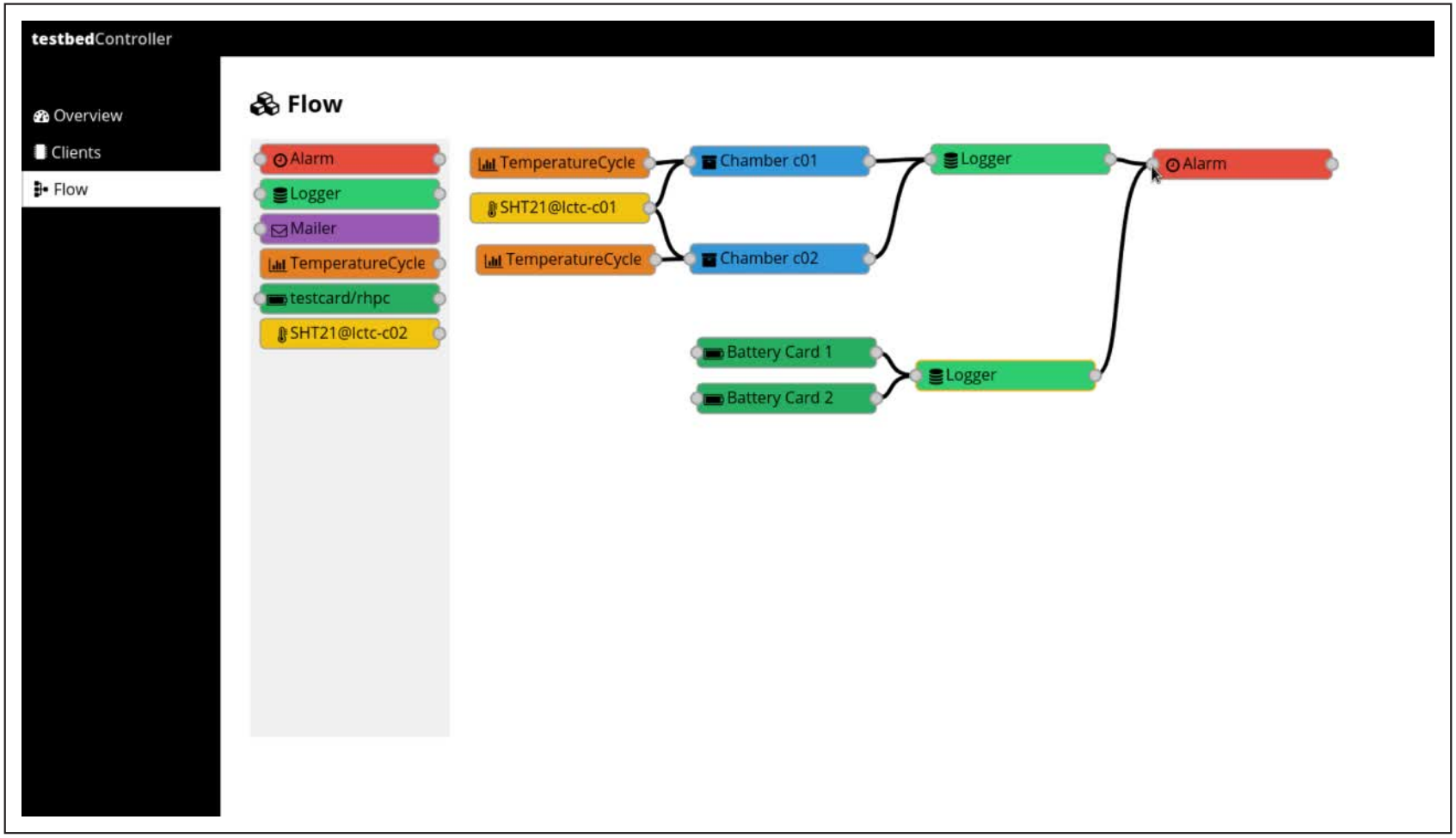
Configuration

- How to configure modules and their interactions?
- Config files can be used, but not user-friendly!

Solution: Configure flow of data

- Publish data on a topic
- Subscribe to topic

Video


testbedController
Overview
Clients
Flow
Flow
Alarm
Logger
Mailer
TemperatureCycle
testcard/rhpc
SHT21@lctc-c02
TemperatureCycle
SHT21@lctc-c01
TemperatureCycle
Chamber c01
Chamber c02
Logger
Alarm
Battery Card 1
Battery Card 2
Logger

Experiences

PotatoNet

- Benefits from error handling

Temperature Testbed

- Benefits from flexibility and re-usability
  - Easy to setup and extend
  - Very flexible for different experiments
  - Live-insights into data using GUI

Conclusion

- We presented a software framework for testbeds
  - Based on simple, small modules
  - Reduces amount of time required for setup and common software errors
  - Enables us to make more experiments in less time
  - ... which enhances research!
- GUI as an optional web client helps at configuration
- Will be available online[2]
- If you have a fancy name: let me know!

[2] `https://gitlab.ibr.cs.tu-bs.de/hartung/testbed-software`

Conclusion

- We presented a software framework for testbeds
  - Based on simple, small modules
  - Reduces amount of time required for setup and common software errors
  - Enables us to make more experiments in less time
  - ... which enhances research!
- GUI as an optional web client helps at configuration
- Will be available online[2]
- If you have a fancy name: let me know!

Thank you, questions?

[2] `https://gitlab.ibr.cs.tu-bs.de/hartung/testbed-software`