A Flexible Software Framework for Testbeds
In Real-World Experiments and Temperature-Controlled Environments

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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

Challenges: Failing nodes, environment, farming activities

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PotatoNet: Architecture

Challenges: Failing nodes, environment, farming activities
Temperature testbed

- Polystyrene box
- Peltier elements for temperature control
- $-15 \, ^\circ\text{C}$ to $80 \, ^\circ\text{C}$ @ $0.12 \, ^\circ\text{C}$ accuracy
Temperature testbed

- Polystyrene box
- Peltier elements for temperature control
- $-15^\circ C$ to $80^\circ C$ @ $0.12^\circ C$ 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

Unit 1

Unit 2
High Level Architecture

Unit 1

Unit 2

e.g. chamber, energy platform, sensor node
High Level Architecture

- Unit 1
  - F1
  - F2

- Unit 2
  - F1
  - F3

- Written in Python
- Small modules (F/one.lf, F/two.lf, F/three.lf)
- Serial Temperature Chamber
- MQTT
- QoS
High Level Architecture

Communication?

Unit 1

Unit 2
**High Level Architecture**

![Diagram of 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

Module M1

Module M2

Module M3

Module Loader
Communication

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

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Problem: Communication

- Idea: Use chamber without network
- Inter-module communication based on MQTT
- Hence we use multiple brokers in our architecture
Communication (2)

Unit 1

M2

LB

M1

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Communication (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
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 online²

- If you have a fancy name: let me know!

²https://gitlab.ibr.cs.tu-bs.de/hartung/testbed-software
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Thank you, questions?

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