Technische Universität Braunschweig

Institute of Operating Systems and Computer Networks

PotatoNet

Outdoor WSN Testbed for Smart Farming Applications

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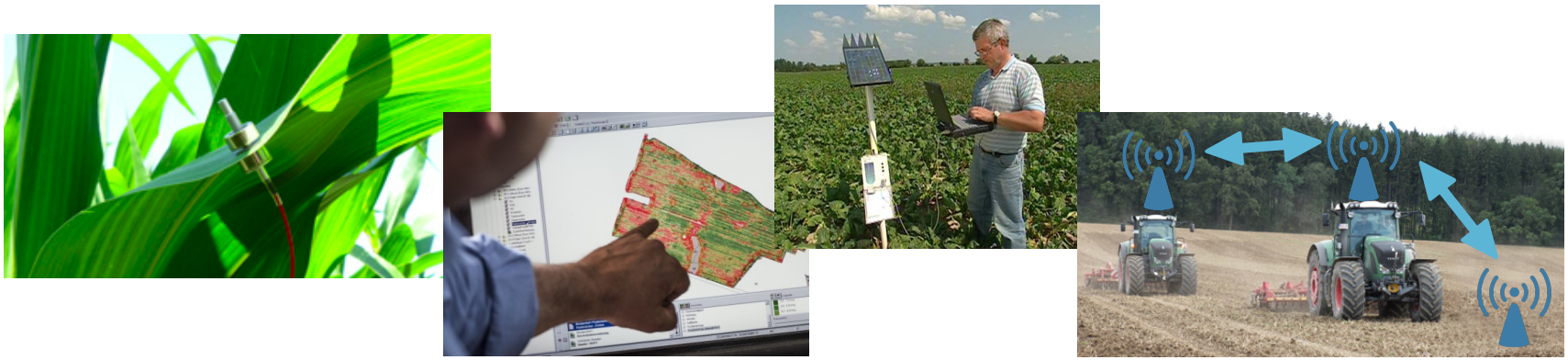
September 23, 2015

PotatoNet – Motivation by Application

Smart Farming – sensor networks in agriculture

- Consequential challenges:
  - Limited maintainability:
    → Robustness and Energy Efficiency
  - Limited connectivity:
    → Limited Infrastructure (Opportunistic Networks)



PotatoNet – Motivation by Research

Research on outdoor (W)SNs

- How to achieve robustness and availability (rough environmental conditions)?
- Deal with constrained energy resources
- How to deal with limited connectivity?



Testbed Design – Preliminary Considerations

Also similar restrictions / challenges for the testbed itself

- Energy Supply for the whole testbed ($\approx 65W$, 10 Nodes)
  $\rightarrow$ Almost impossible to use batteries / Energy Harvesting

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- Limited Internet connectivity
  $\rightarrow$ Rural area with bad cellular connectivity
- Bad maintainability
  $\rightarrow$ Robustness and remote maintenance capabilities

Challenges – Reliable Energy Supply

Joint venture with VSD in Dethlingen

- Potato crop research station
- Several trial fields
- Installation of a permanent power supply

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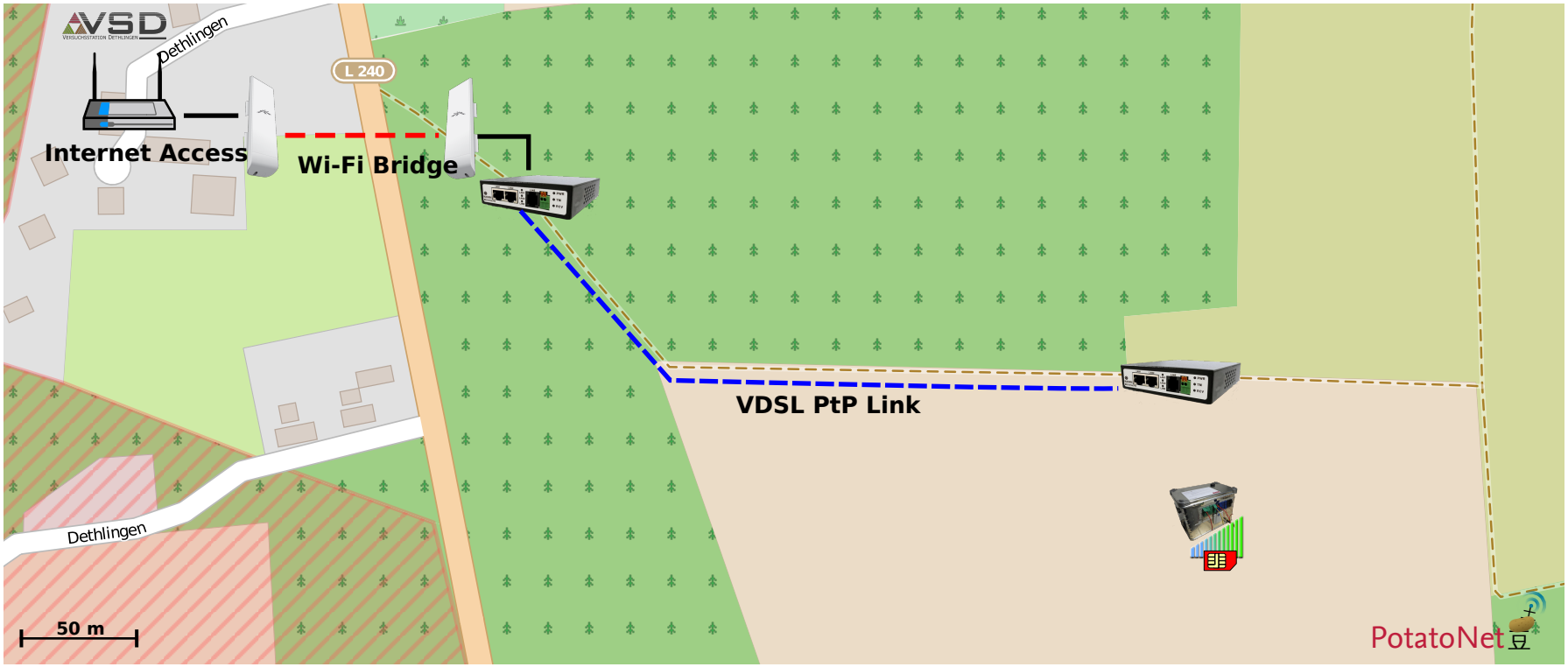
VSD
VERSUCHSSTATION DETHLINGEN

Challenges – Internet/Network Connectivity



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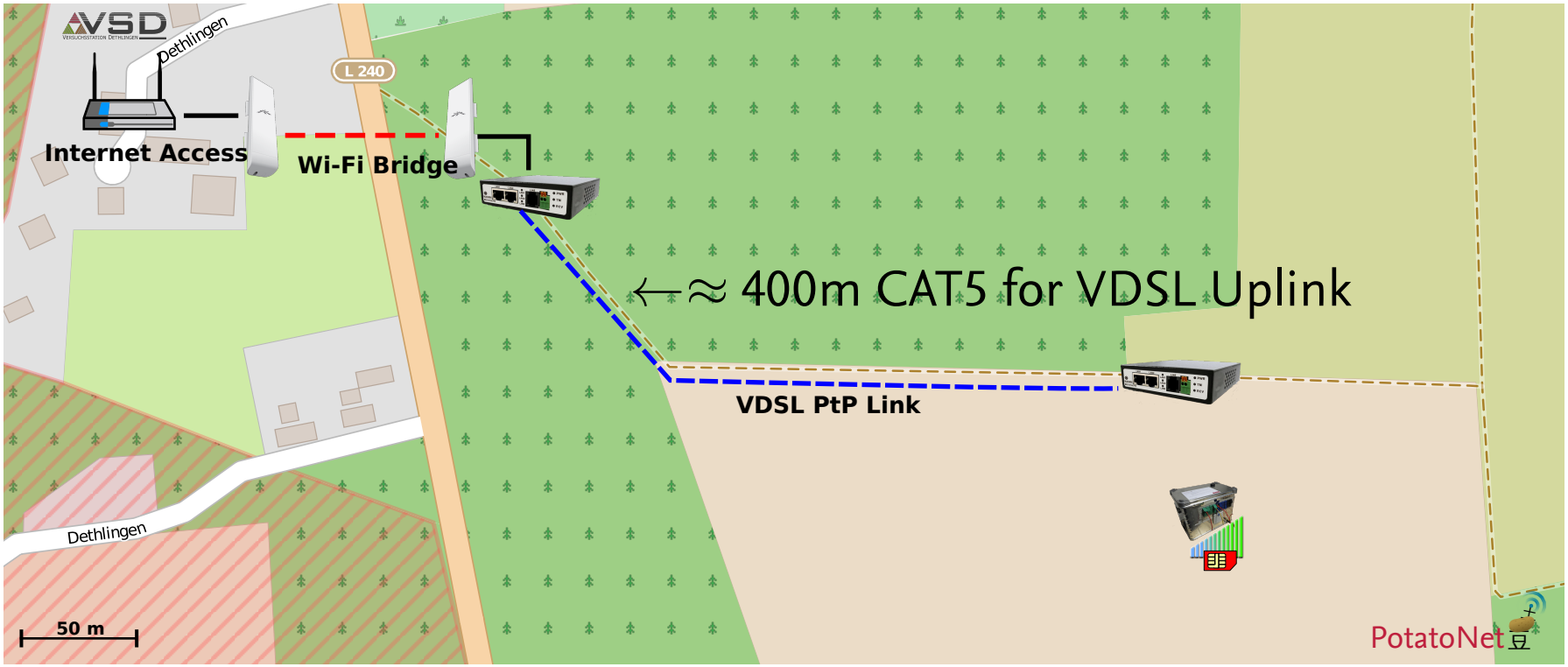

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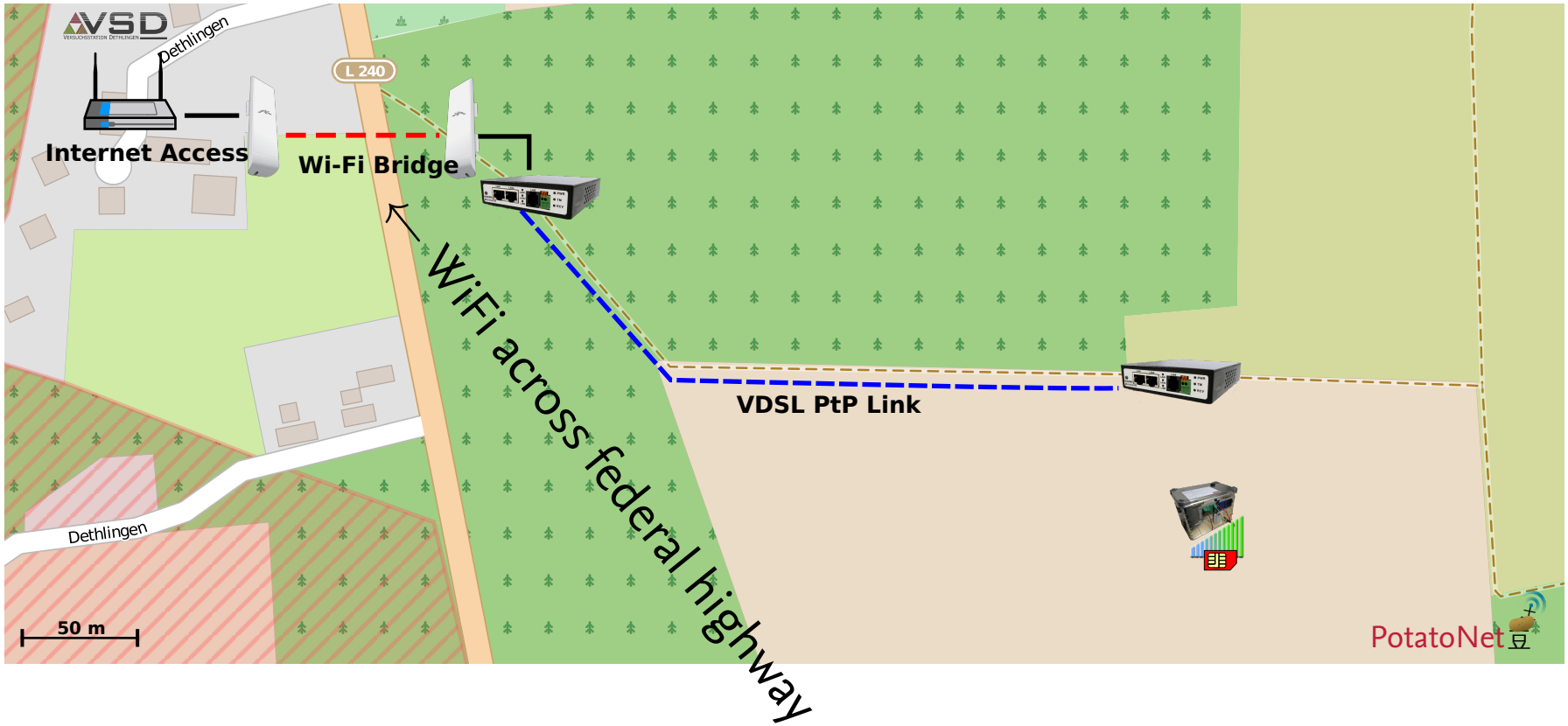

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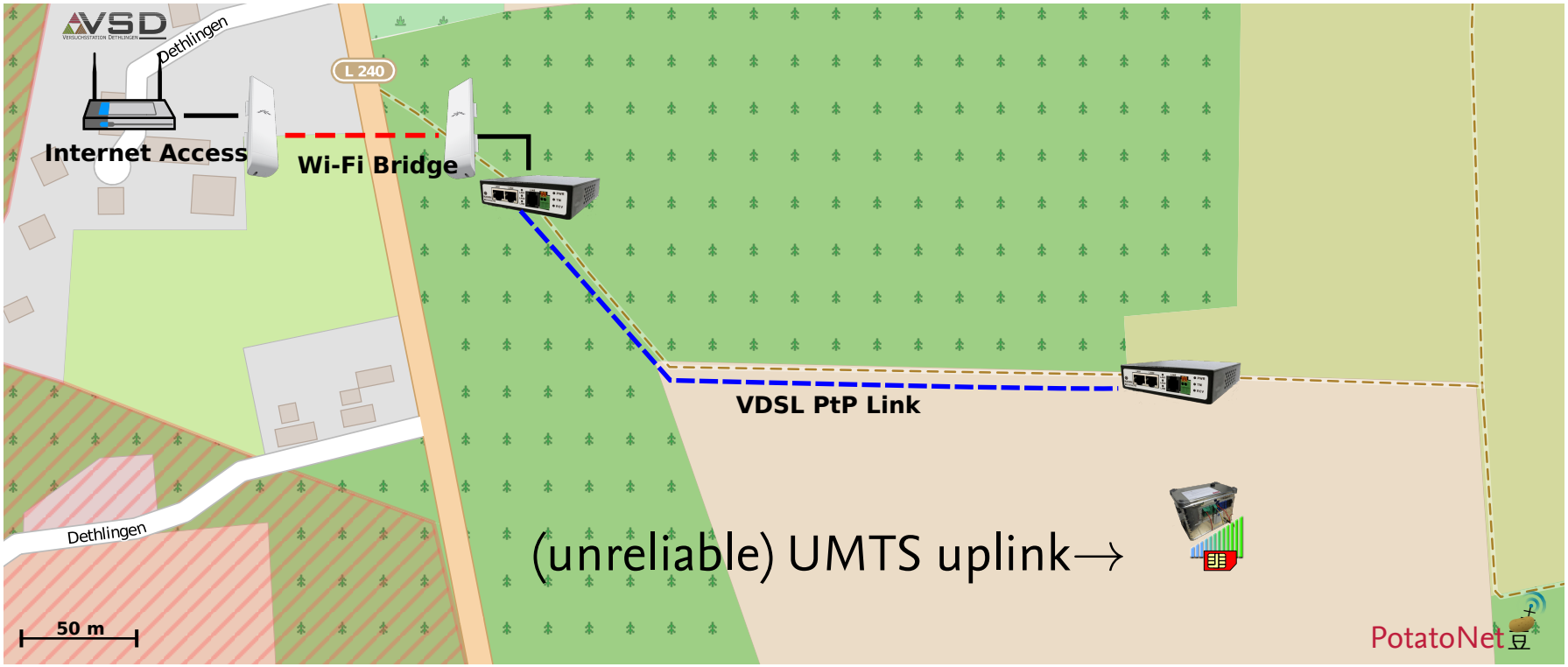
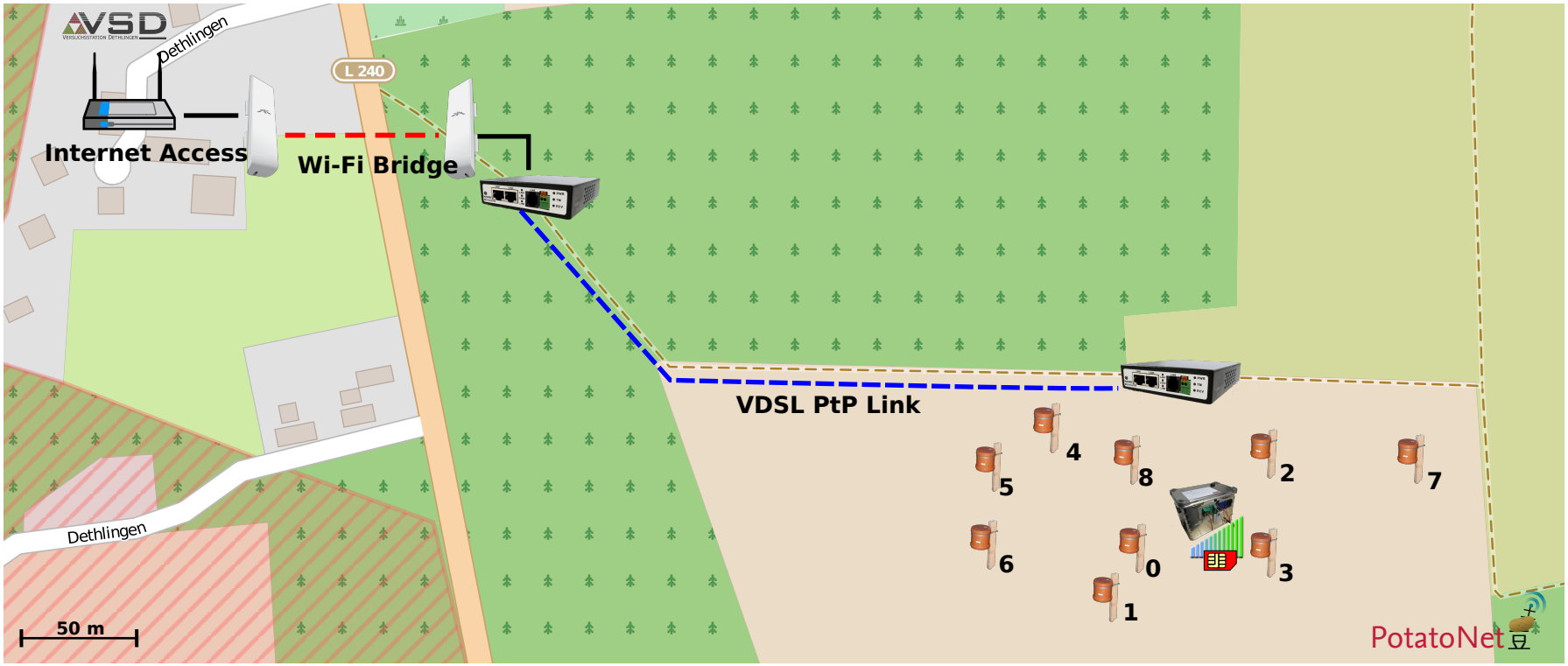


Requirements

Challenges for the network

- Network / nodes accessible from desk
- Remote observation and reprogramming of the sensor nodes
- Remote Hard-Reset of field nodes
- Waterproof housing

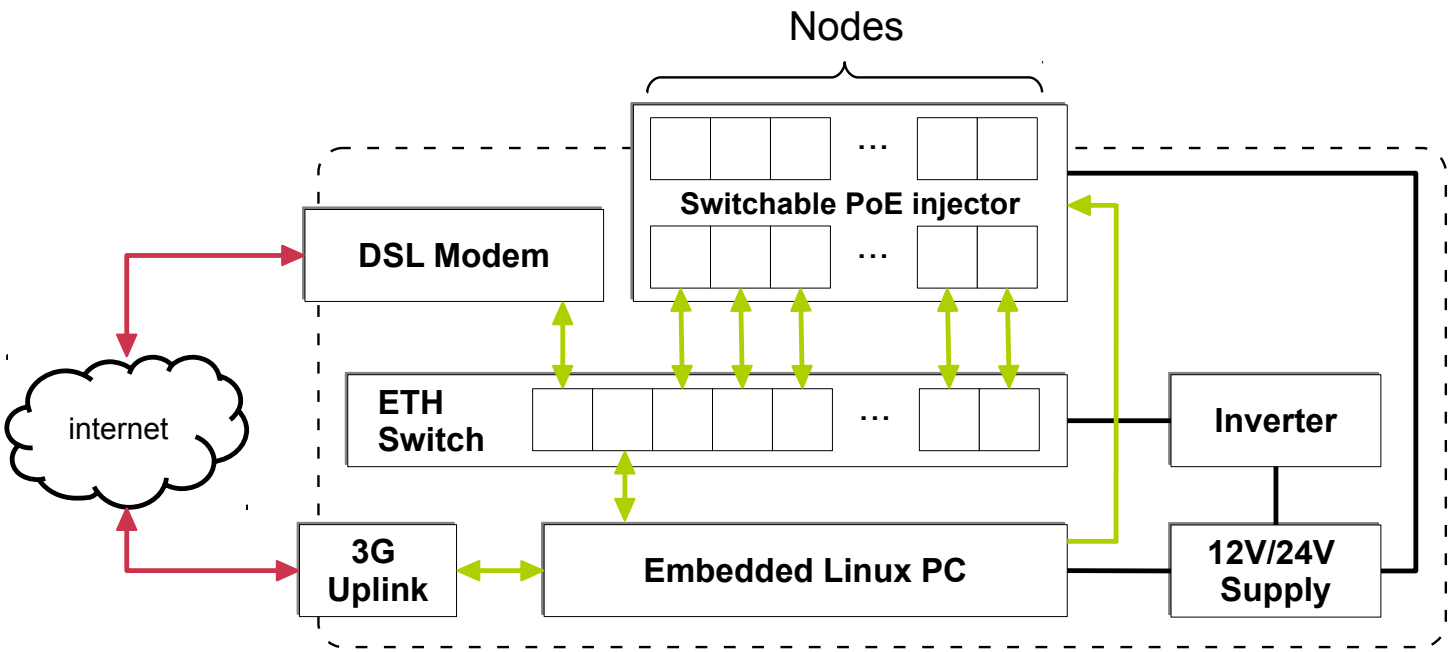
Network – Central Box and Field Nodes



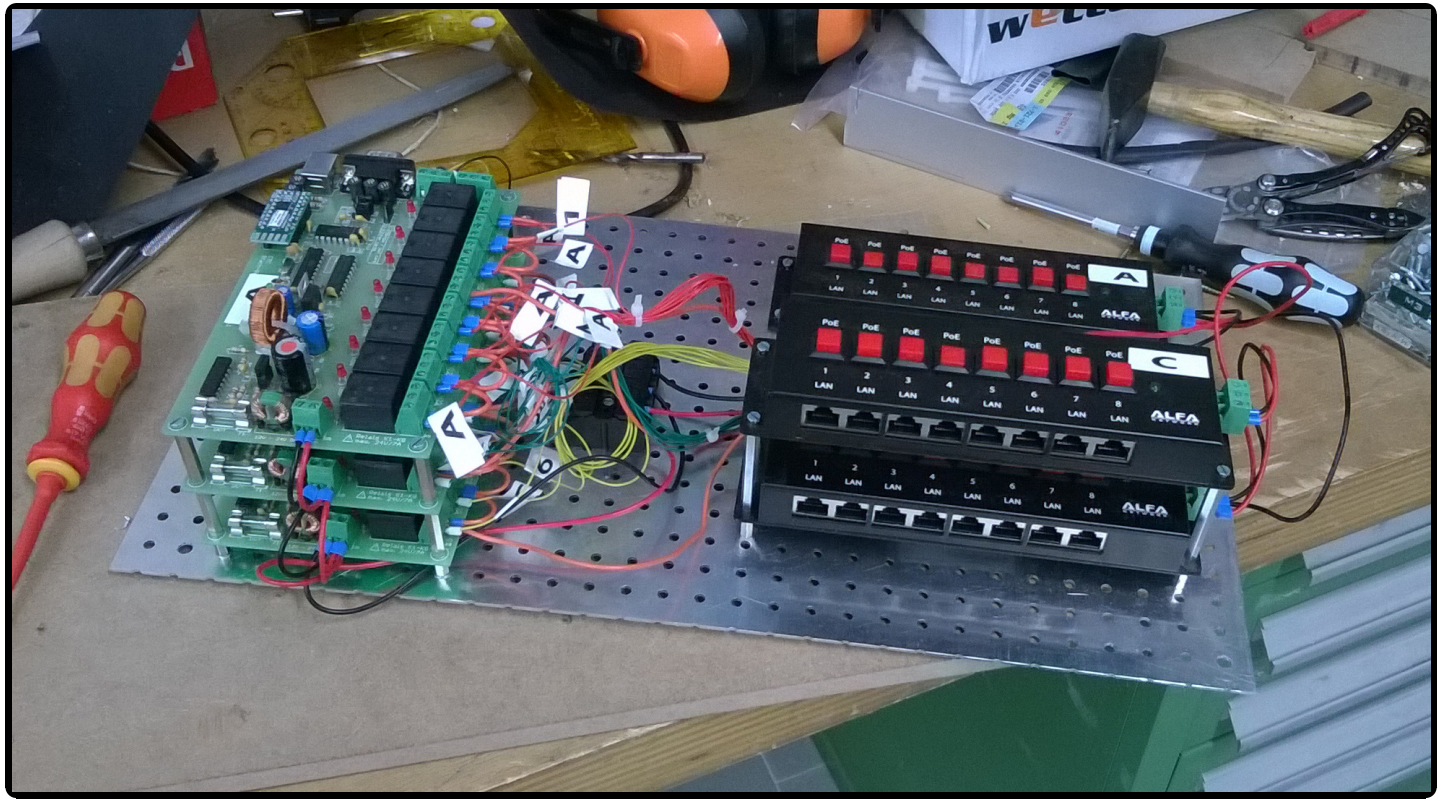
Central Box – Architecture

Components in central box

- Linux IPC (24V powered)
- Ethernet Switch and controllable, passive PoE Injectors
- 24V PSU, Inverter for Ethernet Switch



Central Box – Impressions



Central Box – Impressions

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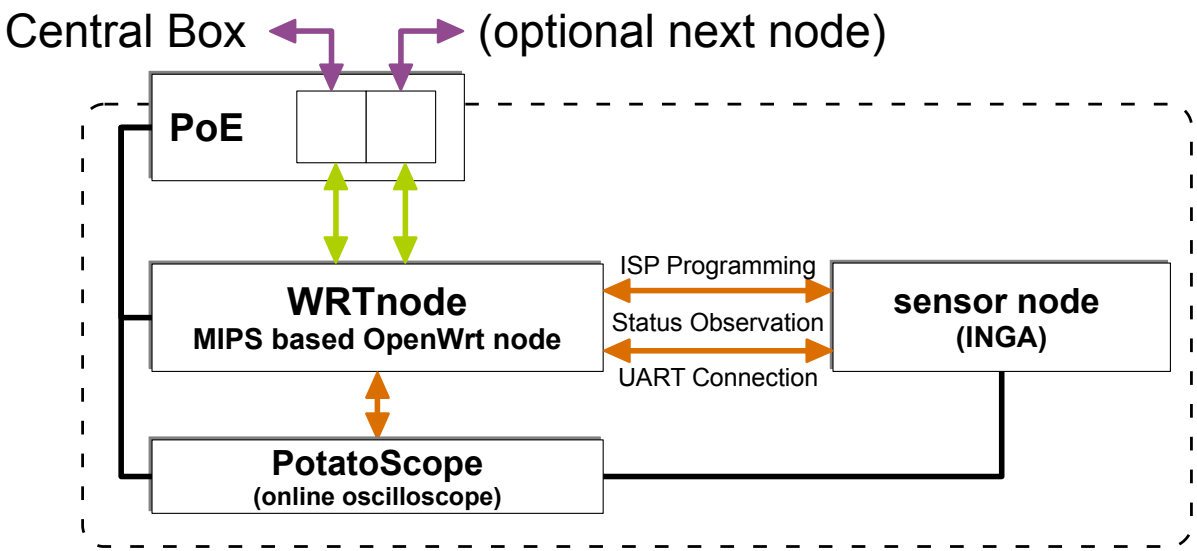
Field Node – Architecture

Components of the field node

- WRTnode (OpenWRT Linux Board)
- INGA Wireless Sensor Node
- Powered via PoE → Concatenation of Nodes possible



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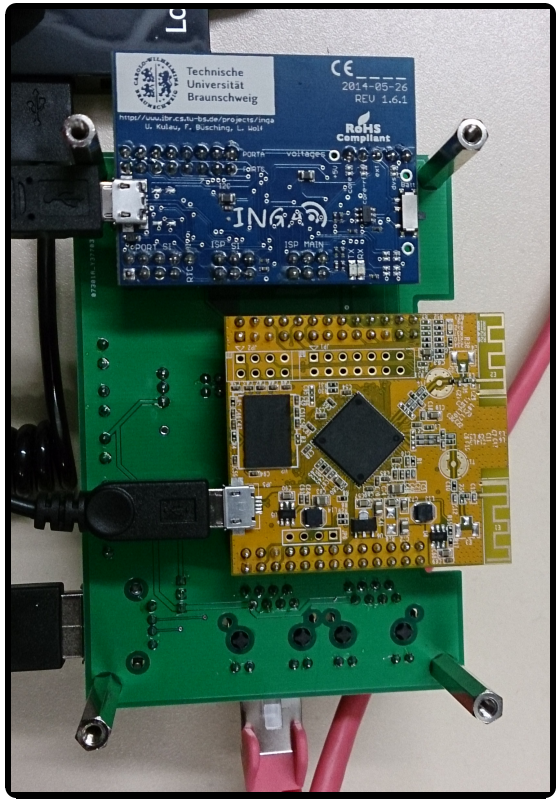

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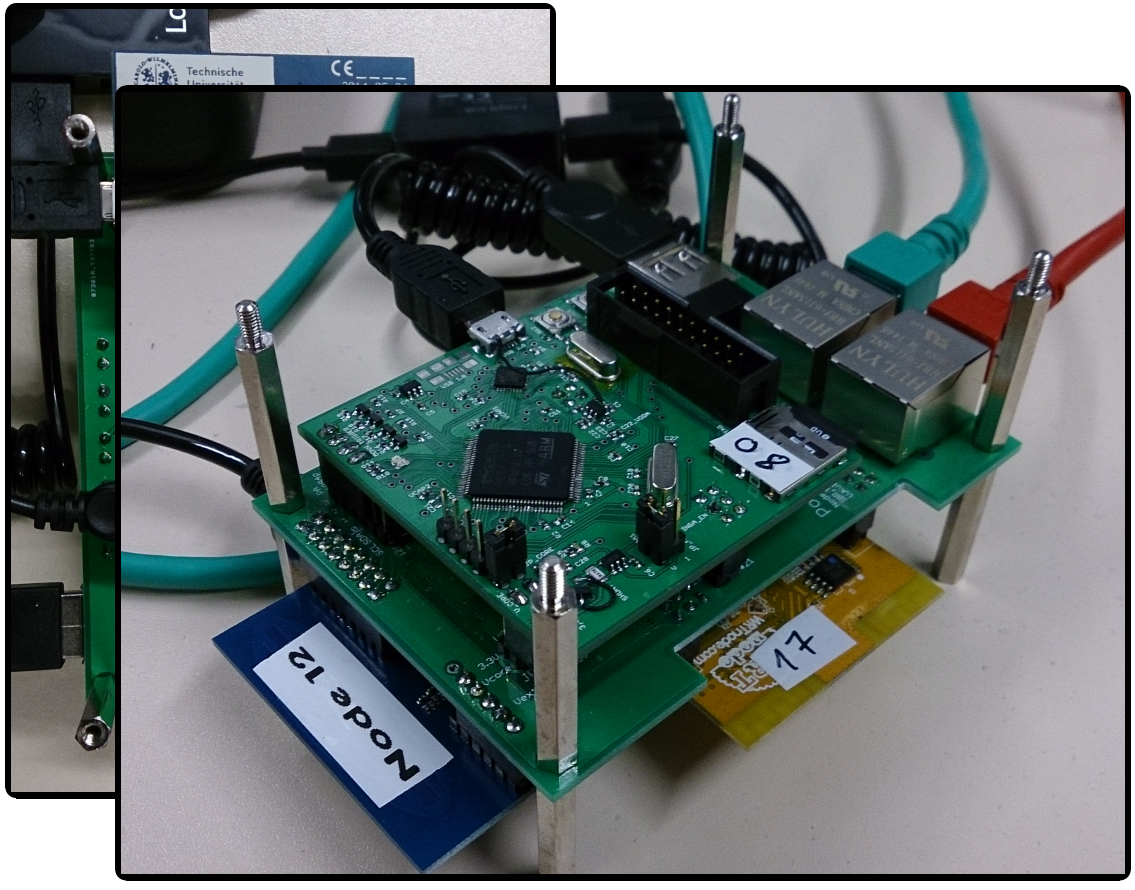

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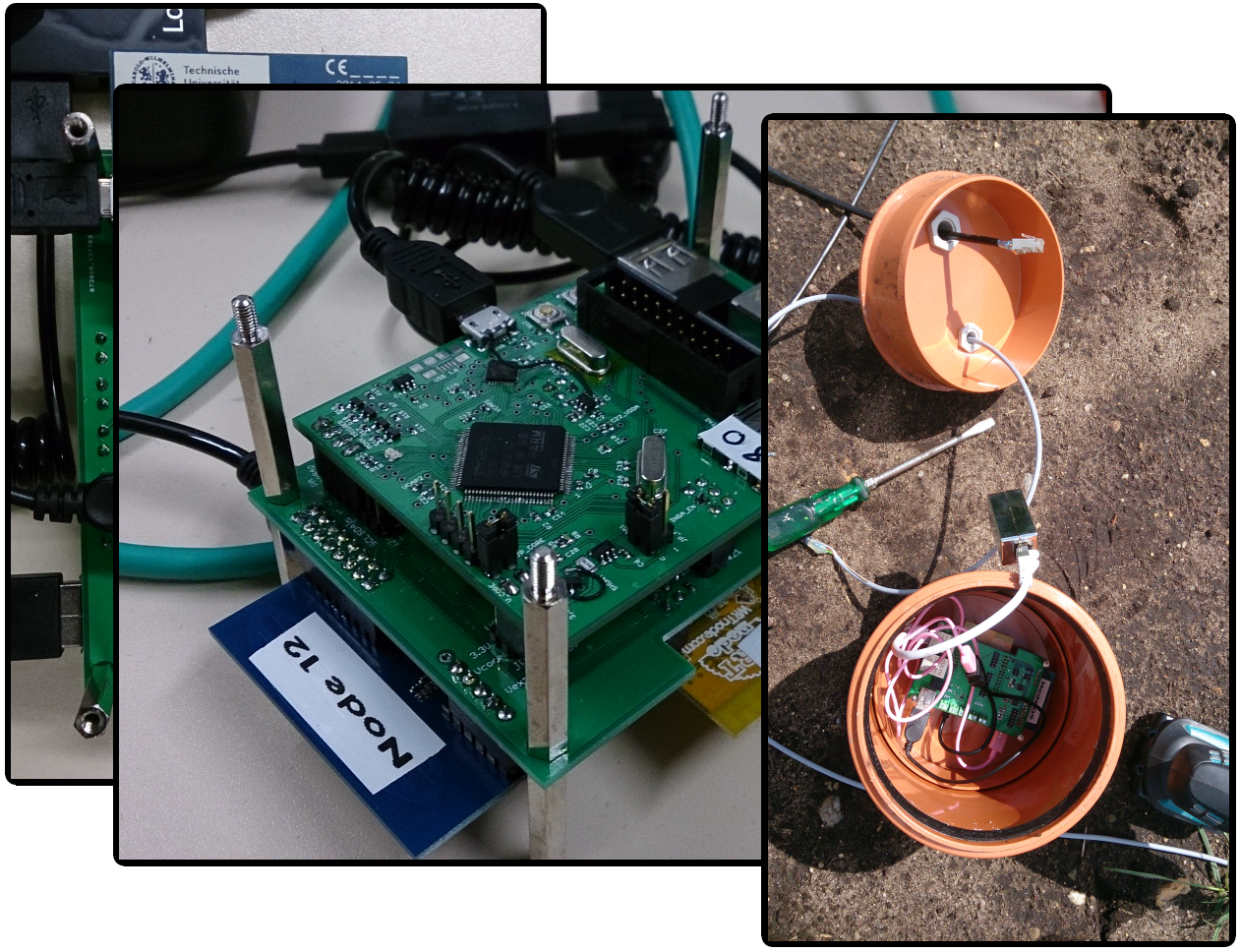
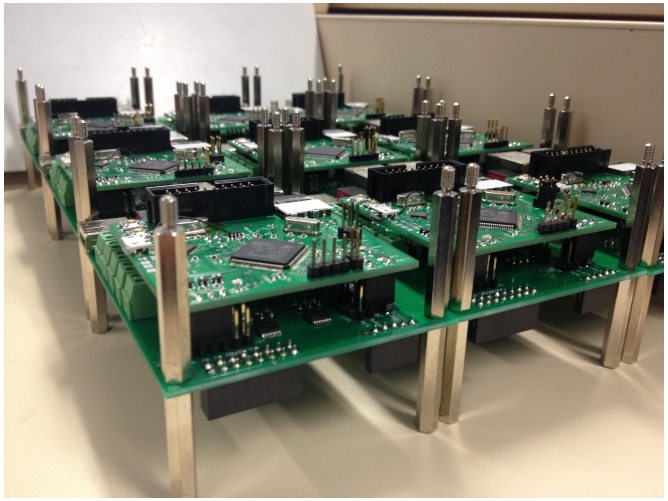


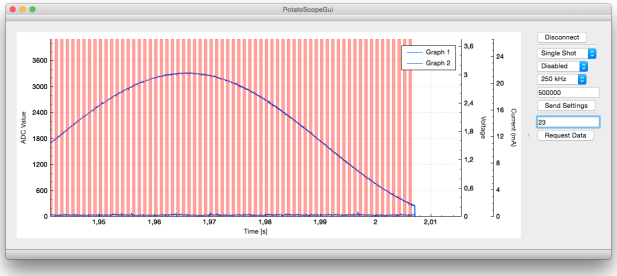
Field Nodes – Impressions

PotatoScope – Temperature-invariant Oscilloscope

Features:

- Measures two channels simultaneously
  - 12Bit resolution, at 250kHz max.
  - Range – 2,5V (3,75V) / 26,6mA
- Implementation of different modes
  - Single-Shot
  - Continuous
  - Triggered
  - Live-View
- Trigger can be used as markers
- Stand-alone usage possible
  - Power supply and communication via USB

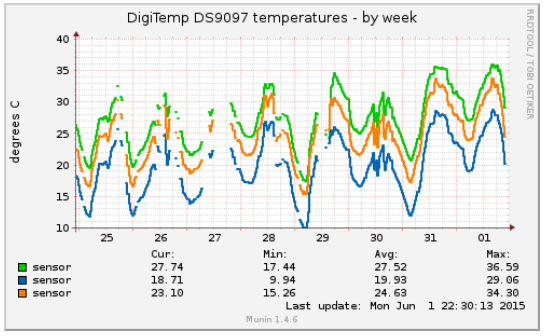




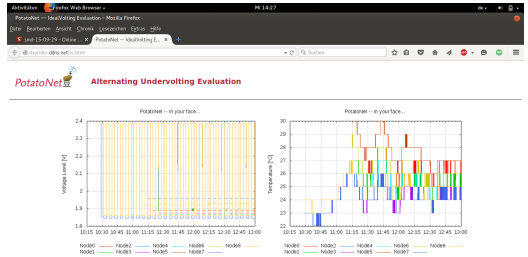
Maintenance and Monitoring

System Overview

- Central Box establishes reverse SSH-Tunnel to university
- Login to central box via SSH possible
- Field nodes can be accessed from box
- *Munin* used for live-monitoring (temperature, CPU- & disk-usage, …)




```
Linux hotpotato 3.2.0-4-686-pae #1 SMP Debian 3.2.65-1+deb7u2 i686

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Sep 16 00:28:23 2015 from localhost

Go deeper.

Recently active nodes:
----------------------
1442496823 64:51:7e:33:98:ca 172.16.1.107 node7 *
1442496670 64:51:7e:33:9a:d0 172.16.1.108 node8 *
1442496658 64:51:7e:33:9a:ae 172.16.1.105 node5 *
1442496662 64:51:7e:33:9a:f6 172.16.1.106 node6 *
1442496655 64:51:7e:33:99:2e 172.16.1.104 node4 *
1442496336 64:51:7e:33:9a:a0 172.16.1.103 node3 *
1442496654 64:51:7e:33:9b:3c 172.16.1.102 node2 *
1442496655 64:51:7e:33:99:38 172.16.1.101 node1 *
1442496483 64:51:7e:33:9a:6c 172.16.1.100 node0 *

root@hotpotato:~#
```



Deployment Experiences

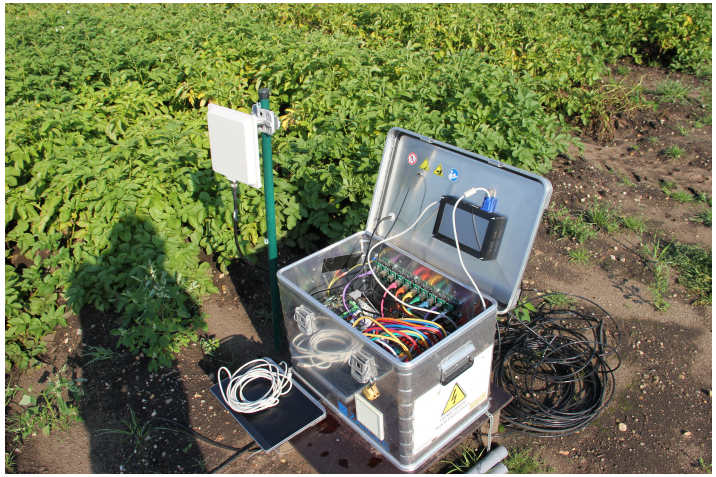
Running pretty stable since May 2015

Failures

- Blackout after thunderstorm
- Slow and unreliable UMTS uplink
- DSL cable cut once
- Fan for ventilation broken

Experiments

- More than 2.5GB of data
  - Download is challenging



What's next?

Future Work

- On-Site data aggregation and evaluation
- Ten more field nodes to come
- During summer: max. 50°C
  → Works during winter: we will see ;)

Conclusions

- Outdoor testbed for Smart Farming applications
- Running stable for nearly 6 months
- Wired DSL/Ethernet backbone and UMTS uplink
- ...

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Thank you!

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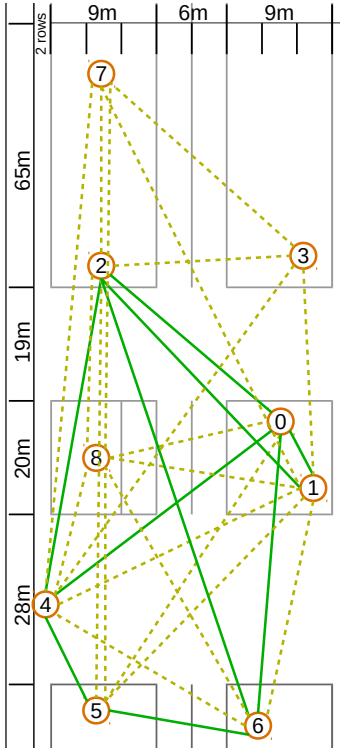
www.ibr.cs.tu-bs.de/projects/potatonet

PotatoNet 2014

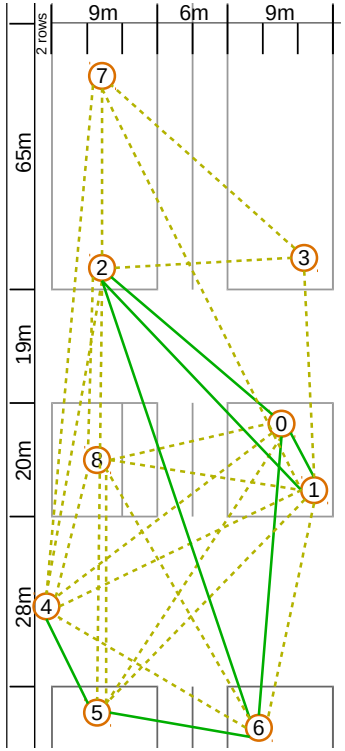
Date	What
May 29	**Additional VDSL PtP link installed**
May 30	First “science” on INGA: Topology
June 20	PotatoNet@TU-Night
June 29	First Undervolting experiments (IV Outdoor test)
July 4	DSL Uplink cut
July 9	Additional hardware (van Balen)
July 17	IdealVolting vs. normal operation
August 21	Temporary removal of nodes
August 26	Nodes set up again, until $\approx$ End September

PotatoNet - Topologies

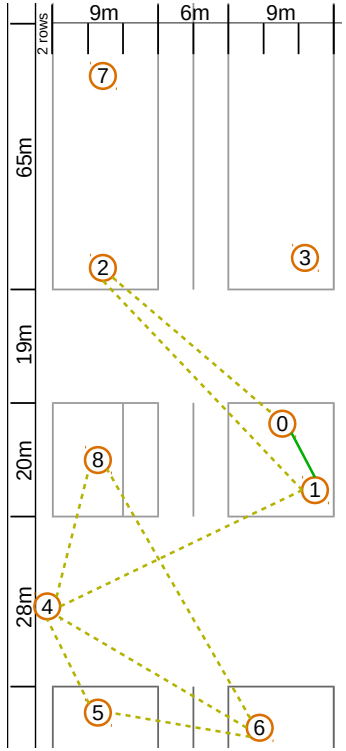
WSN Topologie at different TX levels:



tx level=4dbm



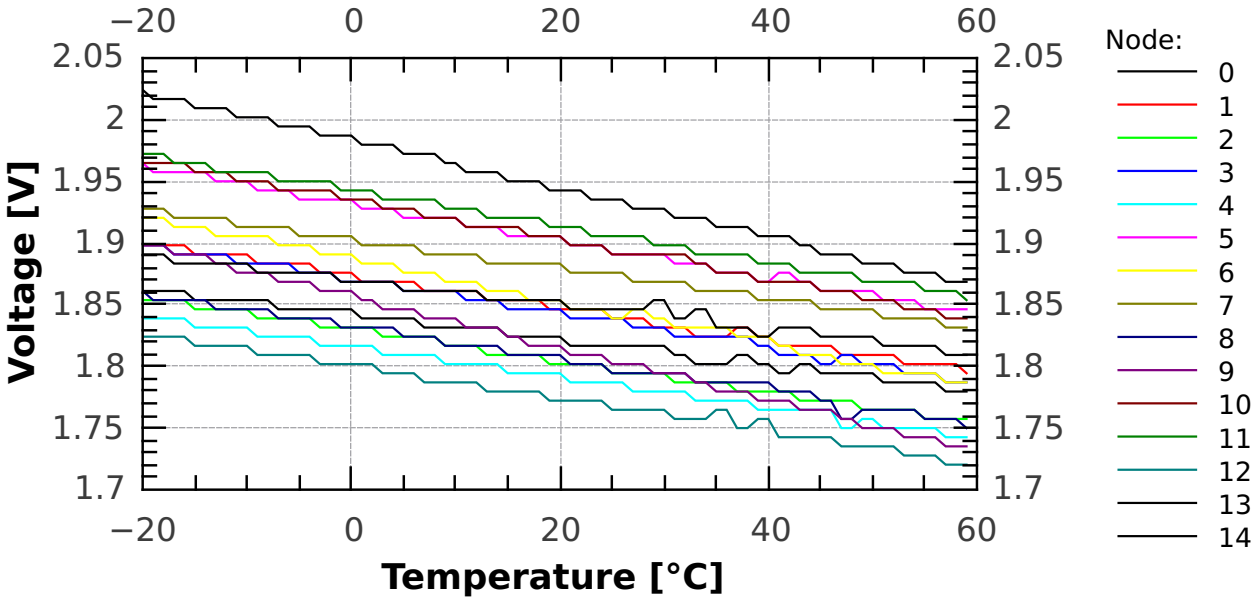
tx level=0dbm



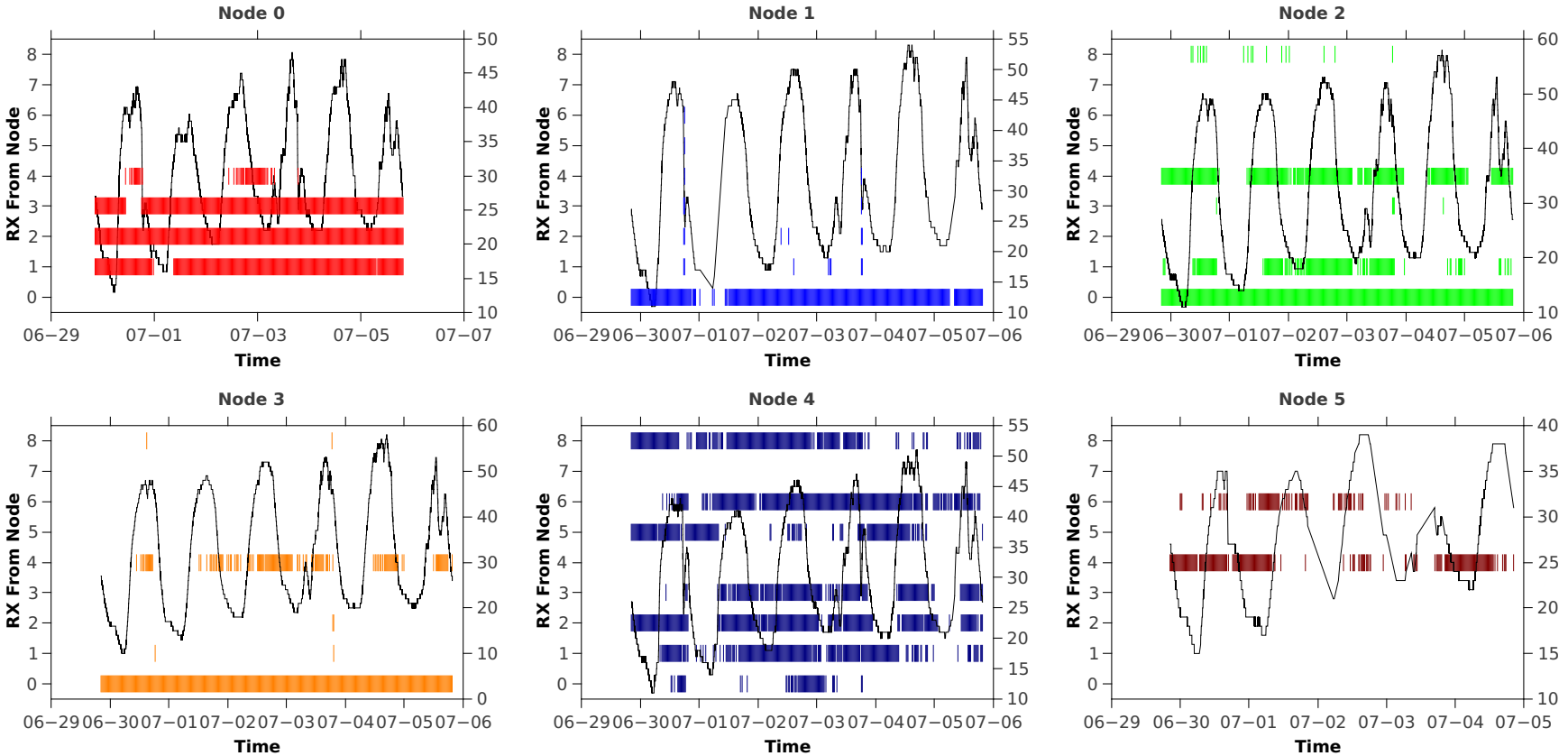
tx level=-17dbm

PotatoNet - Undervolting Experiences 1

Voltage Levels vs. Temperature



PotatoNet - Undervolting Experiences 2



Applications – Potato Plant Dehydration

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