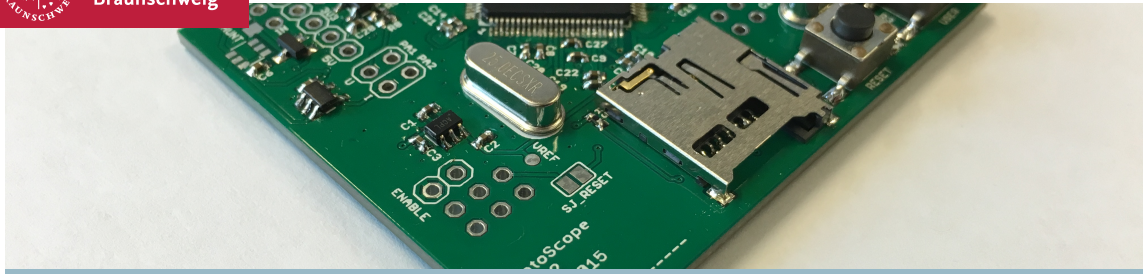
Technische Universität Braunschweig

Institute of Operating Systems and Computer Networks



Distributed Energy Measurement in WSNs for Outdoor Applications

Robert Hartung, Ulf Kulau, Lars Wolf, 2016-06-29

Institute of Operating Systems and Computer Networks, TU Braunschweig

Motivation

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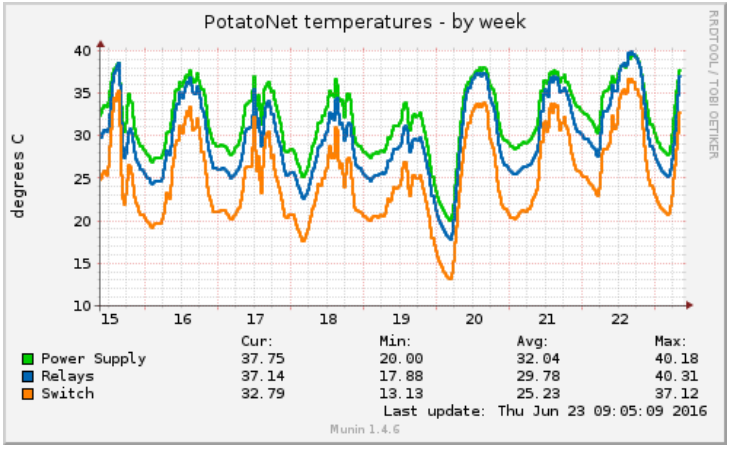
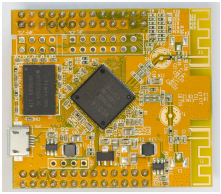

PotatoNet temperatures - by week
RRDTOOL / TOBI OETIKER
degrees C
40
35
30
25
20
15
10
15
16
17
18
19
20
21
22
Cur:
Min:
Avg:
Max:
Power Supply
37.75
20.00
32.04
40.18
Relays
37.14
17.88
29.78
40.31
Switch
32.79
13.13
25.23
37.12
Last update: Thu Jun 23 09:05:09 2016
Munin 1.4.6

PotatoNet – Architecture

INGA sensor node

PotatoNet – Architecture

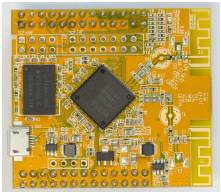
INGA sensor node



WRTnode

PotatoNet – Architecture

INGA sensor node

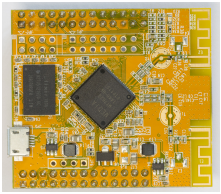


WRTnode

Housing

PotatoNet – Architecture

INGA sensor node

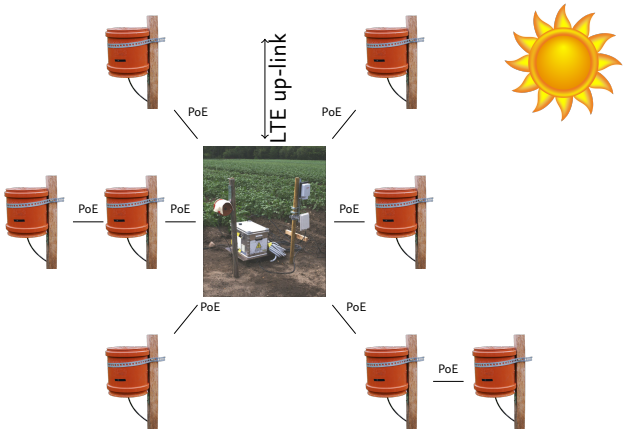


WRTnode

Housing

Nodes

PotatoNet – Architecture



PotatoNet – Node distribution

500m

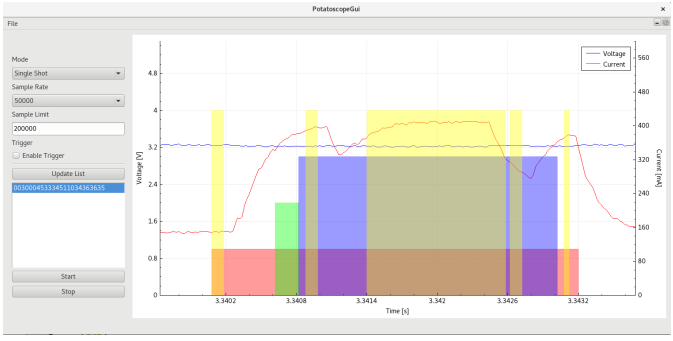
Copyright by Google Maps

Distributed Energy Measurement System

Requirements

- Error <2% in a range of -30°C up to 70°C
- Low cost! (equip many nodes)
- Centralized system and easy-to-use
- Sample rate >= 10kHz
- Trigger/Marker signals

Trigger/Marker



Total

Idle

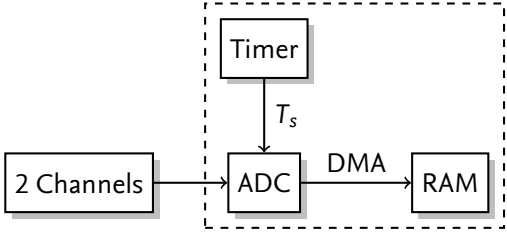
CreateFrame

Send

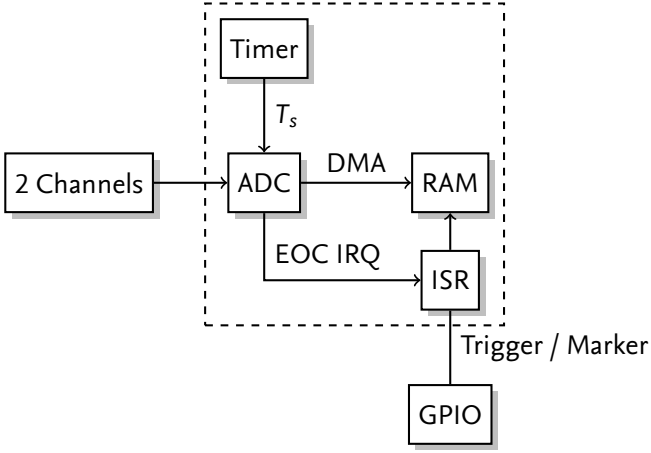
PotatoScope – Architecture

2 Channels

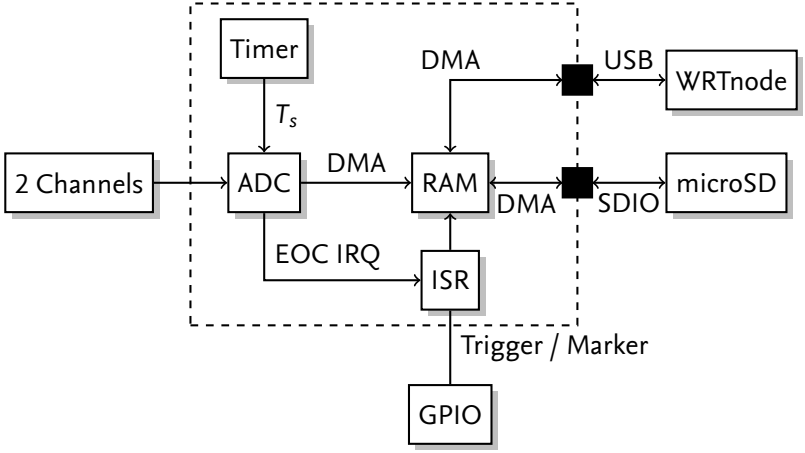
PotatoScope – Architecture



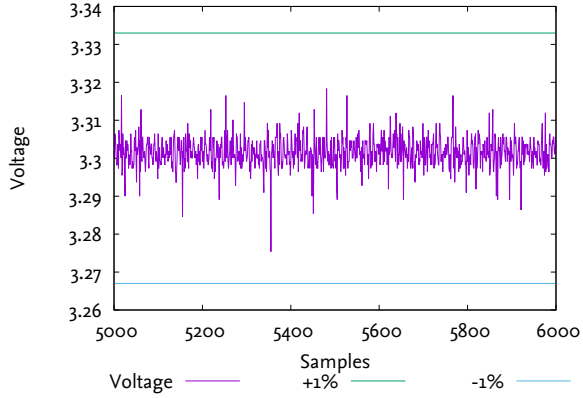
PotatoScope – Architecture



PotatoScope – Architecture

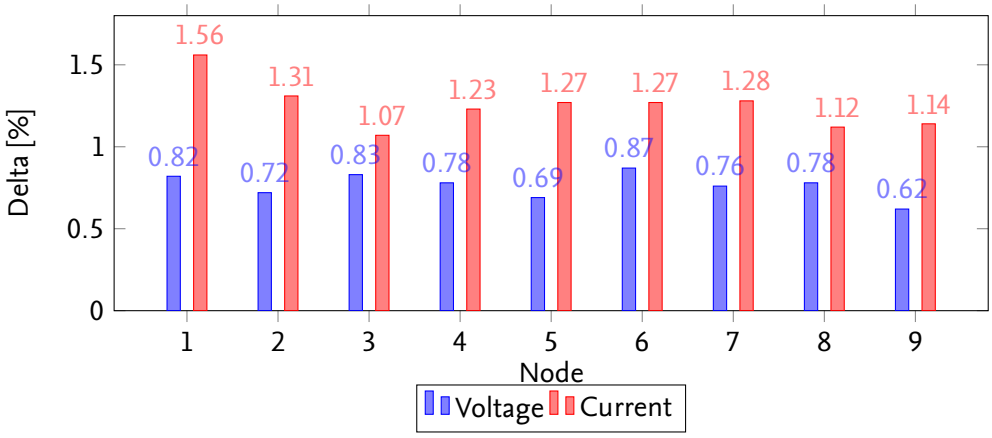


Evaluation – Noise

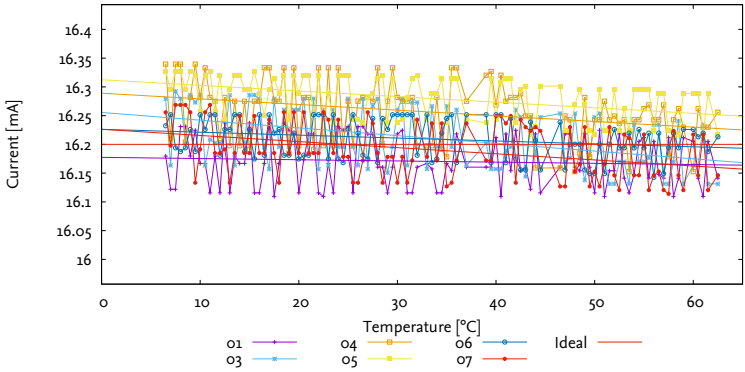


Result: Noise $\pm 0.7\%$

Evaluation – Noise



Evaluation – Drift in current consumption

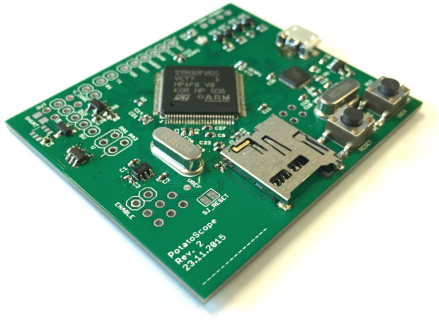


Result: Drift of 0.83% over 100K

Interim Conclusion

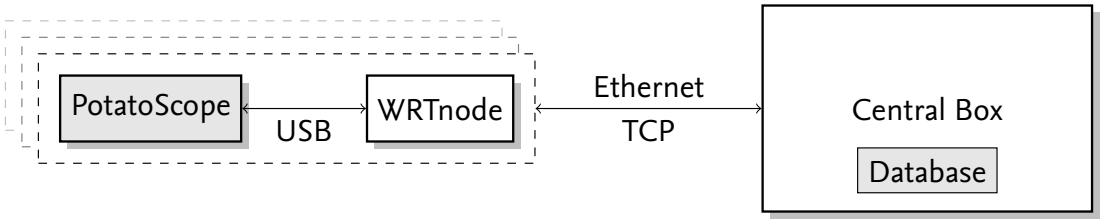
Features

- STM32F2 MCU
- USB 2.0 interface
- microSD card
- 4 trigger/marker GPIOs
- 23 sample rates: 1Hz - 2MHz
- Different modes
- C-based CLI



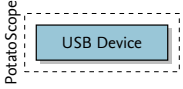
- Reasonable temperature drift (<1%)
- Overall error <2%

DEMS – Architecture

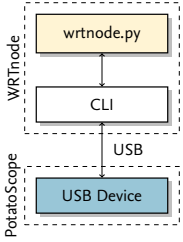


- Decentralized storage
  - Data stored on each microSD card
  - Only meta data stored on central server
- Grouping of nodes

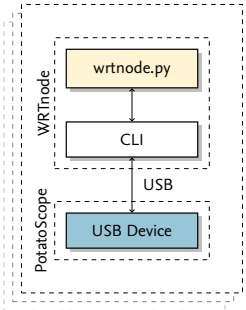
DEMS – Software architecture



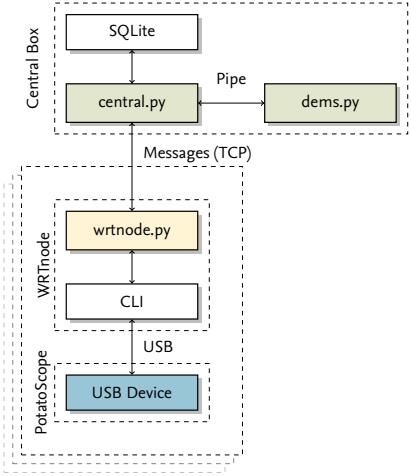
DEMS – Software architecture



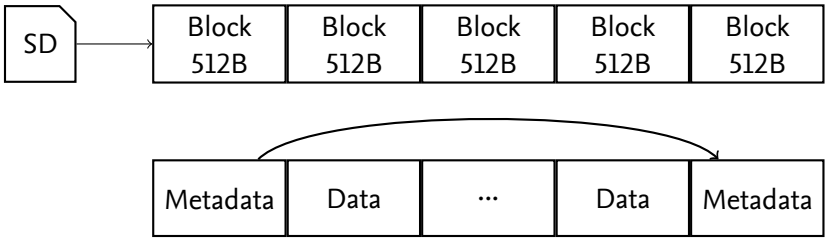
DEMS – Software architecture



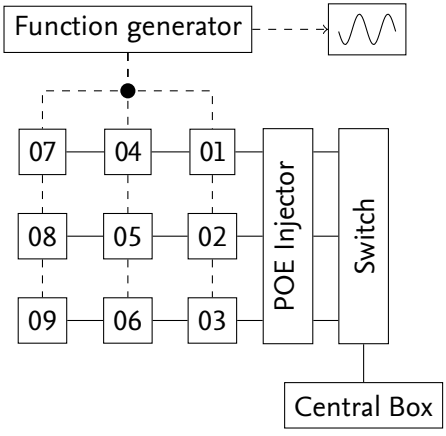
DEMS – Software architecture

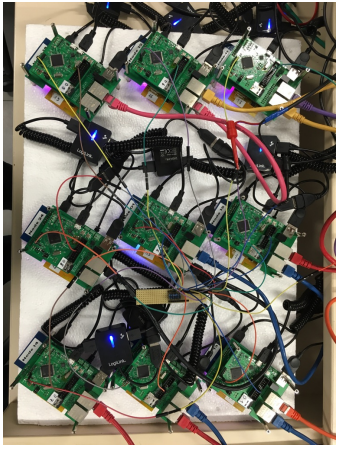


Data storage

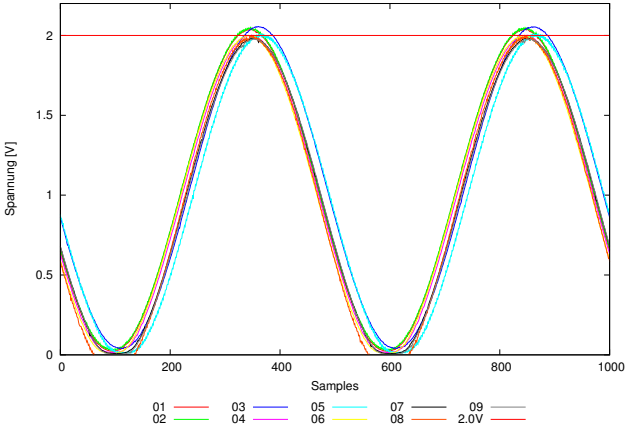


DEMS – Evaluation: Setup





DEMS – Evaluation: Result



Conclusion

- Measurements up to 500kHz
  - Up to 2 MHz in LIVE mode
- Temperature effect small (< 1% drift)
- Overall error <2%
- Easy to use Distributed Energy Measurement System
- Scalable and low-cost

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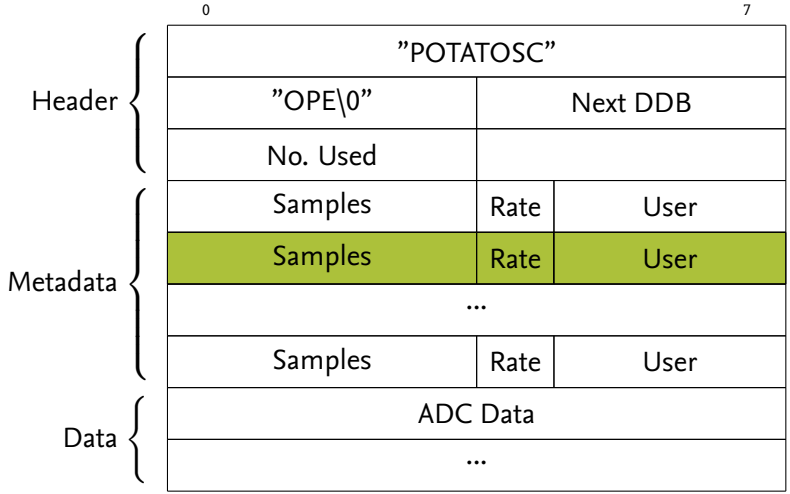
  hartung@ibr.cs.tu-bs.de

- Source Code / Schematics at
  `https://gitlab.ibr.cs.tu-bs.de/potatoscope`
  `https://gitlab.ibr.cs.tu-bs.de/potatonet/dems`

PotatoScope – microSD data structure



Future Work

- PotatoScope, Rev. 3
  - More compact design
  - Exchangeable gain/shunts
- Measurements, e.g.
  - Multi-Hop vs Single-Hop
  - Undervolting
  - Energy-efficiency of ripple