Technische Universität Braunschweig

Institute of Operating Systems and Computer Networks

Adaptive Wireless Sensor Networks

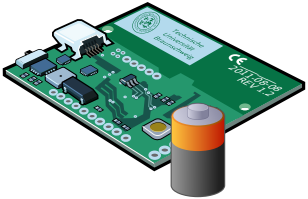
On challenges from temperature and energy harvesting

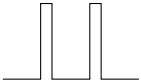
Robert Hartung, July 28, 2017

Part I

Introduction

Traditional Wireless Sensor Networks

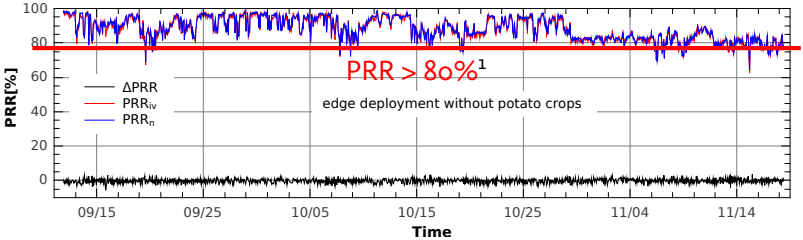


+  = Lifetime

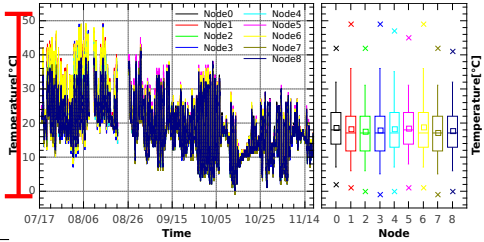
(Outdoor) WSNs: Challenges

- Rain, Fog, Humidity, etc.
- Temperature
- Multipath effects
- ... probably more!

Example: Temperature

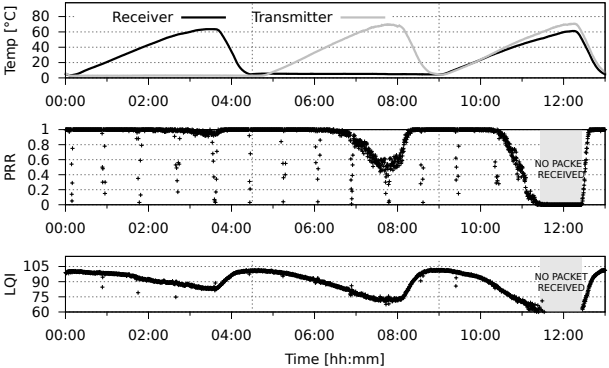


50° range



[1] http://dl.acm.org/citation.cfm?id=2885500

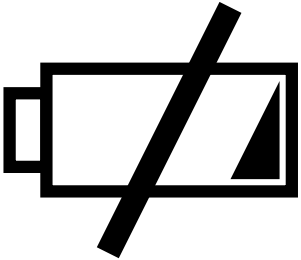
Temperature dependency of ChipCon Radio Transceivers



- Same behavior shown in more than **ten** papers
- Higher temperature $\rightarrow$ decreasing *PRR*
- `Their idea:` Same model for all nodes

Introduction – Conclusion

- WSNs have grown in requirements and complexity
  - Communication might shut down due to temperature
  - *not to speak of the IoT*
- Current focus is temperature
  - Application's purpose not guaranteed
  - Shorter lifetime due to re-transmissions



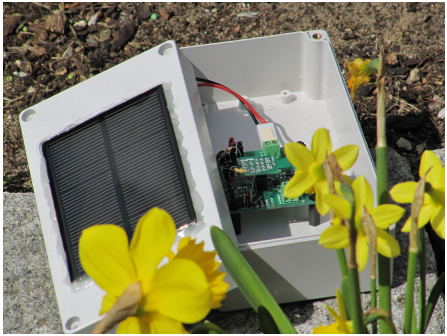
Ideas

- Do not send (delay) packets
- Increase PRR by switching the channel or path?

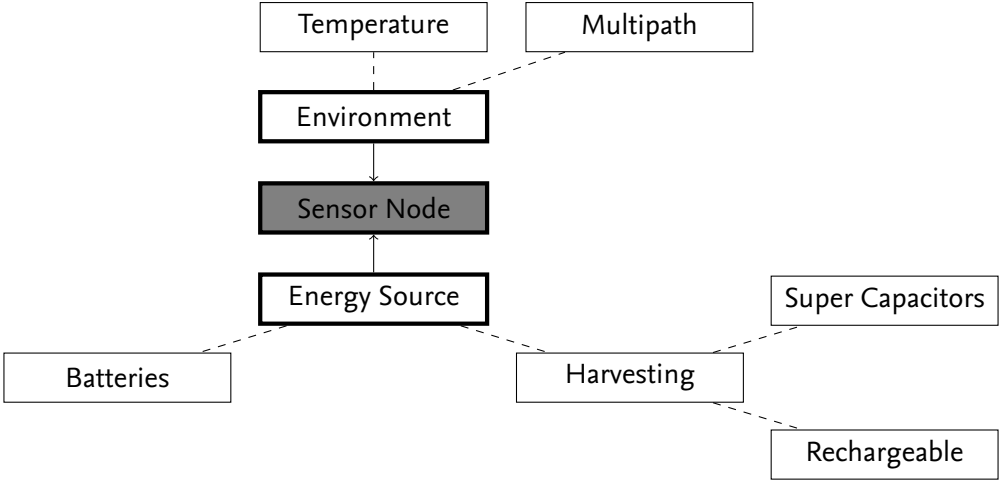
Energy Harvesting

Advances in technology...

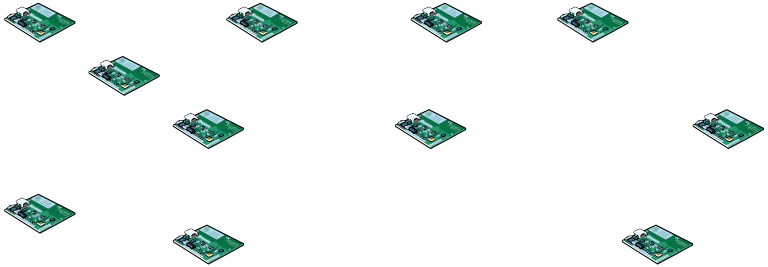
... enables to power more powerful devices (relate to energy transfer (RFID))
but: unreliable/variable and unpredictable



Putting it together



Towards adaptive WSNs



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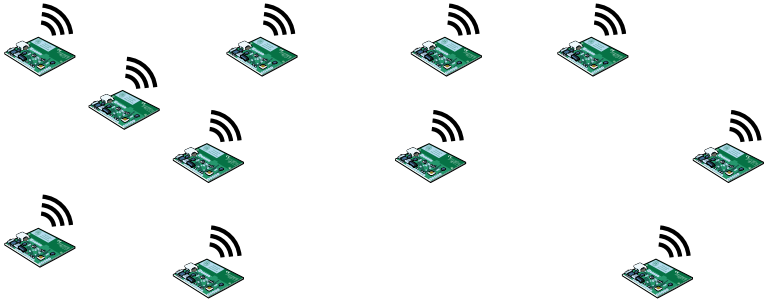

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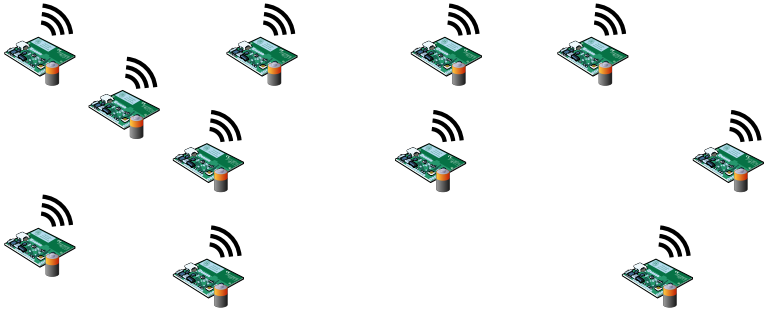

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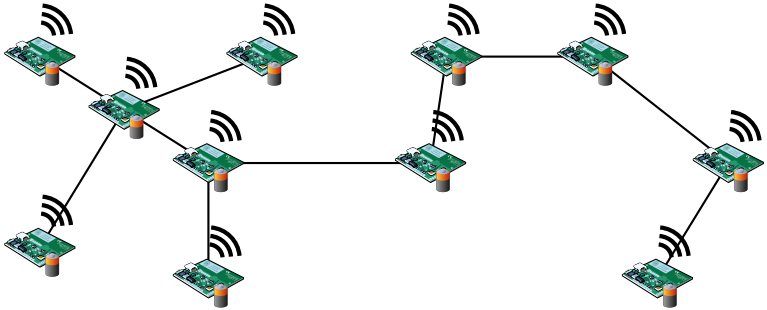

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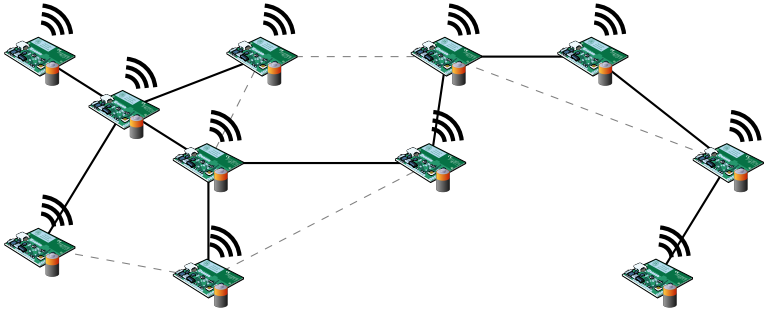

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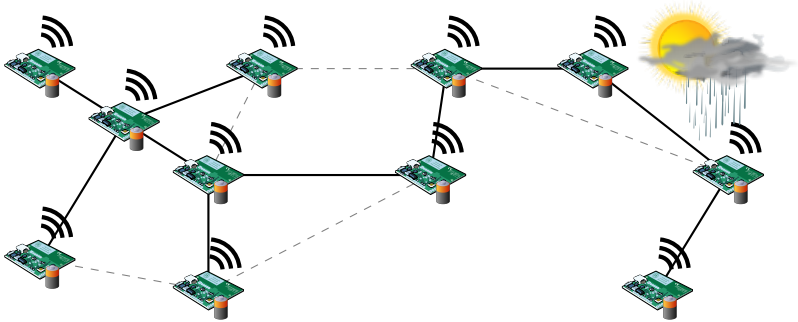

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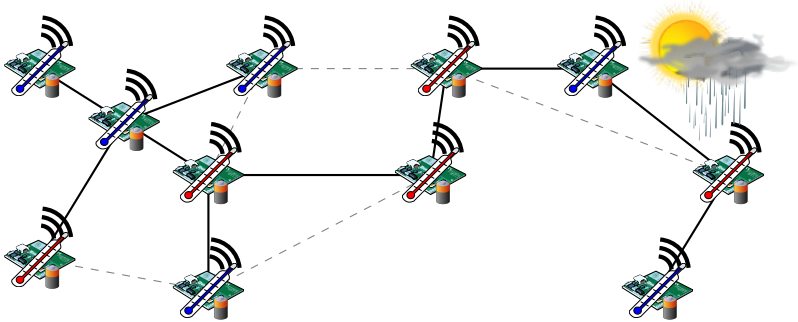

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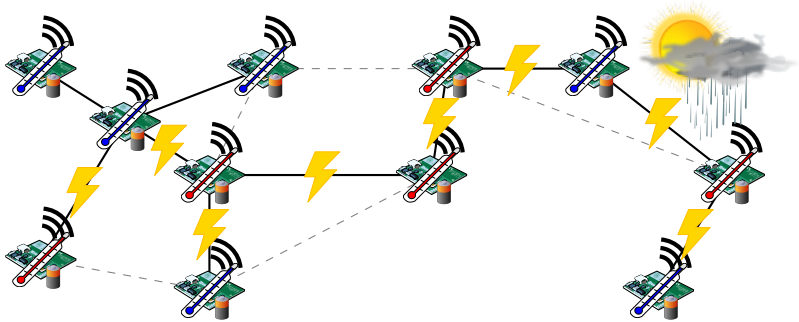


Part II

Steps taken so far

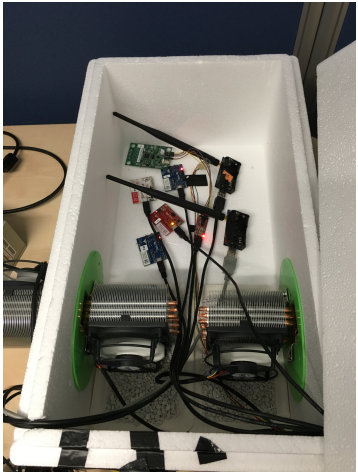
Temperature effects in heterogeneous networks

Purpose

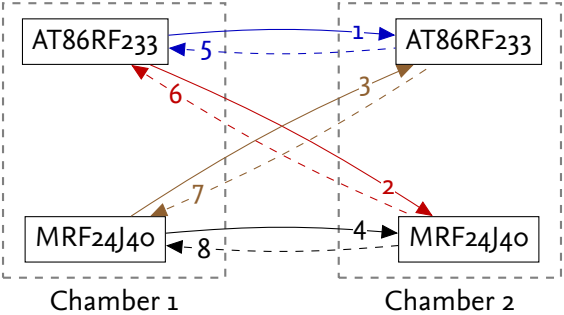
- Temperature controlled chambers[2][3]
- Different sensor nodes
- Show effects on heterogeneous networks

[3] https://www.ibr.cs.tu-bs.de/bib/xml/FGSN:2016.html
[3] https://www.ibr.cs.tu-bs.de/bib/xml/Hartung:Secon:2016.html

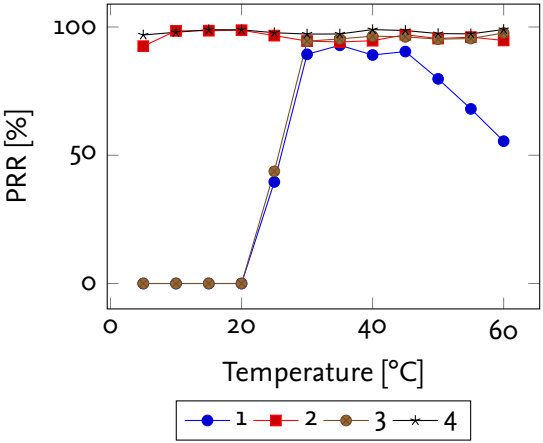
Climatic Chamber

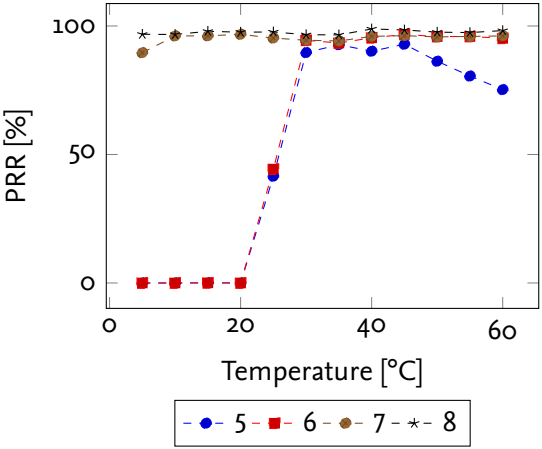


CC: Arrangement



CC: Results


100
50
0
PRR [%]
0
20
40
60
Temperature [°C]
1
2
3
4

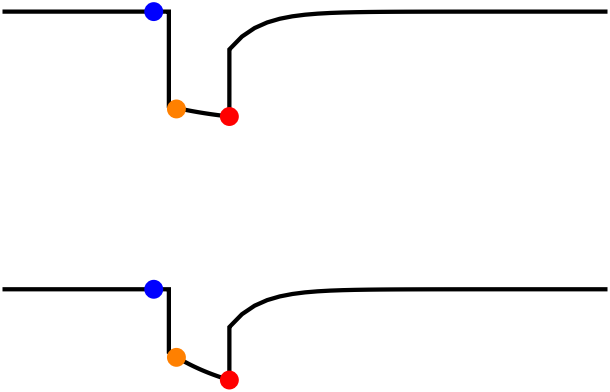

100
50
0
PRR [%]
0
20
40
60
Temperature [°C]
5
6
7
8

LCTC: Uppsala/CoRe Cooperation

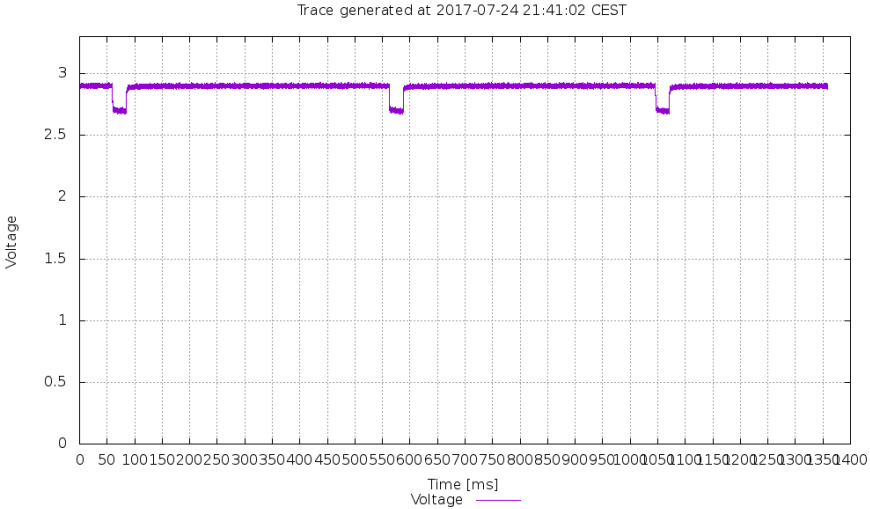
- They are testing 3V Batteries (CR2023)
- Deployment of > 10000 sensors with these batteries
- -> State of Charge (SoC) prediction
- Research: Different Load patterns and their effect on battery lifetime[4] [5]
- We will contribute the temperature effect part

[4] http://ieeexplore.ieee.org/abstract/document/6814721/
[5] https://link.springer.com/chapter/10.1007/978-3-642-38401-1_3

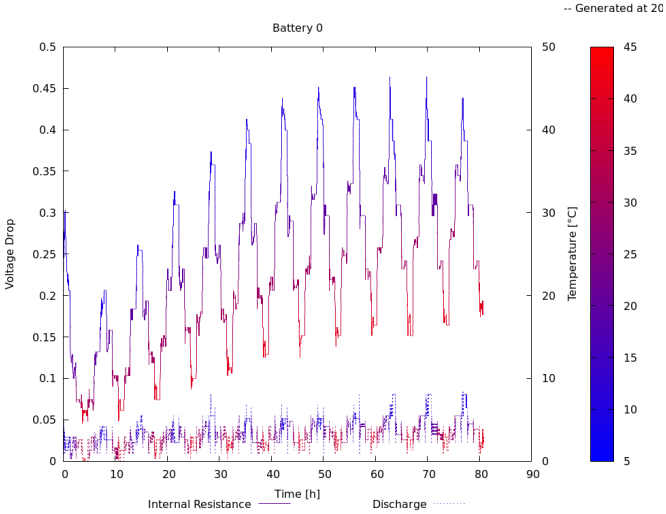
LCTC: Uppsala/CoRe Cooperation (2)



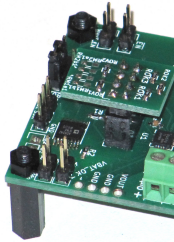
LCTC: SICS Cooperation (3)



LCTC: SICS Cooperation (4)

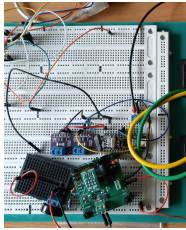


Energy Harvesting



- First prototype[a]
  - Different sources
- Working on a modular version for our sensor platform

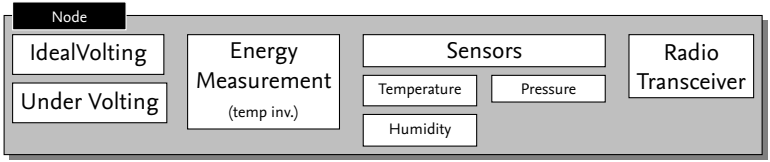
[a] https://www.ibr.cs.tu-bs.de/bib/xml/kulau:SenseApp:2017.html



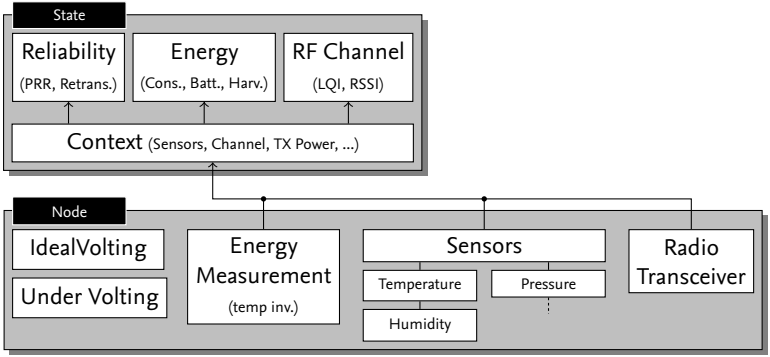
Part III

REAP / Future Work

REAP – Eco System



REAP – Eco System



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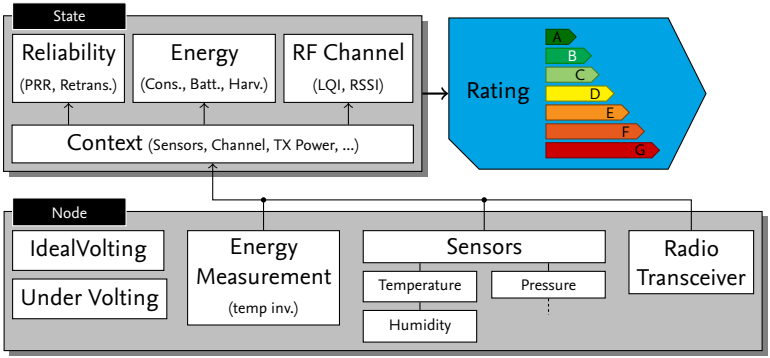

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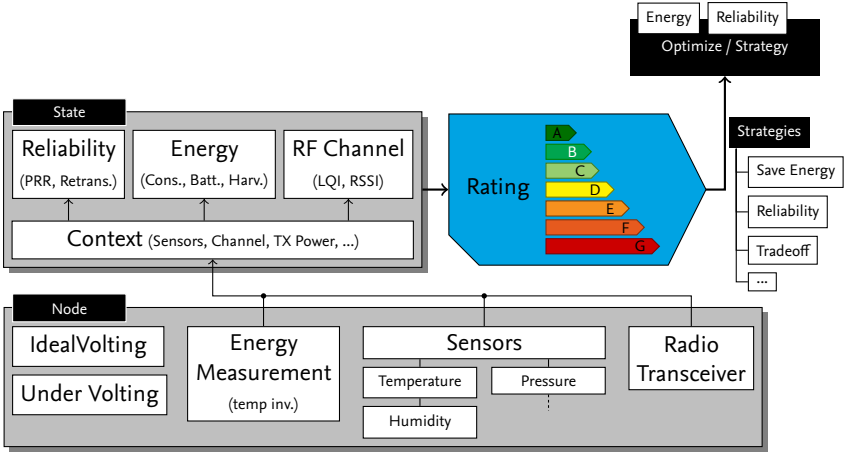

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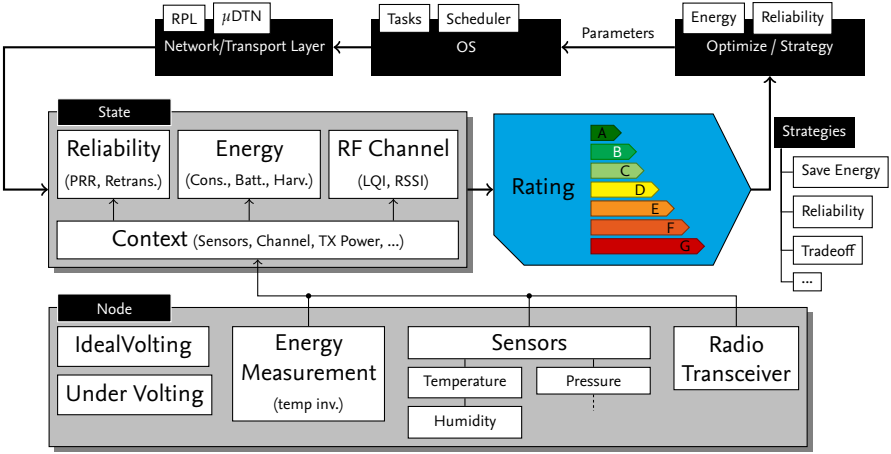
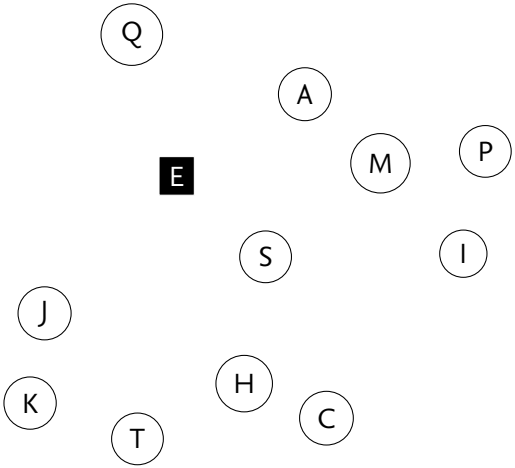


RPL: Principle



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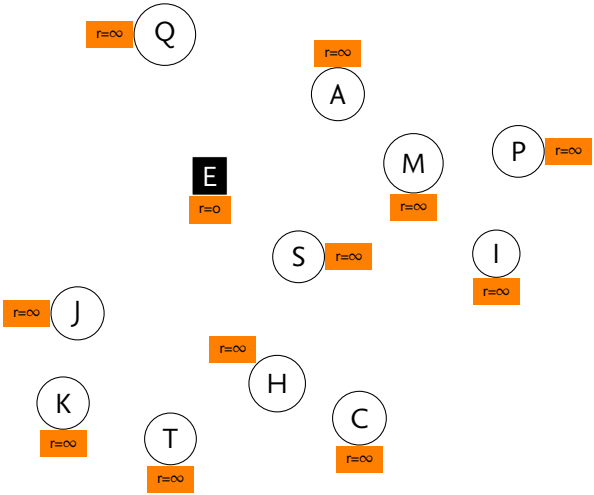

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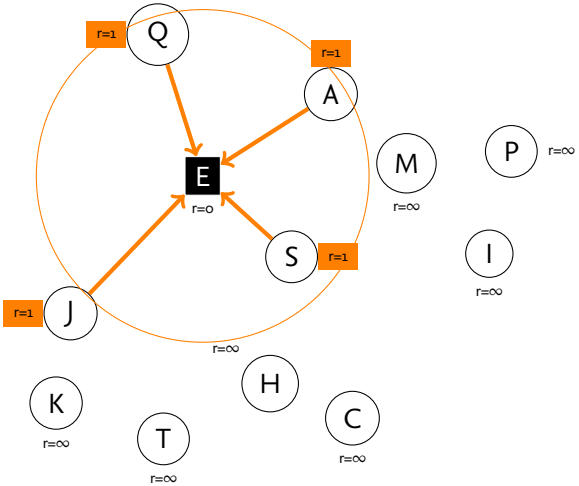

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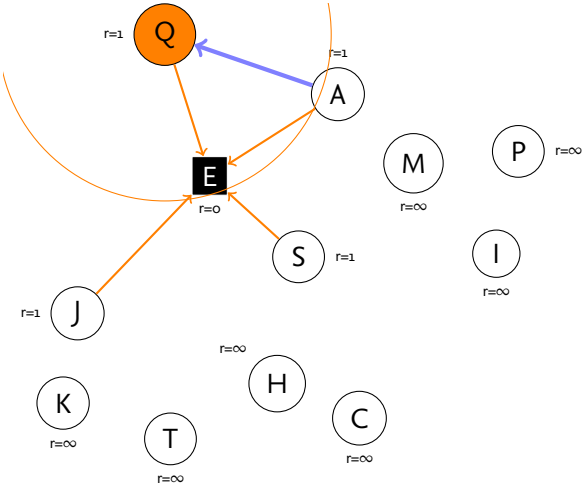

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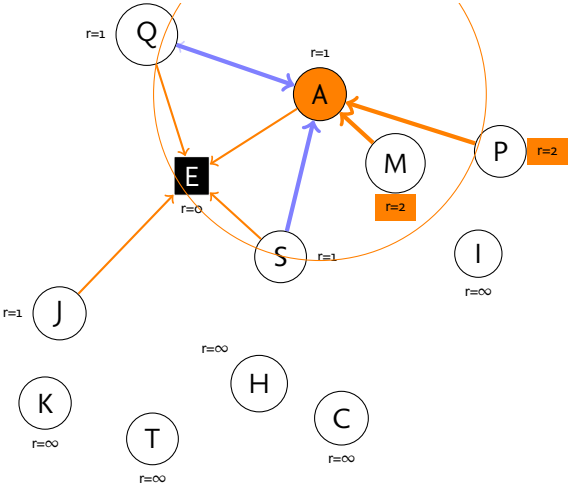

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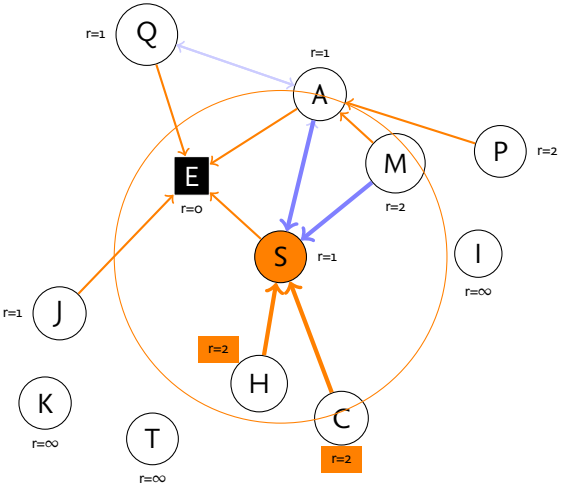

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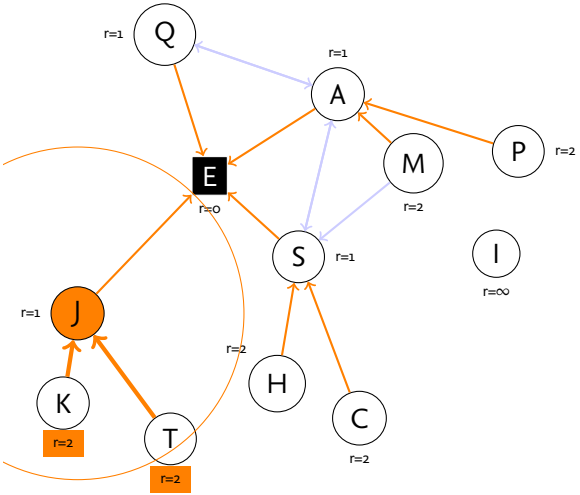

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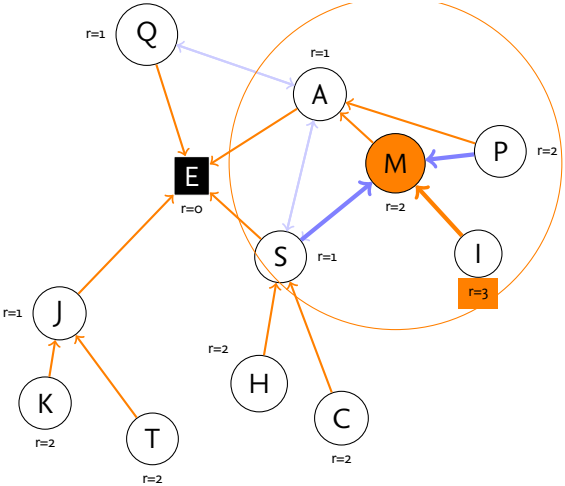

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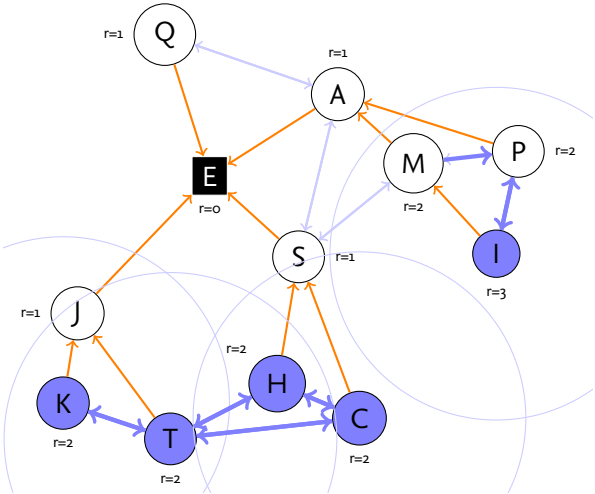

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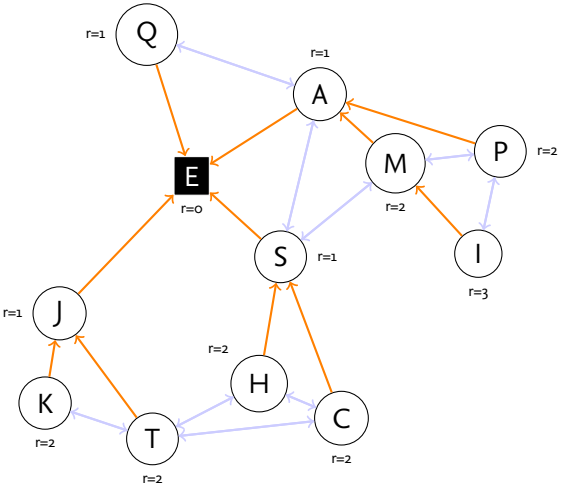
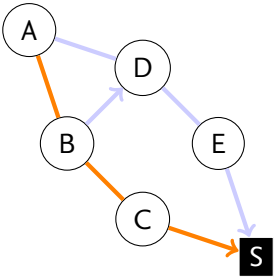


REAP – RPL Example



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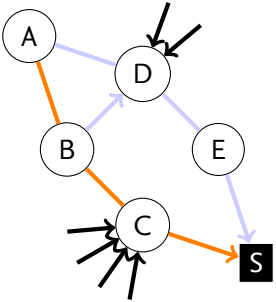

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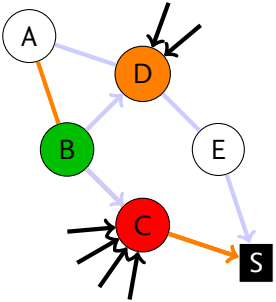

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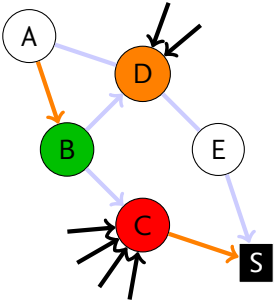

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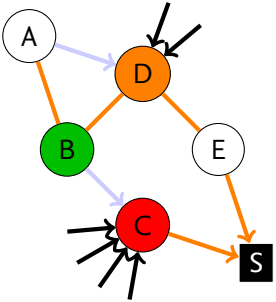

Robust RPL

What happens when nodes experience a reset?

- RPL state information are lost
- Large overhead due to messages

Ideas[6]

- Keep state in flash
- Implement validity check of / max. age?

[6] https://www.ibr.cs.tu-bs.de/bib/xml/Kulau:WOWMOM2017.html

Future Work

Measurements

- Supercaps (Charge/Discharge vs. Temperature)
- Heterogenous measurement

COOJA

- Optimization & Parallelization
- Temperature-dependent radio models

RPL

- Design & Write OF
- Simulate with different parameters

Interested in cooperations!

Two-platform nodes

Ampihsbaena[7]

- Low-power platform (STM32)
  - IEEE 802.15.4
  - Sensors
  - Harvesting
- High-power platform
  - WiFi
  - DTN

[7] https://www.ibr.cs.tu-bs.de/bib/xml/Rottmann:MASS:2016.html