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Self-Adaptive Reliable Sensor Networks

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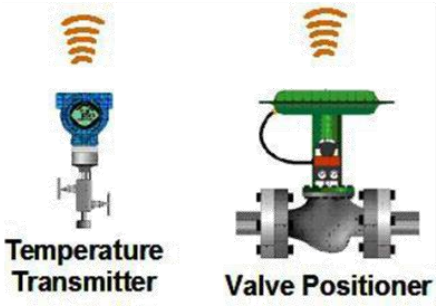
Reliability

Importance of reliability

- *Buzzwords: Industry 4.0, Tactile Internet, Internet of Important Things*
- *Monitoring & control of critical systems*



Reliability depending on application

1. *Successful data delivery* *packet loss ratio e.g.* 10^{-5}
2. *Adhere to given delay bounds* *end-to-end delay e.g.* *<10ms*

Key performance metrics

- *Time-to-Failure (TTF), Time-to-Repair (TTR)*
- *Delay & Jitter (cf. control loops)*
- *Throughput is not important here*

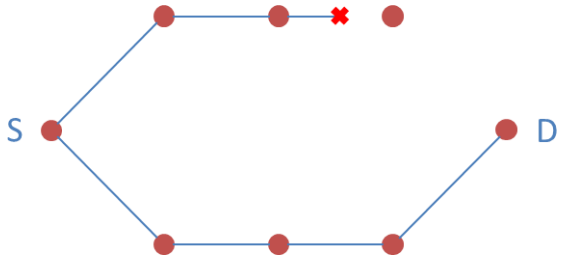
Methods

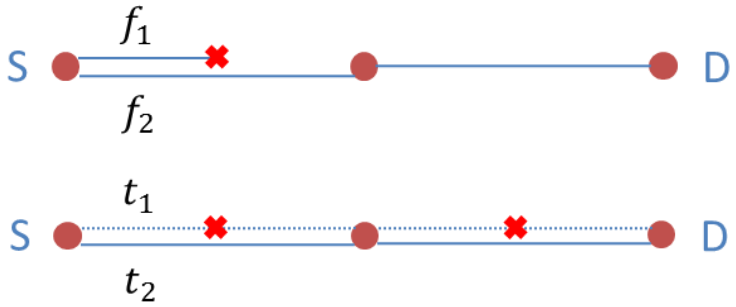
Single-Hop networks

- *Precalculate optimal* **channel hopping** *sequences for given interferer*

Multi-Hop networks

- *Provision* **multiple routes***: Known alternative route on failure, multiple routes or frequencies in parallel to increase chance of delivery*
- *Distributed channel hopping algorithms*





Single- and Multi-Hop: *Adapt to changing conditions*

➔ *Link Layer & Network Layer need to be considered*

Evaluation: Testbed & Simulation

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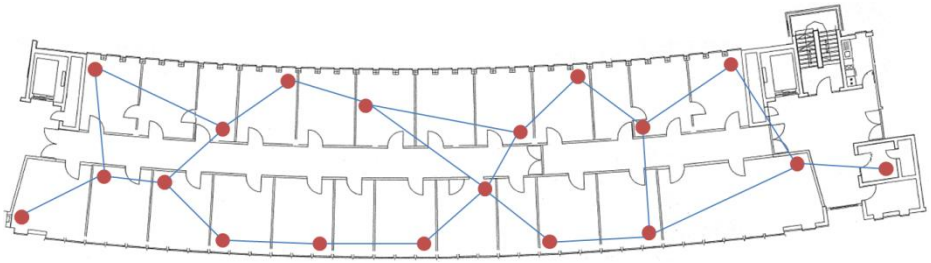
VEPSNet$_e$ sensor network [1]

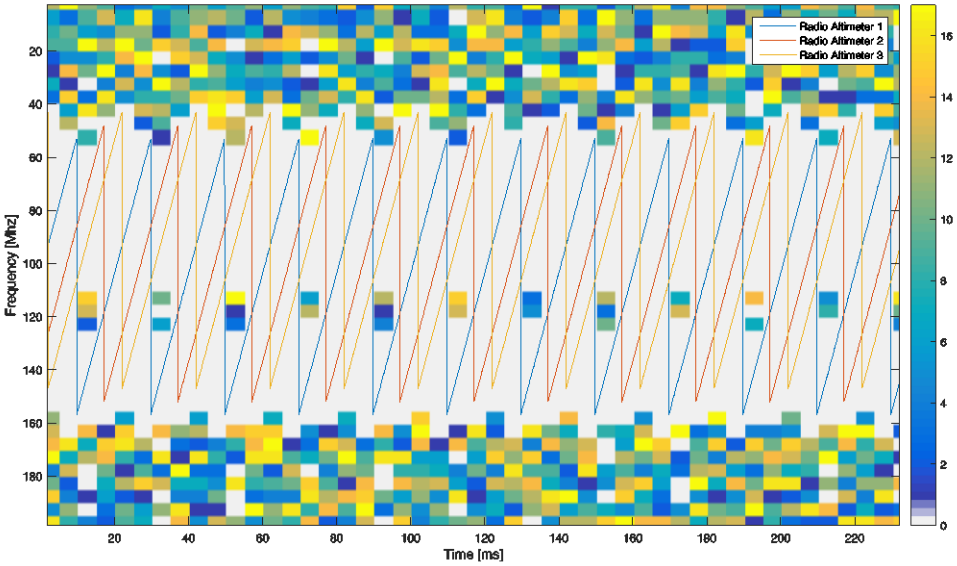
- *Central control & logging over Ethernet*
- *Focus on low entry effort & live data analysis*
- *Versatility: Multiple interfaces, programming languages, …*



[1] *Versatile Experiment Platform for Sensor Networks*

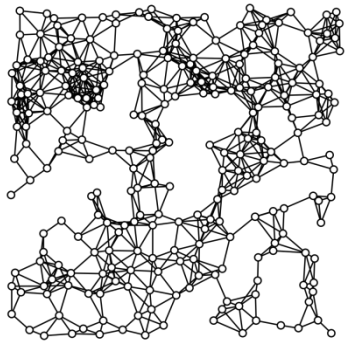
ISA100.11a model for the MiXiM framework (OMNeT++)

- *Interference Mitigation*
  - *optimizing* **hopping sequences**
  - *adaptation during runtime by employing the concept of* **Cognitive Radio**
- *Future: Use as a base for ISA100.11a/IEEE 802.15.4e/ WirelessHART simulations*



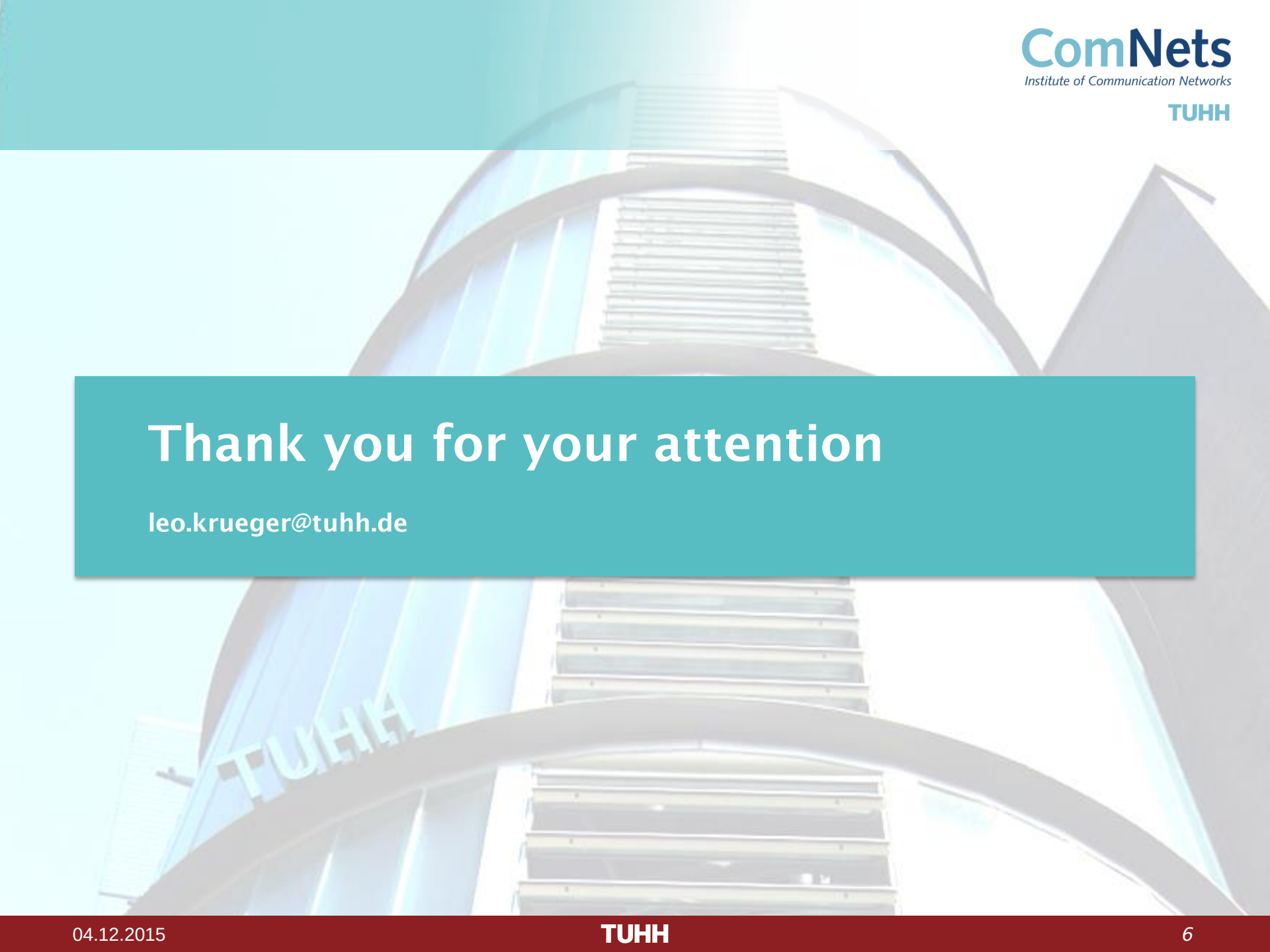
Analytical Evaluation

Verification: Multiple routes



- *Using* **Random Geometric Graphs** *to model WSNs [2]*
- *Propagation models to model the „probability of an edge“*
  - *Start with unit disk: probability either 1 or 0*
  - *Realistic propagation models*
- *Proof for a given graph: There exist 2 disjoint paths between any pair of nodes → k-connectivity [3]*
  - *Network with current structure can guarantee reliability by having the ability to provision multiple routes*
  - *Demanding additional constraints: Distance between routes*
- *Usage of the Random Geometric Graph to derive an interference graph, giving the probability of interference between any two nodes*
  - *Calculate schedule/hopping sequences (time, frequency) leading to lowest interference*

➔ *Maximize Time-to-Failure (TTF), minimize Time-to-Repair (TTR)*



Thank you for your attention

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References

[1] *Leo Krüger and Koojana Kuladinithi and Maciej Muehleisen and Andreas Timm-Giel (2015). Minimising the Entry Effort in Experimenting with WSN Testbeds to Perform Heterogeneous Research.*

[2] *Haenggi, M.; Andrews, J.G.; Baccelli, F.; Dousse, O.; Franceschetti, M., "Stochastic geometry and random graphs for the analysis and design of wireless networks," in Selected Areas in Communications, IEEE Journal on , vol.27, no.7, pp.1029-1046, September 2009*

[3] *Mathew D. Penrose. 1999. On k-connectivity for a geometric random graph. Random Struct. Algorithms 15, 2 (September 1999), 145-164*