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Source: Johannes Eckhardt **Company:** TU Braunschweig, Institut für Nachrichtentechnik
Address: Schleinitzstr. 22, D-38092 Braunschweig, Germany
Voice: +495313912474 FAX: +495313915192, E-Mail: eckhardt@ifn.ing.tu-bs.de
Re: n/a
Abstract: This presentation shows the methodology and results of a system level simulation of top-of-rack links in a realistic data center model. The propagation is modelled via ray tracing and beam steering is implemented accounting for varying antenna patterns as a function of the steering angle. Link level simulations are performed for each link considering the actual incident interference signals at the receiver. The simulations show the high impact of interference on the link performance and recommendations for interference reduction are given.

Purpose: Information of the Standing Committee THz

Technische Universität Braunschweig

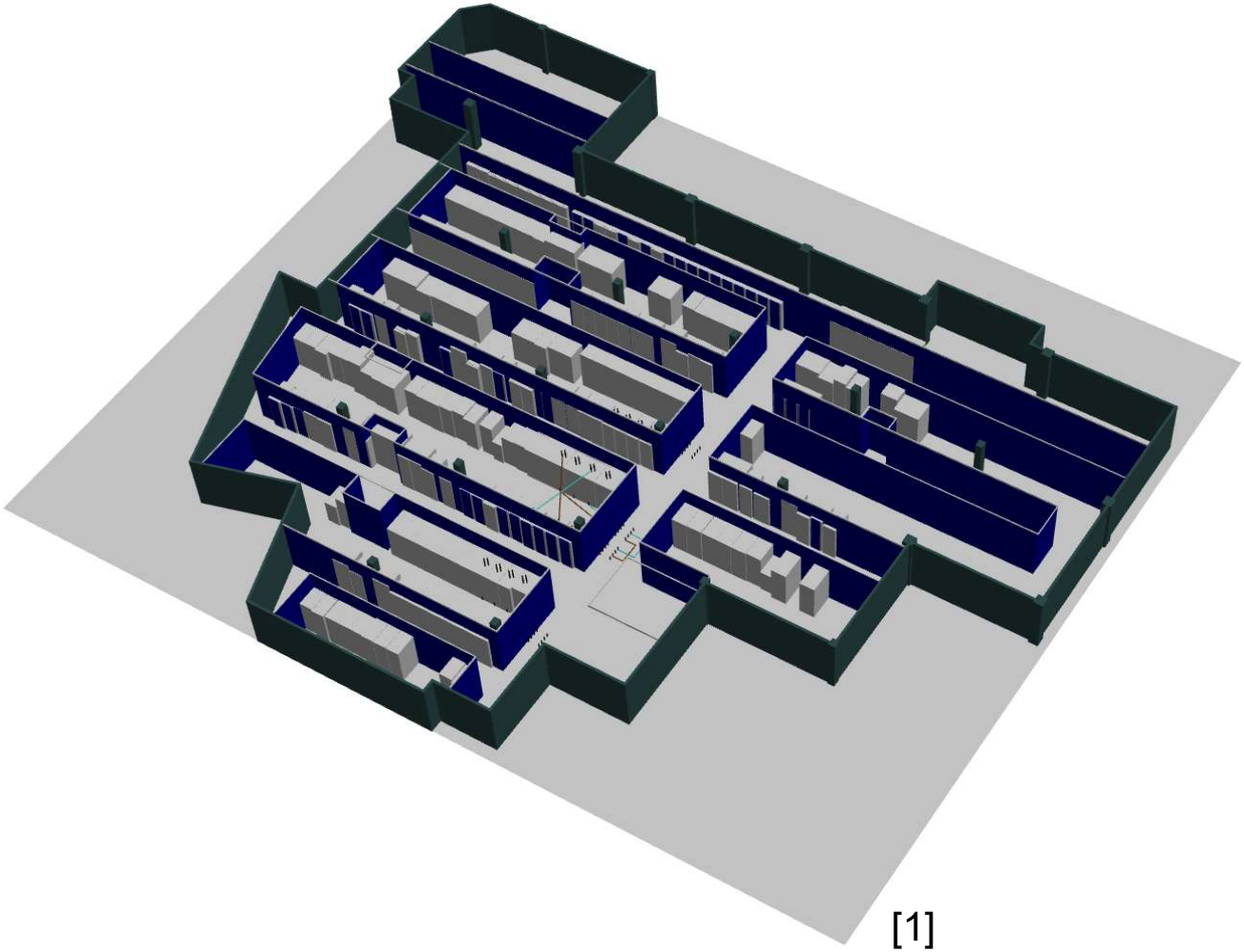
Institut für Nachrichtentechnik

Realistic Simulation of Wireless Links in a Data Center at Low Terahertz Frequencies

Johannes M. Eckhardt, Christoph Herold, and Thomas Kürner
Institute for Communications Technology (IfN)
Technische Universität Braunschweig

Overview

- SiMoNe
- Scenario Description
- Simulation Methodology
- Simulation Parameters
- Selected Results



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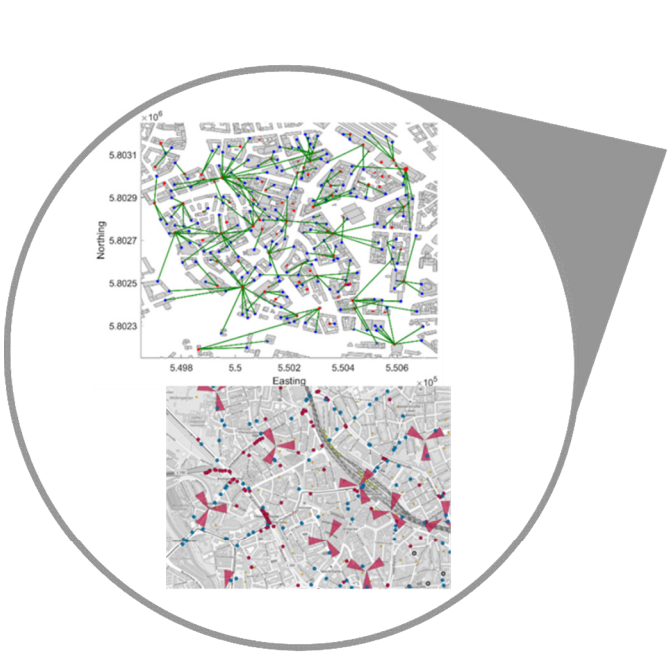
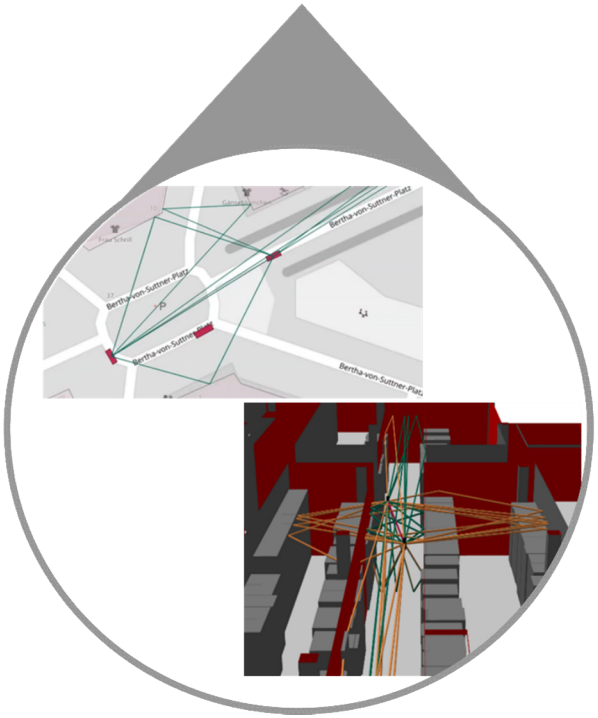
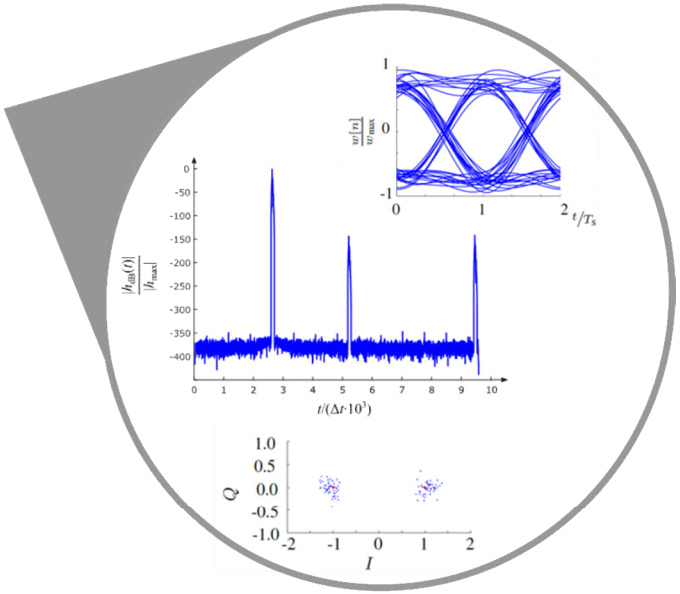
Simulator for Mobile Networks (SiMoNe)



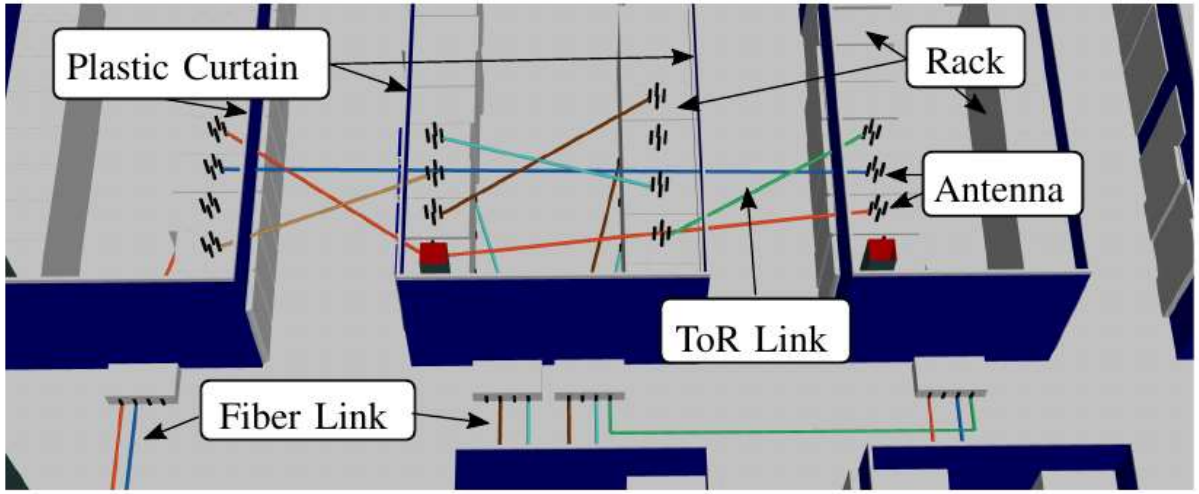
SiMoNe
Simulator for Mobile Networks





Scenario Description

- 3D Model of the Dell EMC Research Data Centre
- 16 racks
- Each rack with 4 Top-of-Rack antennas (90° steering range)
- 3 events simulated
  - Link failure detection and boost procedure
  - Interference detection
  - Short & long link flexibility



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Simulation Methodology

- Definition of events
- Ray tracing of the scenario
  - 15 x 15 impulse responses for each TX – RX pair
    - 57600 impuls responses
- Segmentation to quasi-static states
- Link level simulations for interference links
- Superposition of interference according to states
- Link level simulation of communication links
- Evaluation of BER, SINR, data rate

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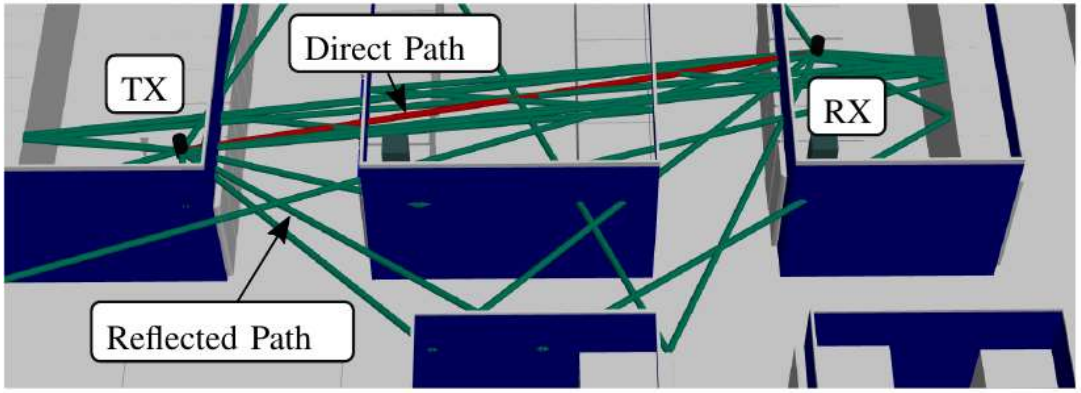
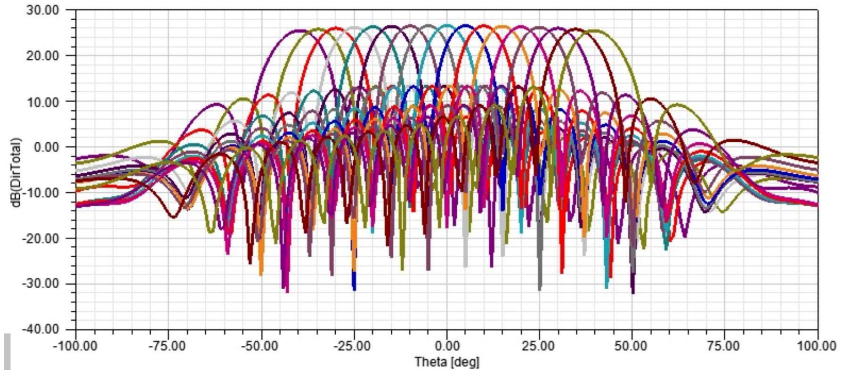
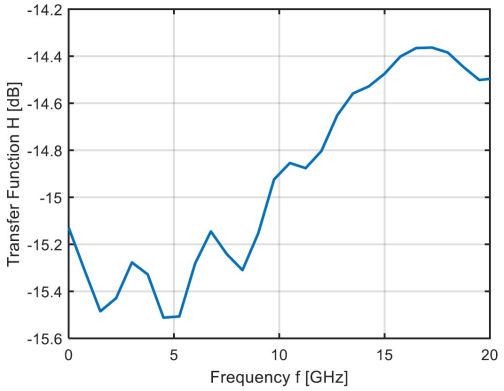


Simulation Parameters

- IEEE 802.15.3d THz-SC PHY
  - LDPC 11/15
  - QPSK
  - 2.16 GHz channel bandwidth
- TERAPOD
  - -8 dBm TX power
  - 16 x 16 patch antenna array, 24 dBi gain, 7° HPBW
    - Antenna pattern is a function of steering angle
  - LNA charactersitcs: noise figure and S-parameters
- General
  - 1 Gbit transmitted → best BER of $1 \cdot 10^{-9}$
  - 300 GHz carrier frequency
  - Thermal noise, k*B*T*F, -68.51 dBm
  - Power amplifier and phase noise characteristics are taken from [3,4]



Antenna pattern for different steering angles [2]

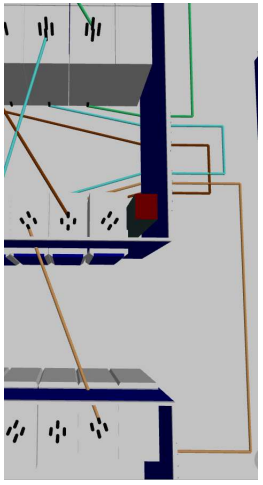


LNA characteristics [2]

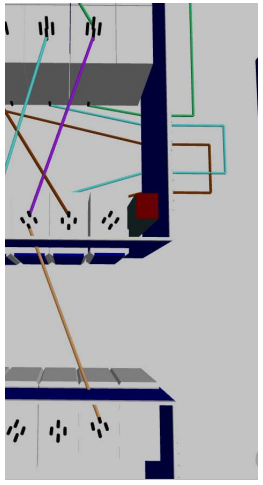
Link failure and boost operation

- Fiber link failes and boost operation is lauched
- Interference impedes high data rate

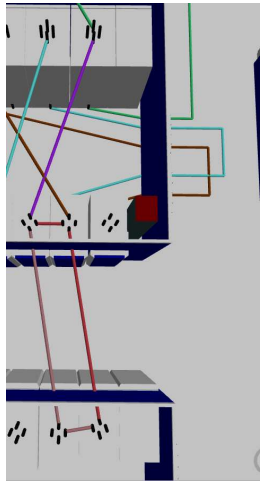
$t < 10$ s



$t = 10$ s



$t = 10.5$ s



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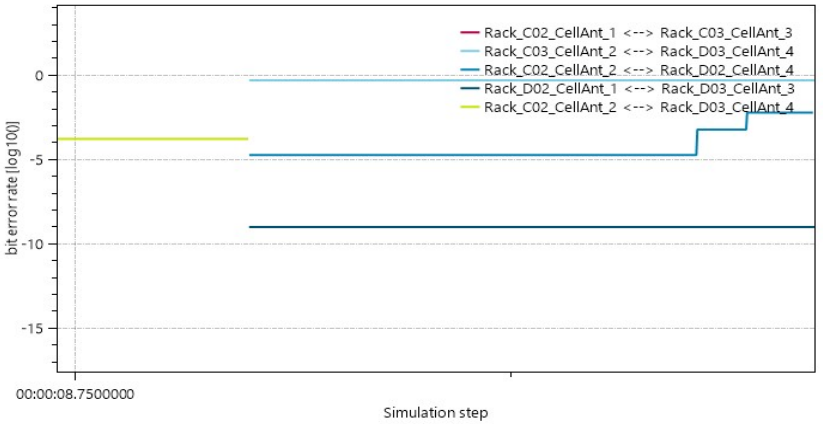
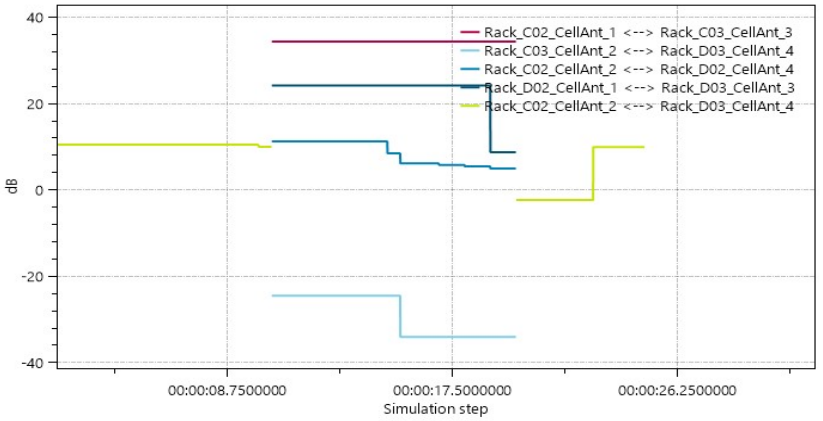


SINR



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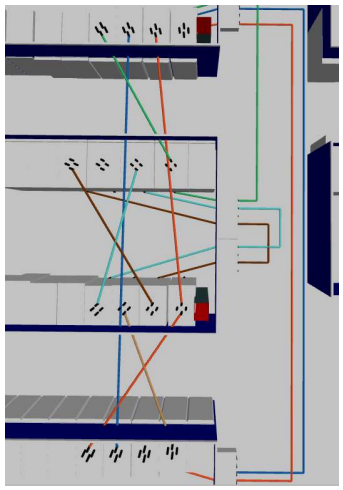
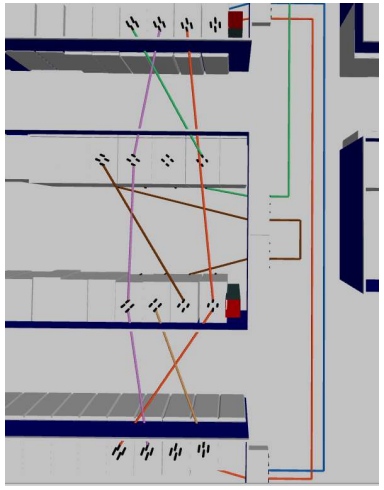
Long and short flexibility links

- Long link is replaced by multi-hop link
- Multi-hop link has better SINR

t = 20 s



t = 22 s



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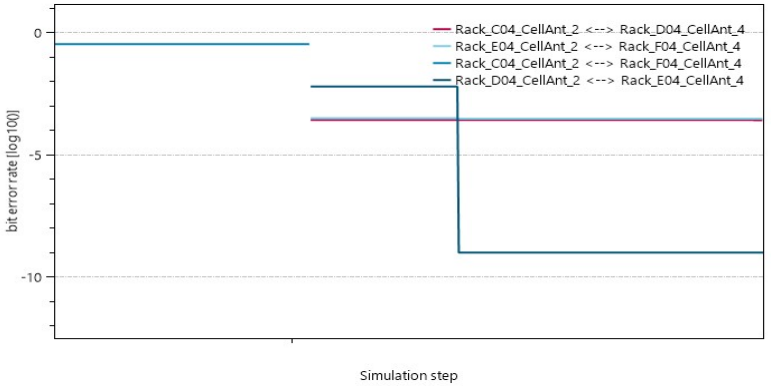
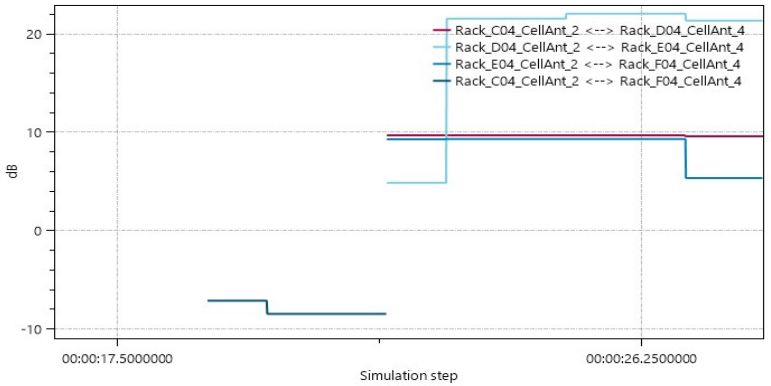


SINR

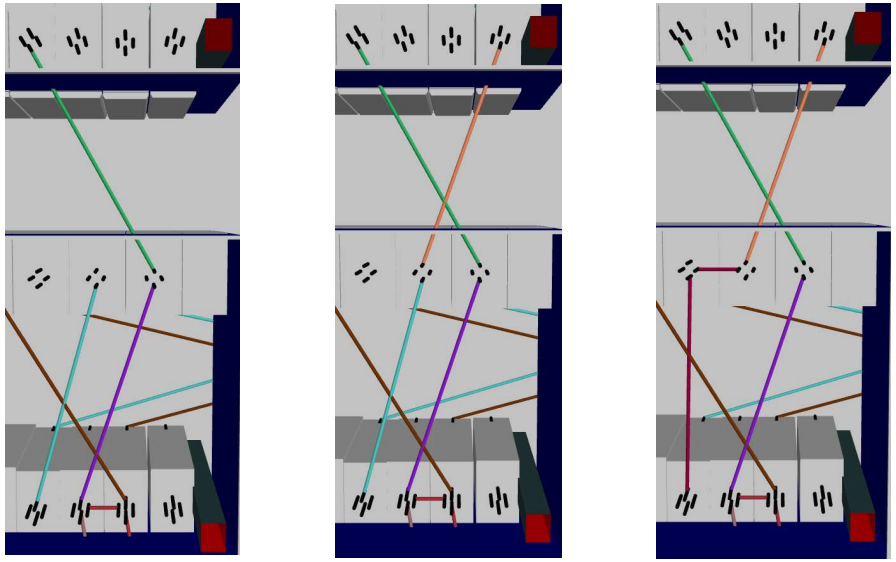


[1]

Interference detection

- Interfering link is replaced by multi-hop link
- Multi-hop link has better SINR
- Interference of interfered link is dominated by other link

t = 12 s *t* = 15 s *t* = 15.5 s



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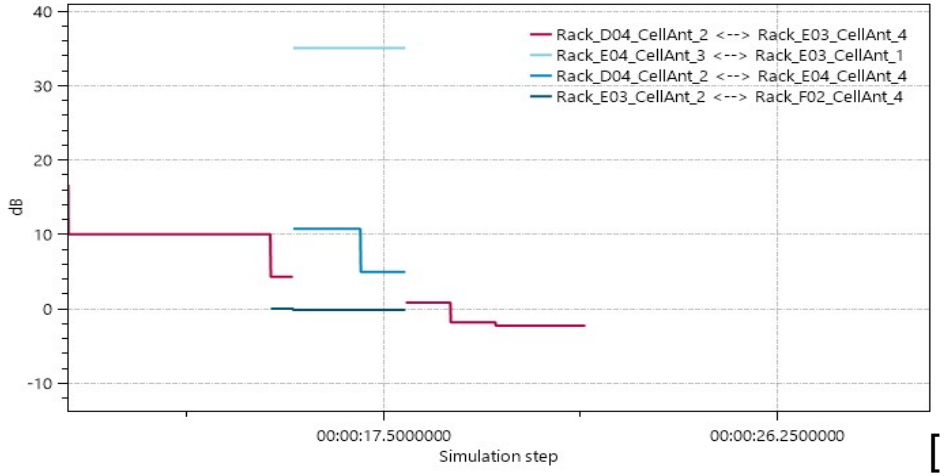
SINR



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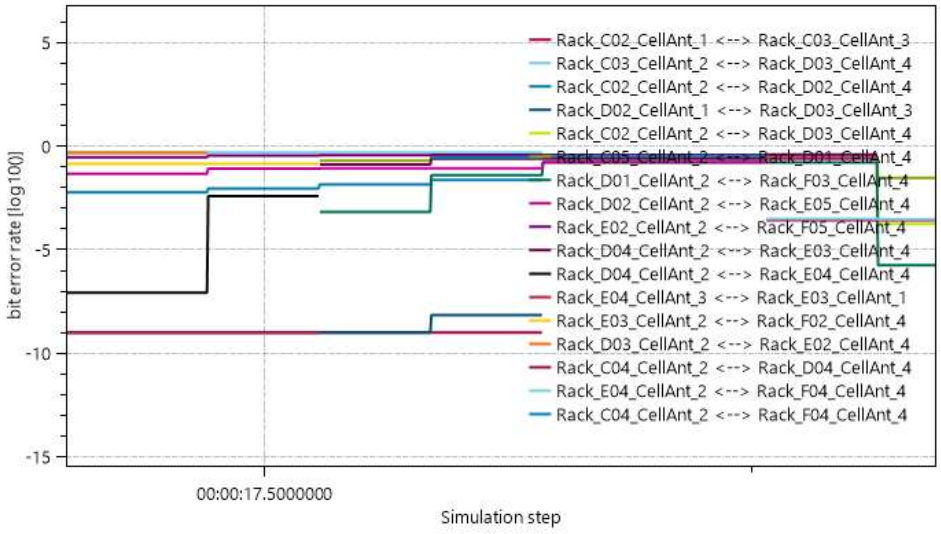
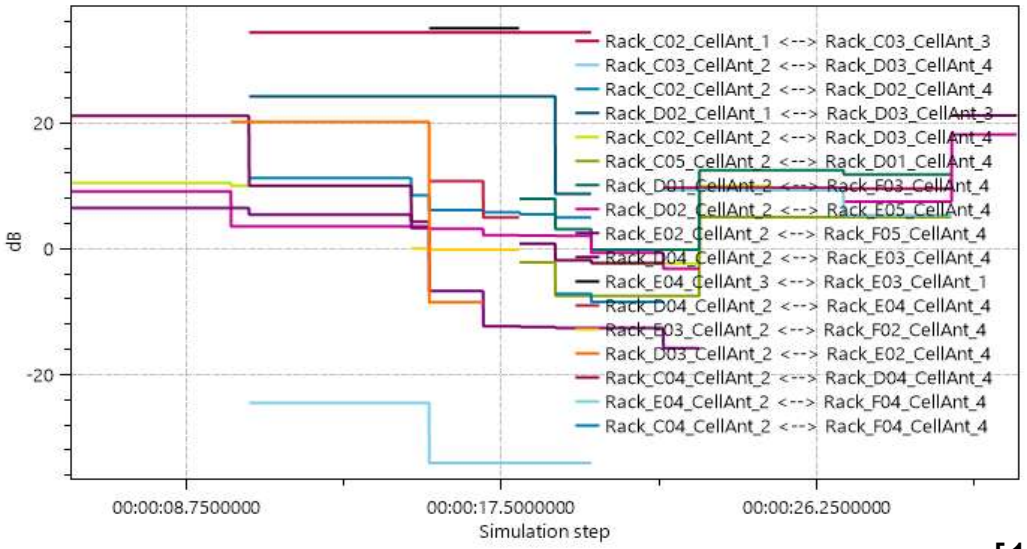
Global view

- Strong interference between wireless links

BER



SINR



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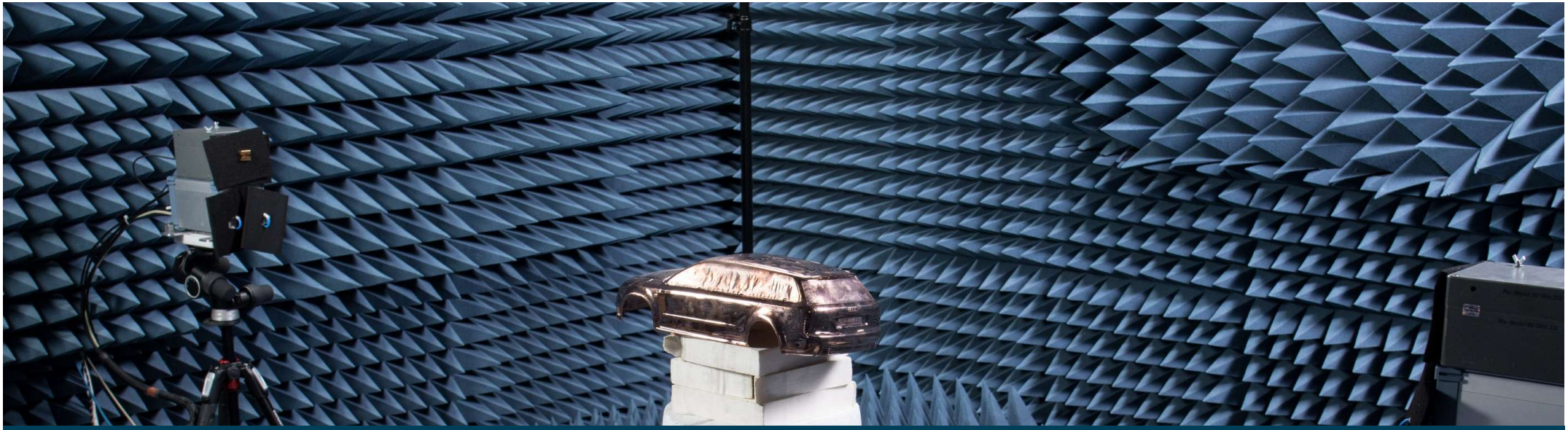
Conclusion

- Interference limits performance
  - Reduce multipath propagation
  - Interference mitigation by frequency multiplexing
  - Side lobes can be decreased in future

- Balanced link budget
  - Assure clear direct path (line-of-sight)
  - Higher TX power would allow for higher bandwidth



Thank you for your attention!

Dipl.-Ing. Johannes Eckhardt
eckhardt@ifn.ing.tu-bs.de

[1] J. M. Eckhardt et al., D6.4 Final Simulation Demonstrator, H2020 TERAPOD deliverable, June 2021
[2] C. Renaud et al., D3.6 Second generation of devices for integration and packaging, H2020 TERAPOD deliverable, January 2020
[3] L. John, A. Tessmann, A. Leuther, P. Neininger, T. Merkle and T. Zwick, "Broadband 300-GHz Power Amplifier MMICs in InGaAs mHEMT Technology," in IEEE Transactions on Terahertz Science and Technology, vol. 10, no. 3, pp. 309-320, May 2020.
[4] Dan, I., Ducournau, G., Hisatake, S., Szriftgiser, P., Braun, R., & Kallfass, I. (2020). A superheterodyne 300 GHz wireless link for ultra-fast terahertz communication systems. International Journal of Microwave and Wireless Technologies, 12(7), 578-587.

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