Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Simulation and Automatic Planning of 300 GHz Backhaul Links - First Results from H2020-ThoR

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Re: n/a

Abstract: This contribution presents an algorithm for automatic planning of 300 GHz backhaul/fromthaul links arranged in ring topology and using IEEE Std. 802.15.3d.

Purpose: Information of the Technical Advisory Group THz

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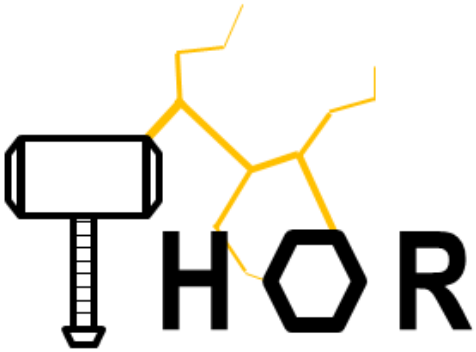

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Horizon 2020

Automatic Planning Algorithm of 300 GHz Backhaul Links Using Ring Topology

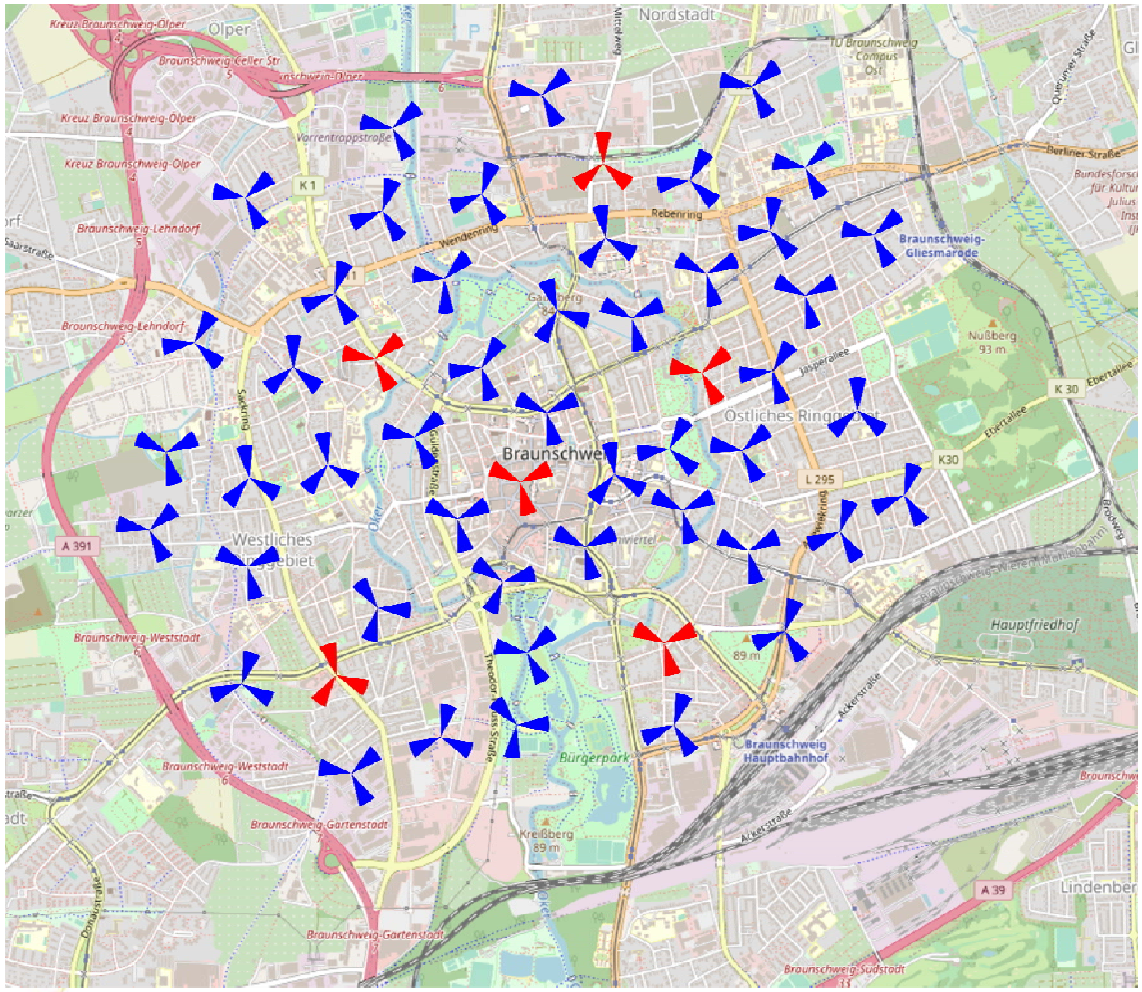
Bo Kum Jung, Thomas Kürner, TU Braunschweig

This presentation is based on B. K. Jung and T. Kürner, "Automatic Planning Algorithm of 300 GHz Backhaul Links Using Ring Topology," *2021 15th European Conference on Antennas and Propagation (EuCAP)*, 2021, pp. 1-5, doi: 10.23919/EuCAP51087.2021.9411010.

Outline

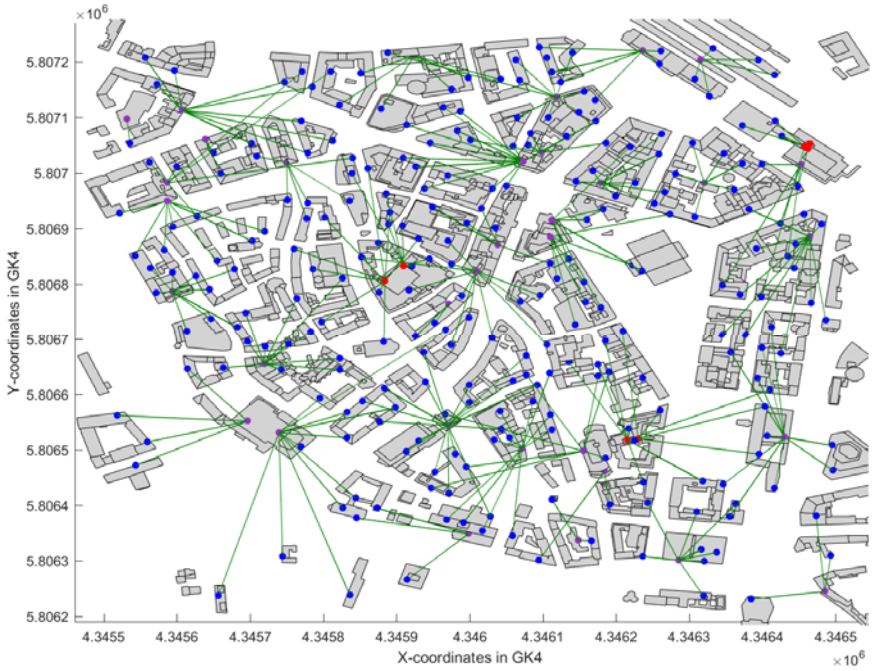
1. Introduction
2. Planning Approach
3. Simulation Results
4. Conclusion

Introduction



- Cable backhaul
  - Man‘s labour
  - Time & Cost intensive
  - Geographical limits
  - Poor maintenance performance
- Alternative
  - Wireless backhaul

Previous Planning Approach Based on Star Topology [1]



Star topology

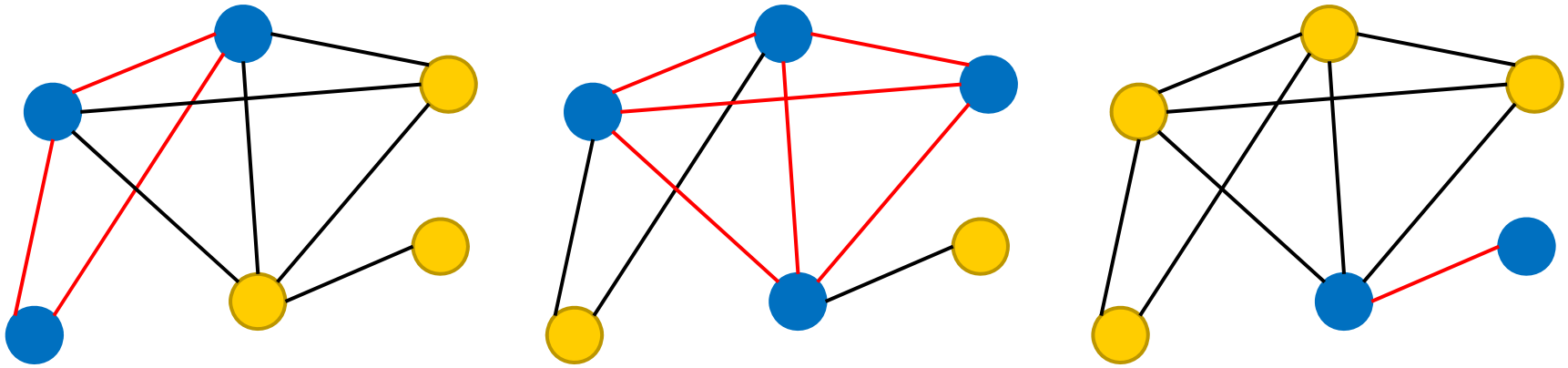
- + easy to build up
- - lack of redundancy
  - fatal of link failure
- Alternative: **ring topology**

[1] B. K. Jung, N. Dreyer, J. M. Eckhardt and T. Kürner „Simulation and Automatic Planning of 300 GHz Backhaul Links“. IRMMW-THz, Paris, France, 2019.

Graphic Theoretical Basic of Ring Topology

- What is **clique**?

Clique in graphic theory is **a subset of vertices** of an undirected graph such that every two distinct vertices in the clique are adjacent

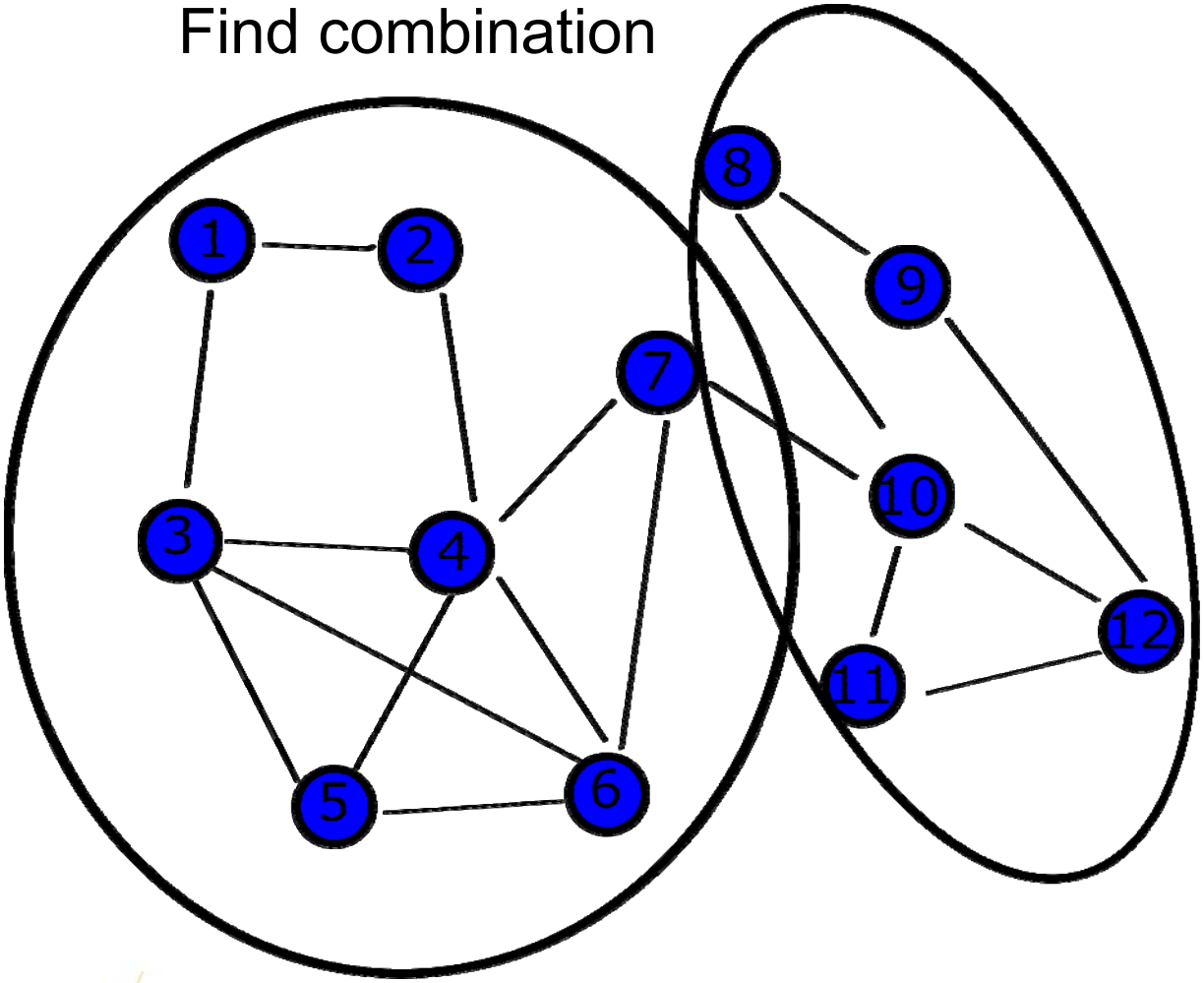


Planning Steps Determining Ring Topology

- Determine Neighbour list between cell sites
- Figure out possible cliques using Bron-Kerbosch algorithm
- Extend cliques
  - Clique-Extension done through number of cell sites (1,2,3,…,n-2,n-1,n)
  - Gather every cliques which contain vertex of number of cell site (m)
  - Gather every cliques which have clique number 2
  - Check combination of gathered cliques using Hamiltonian-cycle check
- Find possible combinations of cliques which cover all cell sites
- Determine exact path considering minimum angle of links and link distance

Example of Planning Steps of Ring Topology Based Network

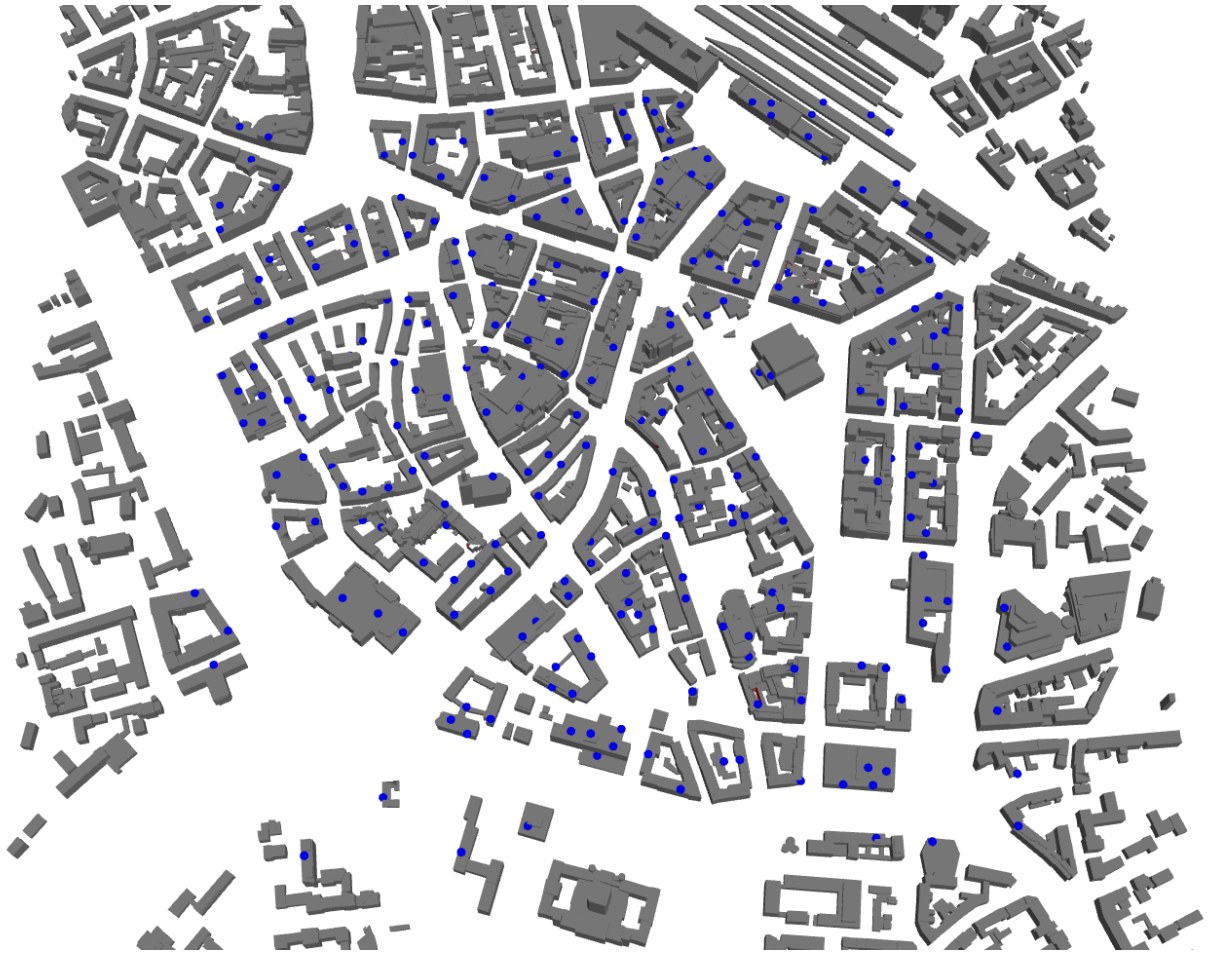
Find combination



Combination:

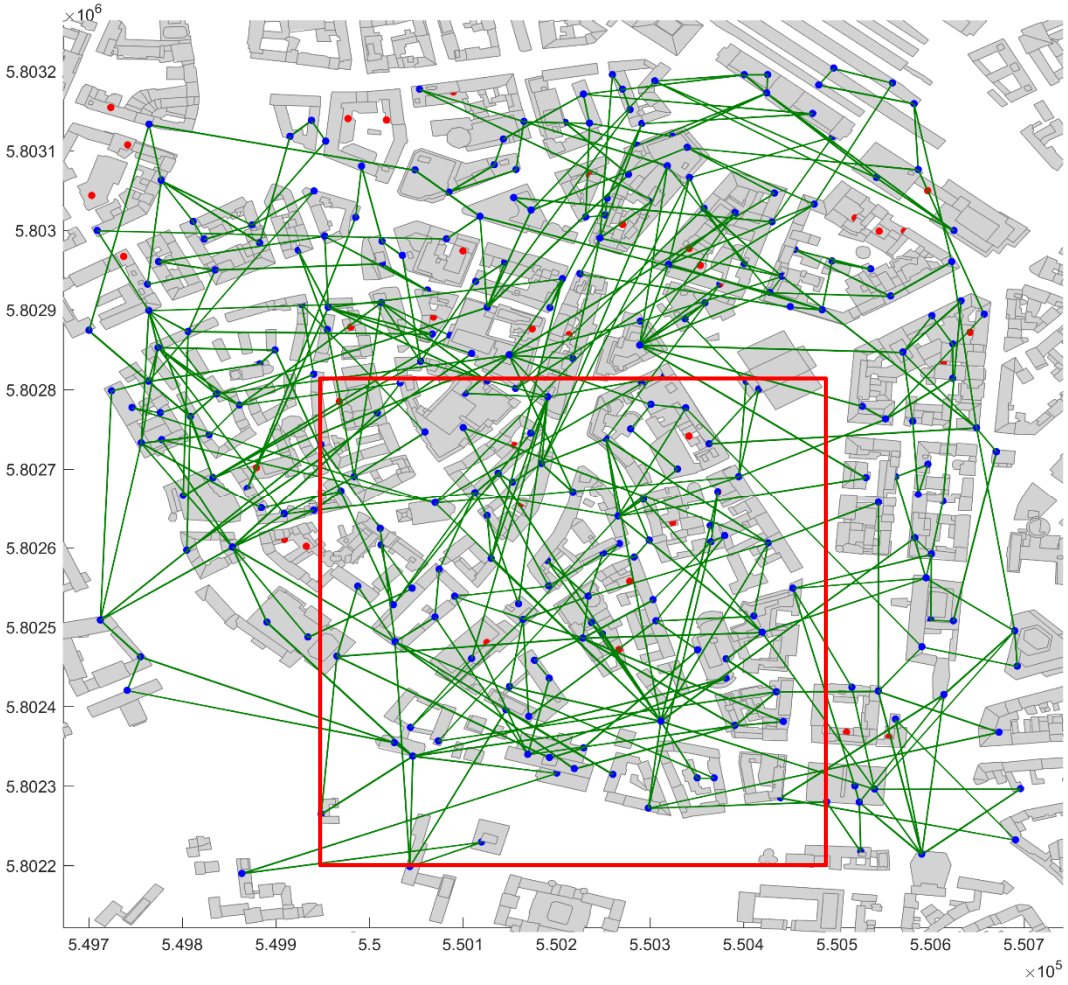
- 1,2,3,4,5,6,7
- 8,9,10,11,12
- 2,4
- 3,4,5,6
- 4,6,7
- 7,10
- 10,11,12
- 10,8
- 8,9
- 9,12
- 1,2,3,4
- 1,2,3,4,5,6,7
- 8,9,10,11,12

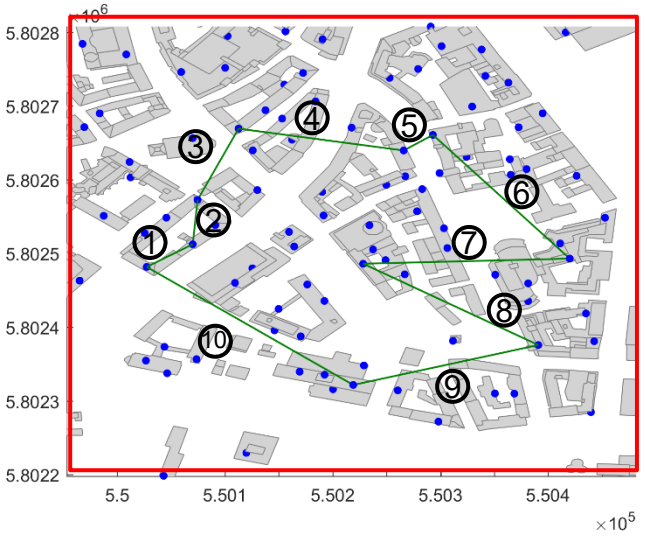
Simulation Scenario



- Hannover scenario
  - High traffic region
  - 1km x 1km
  - **300** small cells
  - 1m antenna height
- Configuration parameter
  - 4° safety margin
  - 400 m link distance
  - 10 candidates
- Optimization factor
  - Reducing N of cable based backhaul

Simulation results



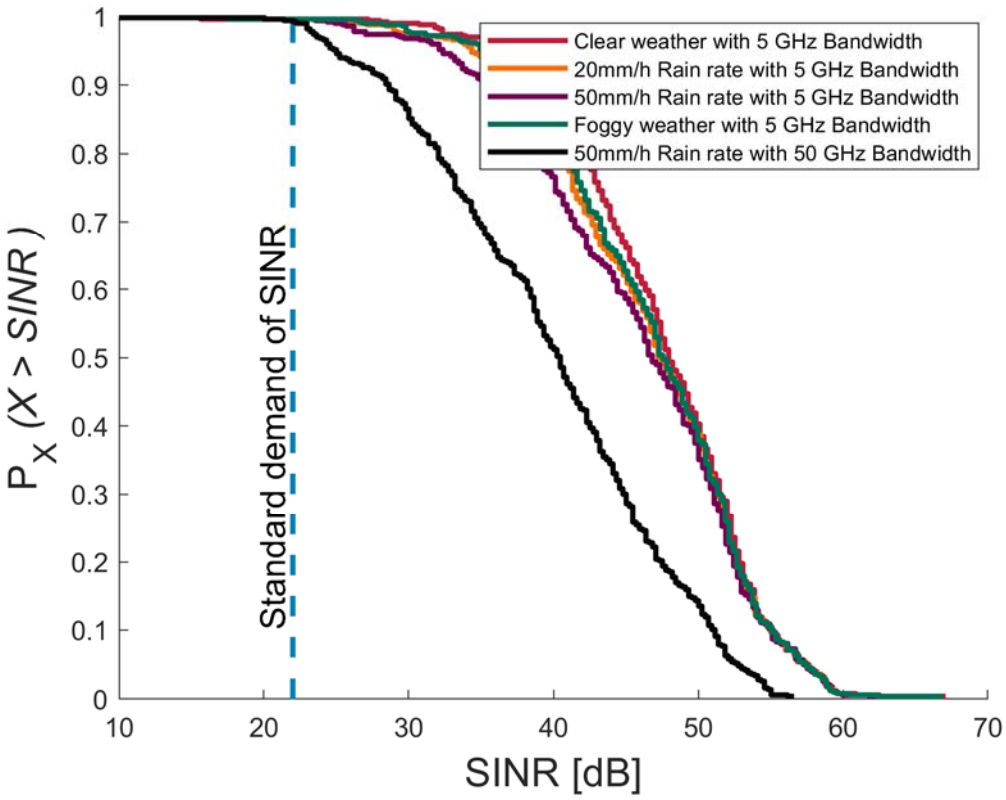


Simulation results

- **281** cell sites possible to apply ring concept
- **50** lists of cell sites combinations
- **410** wireless link required

	Star	Ring
N of cable	92	Max 143
N of Wireless Link	208	410

Assessment of the Planning Results



- Standard demand of SINR is the required SINR value to use highest modulation and coding scheme defined in IEEE standard
- ~99,4 % links with 5 GHz bandwdith exceed this value under any given weather conditions
- ~99 % links with 50 GHz bandwidth exceed this value under the heavy rain condition

Conclusion

- The given algorithm can plan wireless backhaul network automatically in ring shapes.
- More stable operation is guaranteed against link failure due to the redundant traffic paths.
- The highest modulation and coding scheme defined in IEEE is applicable on >99 % of the planned wireless backhaul links regardless of given weather conditions even using 50 GHz band width.
- ~73 % of backhaul links can be replaced by wireless connections instead of fibre connections

Thank you for your attention!

ご清聴ありがとうございました

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