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**Re:** n/a

**Abstract:** This contribution presents some results on statistical characteristics of human blockage effect of future millimeter wave (mmWave) and THz communications. We obtain the distributions of Line-Of-Sight (LOS) path and blockage durations as well as blockage numbers via simulations, subsequently evaluate the system performance in presence of the distributed antennas.

**Purpose:** Contribution for discussion at the IG THz

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# Study on Statistical Characteristics of Human Blockage Effects in Future Indoor Millimeter Wave and THz Wireless Communications

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<http://ibrow-project.eu/>

# Outline

- **Motivation**
- Simulation Setup
- Statistical Evaluation
- Conclusion

# Motivation

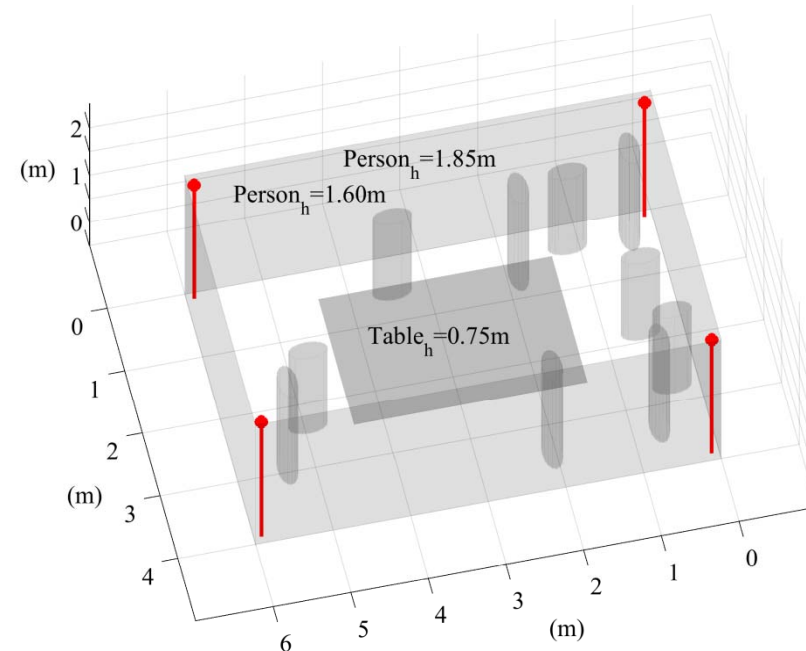
- The mmWave and Terahertz (THz) communications are a competitive solution to the future multi-Gigabyte short range data transmission.
  - Huge bandwidth
  - High Data rate
- Higher frequency compared to the traditional communication systems leads to weaker diffraction.
- The human blockage is a serious problem that can block the Line-of-Sight (LoS) path.
- We present a statistical study of this problem with a ray-launching simulator and a realistic user movement model.
- The Distributed Antenna System (DAS) is suggested as a solution.

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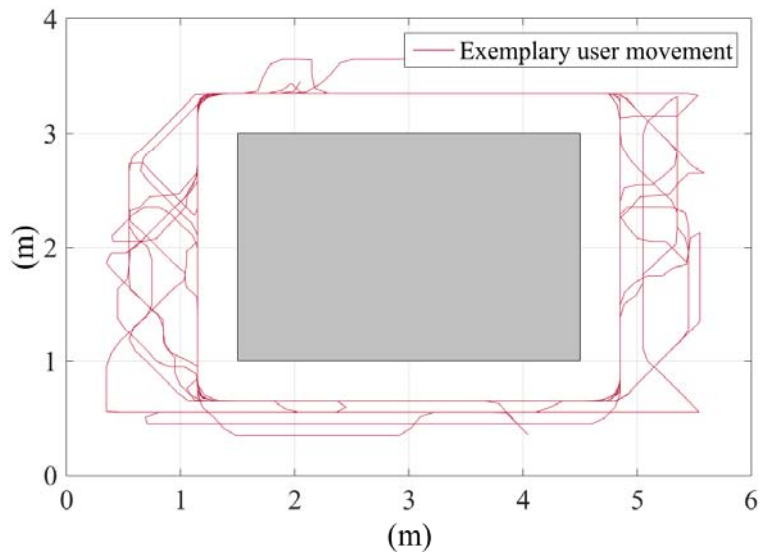
# Considered Scenario

- A meeting room of size 6 m x 4 m is considered.
- Human bodies are modeled as elliptic cylinders.
  - Male: 1.85 m tall
  - Female: 1.60 m tall
- Four antennas are placed in the four corners of the room and under the roof.
- We only consider the LOS path due to the high path losses of other paths.



# Realistic Human Movement Model and Ray-launching Simulation

- A realistic human movement model is applied to produce the human trajectories.
- People have two states, i.e. “stay” and “move”.
- 5 and 10 people are considered in the simulation.
- A time-differential ray-launching simulator is applied to efficiently calculate the availability of the LOS path.

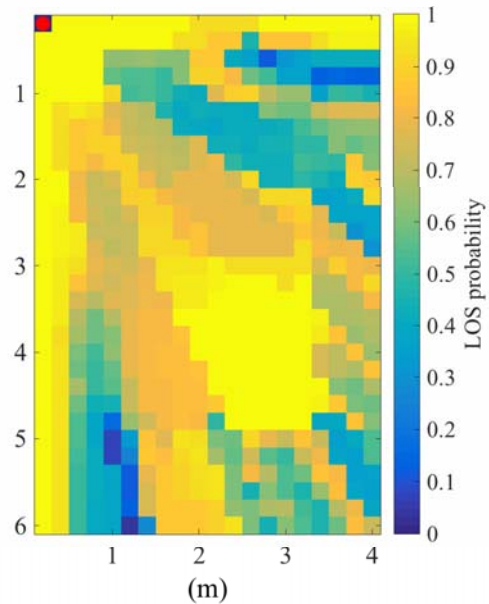


# Outline

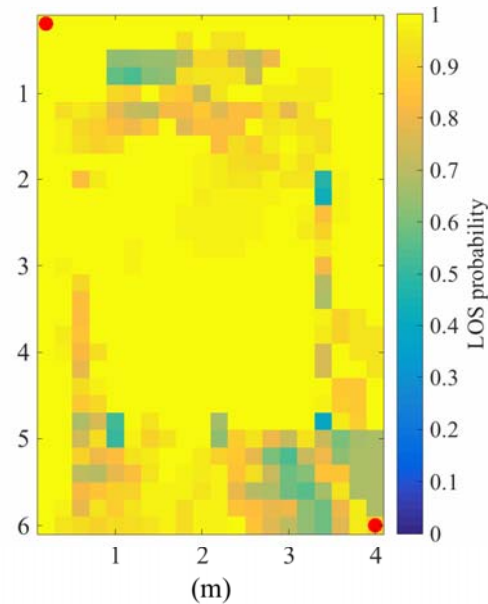
- Motivation
- Simulation Setup
- **Statistical Evaluation**
- Conclusion



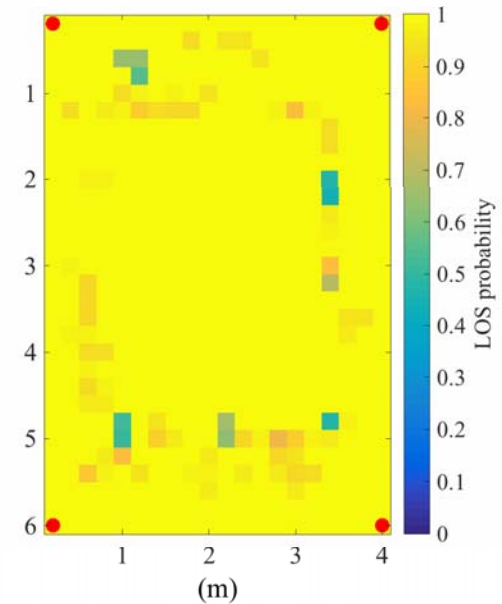
# LOS Probabilities with DAS



One antenna



Two antennas

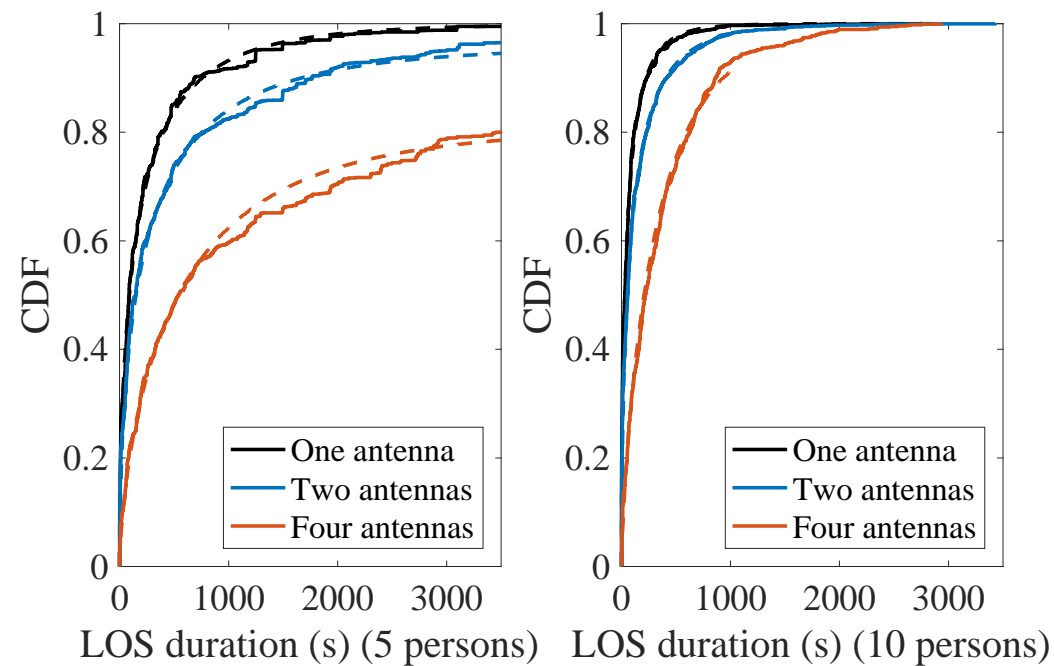


Four antennas

The simulation is carried out with 10 people.

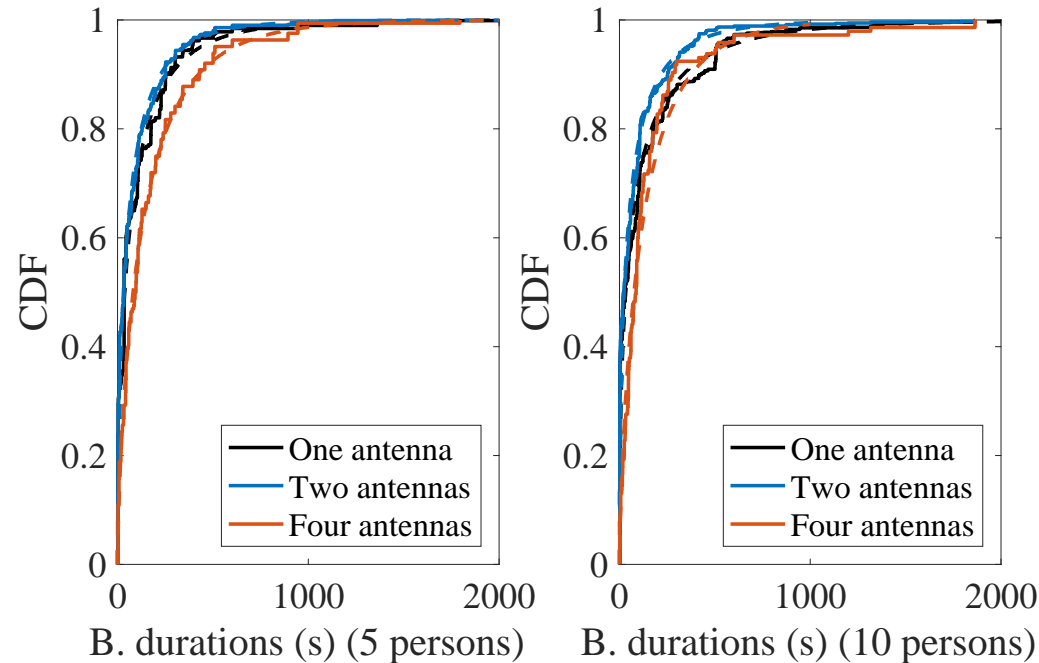
DAS improves the availability of the LoS path.

# Cumulative Distribution Functions (CDF) of LOS duration



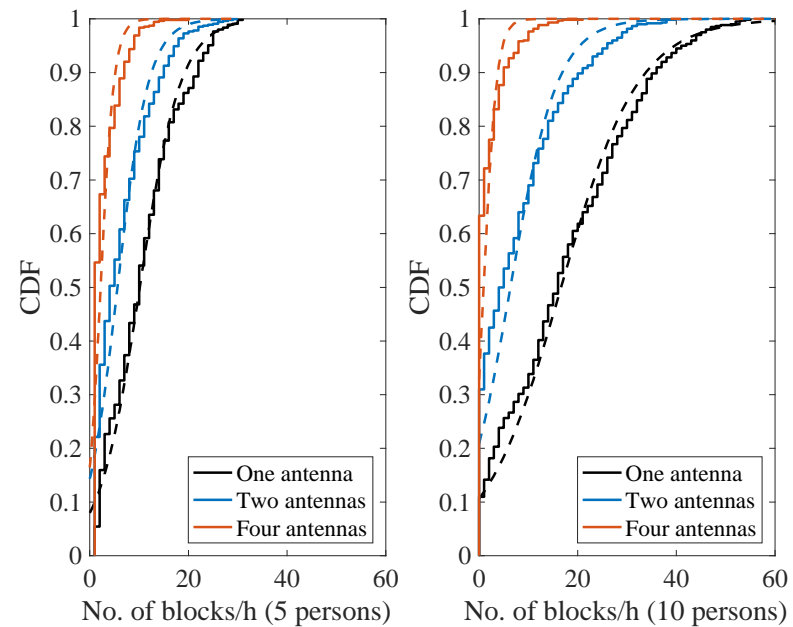
- The CDF of the LOS duration (solid lines) can be approximated by the Weibull distribution (dashed lines).
- The LOS duration is longer with more antennas.

# CDF of Long Blockage Duration



- The blockages are classified into short blockages (walking through) and long blockages (staying between).
- The CDF of the long LOS blockages (solid lines) can be approximated by the Weibull distribution (dashed lines).
- Number of antennas play a less important role here.

# CDF of Numbers of Blockages per Hour



- The CDF of numbers of blockages per hour can be approximated with the logistic distribution.
- More antennas lead to less numbers of blockages.

# Distributions of LOS Path Blockage

Item	Distribution	Parameters for 10 persons	Parameters for 5 persons
LOS duration, one antenna	Weibull	$\lambda = 57.4907, k = 0.6087$	$\lambda = 172.098, k = 0.5622$
LOS duration, two antennas	Weibull	$\lambda = 99.6115, k = 0.5926$	$\lambda = 306.572, k = 0.5323$
LOS duration, four antennas	Weibull	$\lambda = 328.113, k = 0.7972$	$\lambda = 571.823, k = 0.6904$
Short blockage, one antenna	Constant	Duration = 1 s, portion = 0.74	Duration = 1 s, portion = 0.70
Short blockage, two antennas	Constant	Duration = 1 s, portion = 0.77	Duration = 1 s, portion = 0.76
Short blockage, four antennas	Constant	Duration = 1 s, portion = 0.84	Duration = 1 s, portion = 0.83
Long blockage, one antenna	Weibull	$\lambda = 66.7625, k = 0.5175$	$\lambda = 69.2012, k = 0.5973$
Long blockage, two antennas	Weibull	$\lambda = 48.1449, k = 0.5515$	$\lambda = 56.2202, k = 0.6015$
Long blockage, four antennas	Weibull	$\lambda = 124.1050, k = 0.7539$	$\lambda = 134.514, k = 0.7271$
Blockages per hour, one antenna	Logistic	$\mu = 16.6218, s = 7.8186$	$\mu = 10.1228, s = 4.1489$
Blockages per hour, two antennas	Logistic	$\mu = 6.3522, s = 4.7713$	$\mu = 5.6083, s = 3.1414$
Blockages per hour, four antennas	Logistic	$\mu = 0.9294, s = 1.2981$	$\mu = 2.1976, s = 1.3528$

- The table provides enough information for a simple simulation on the system performance considering the human blockage effect.

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# Conclusion

- We present a study on the statistical characteristics of the human blockage effect on the LOS availability of mmWave and THz communications.
- Durations of LOS, blockages and number of blockages per hour can be approximated with different distributions.
- Different services require different corresponding LOS availabilities. We provide a simple approach of simulation on the system performance.
- DAS is an effective solution against the human blockage problem.