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

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

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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

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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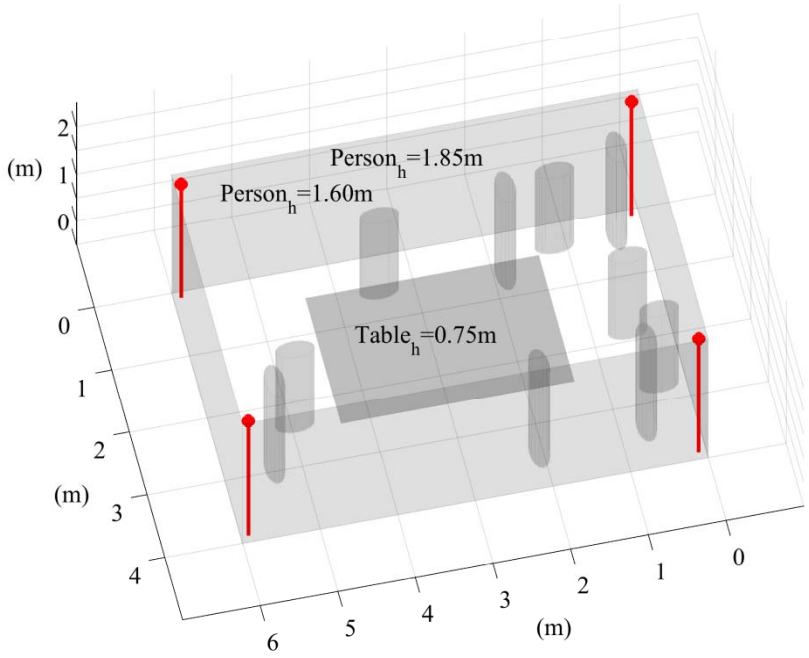
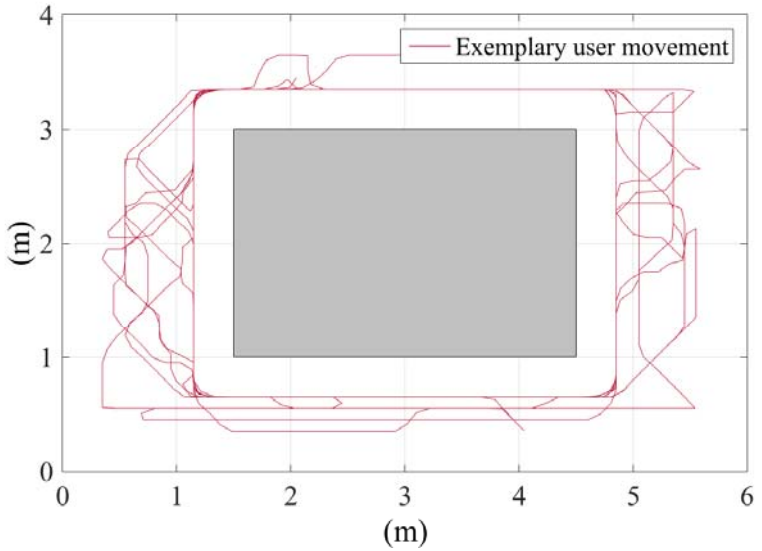
Considered Scenario

- 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.



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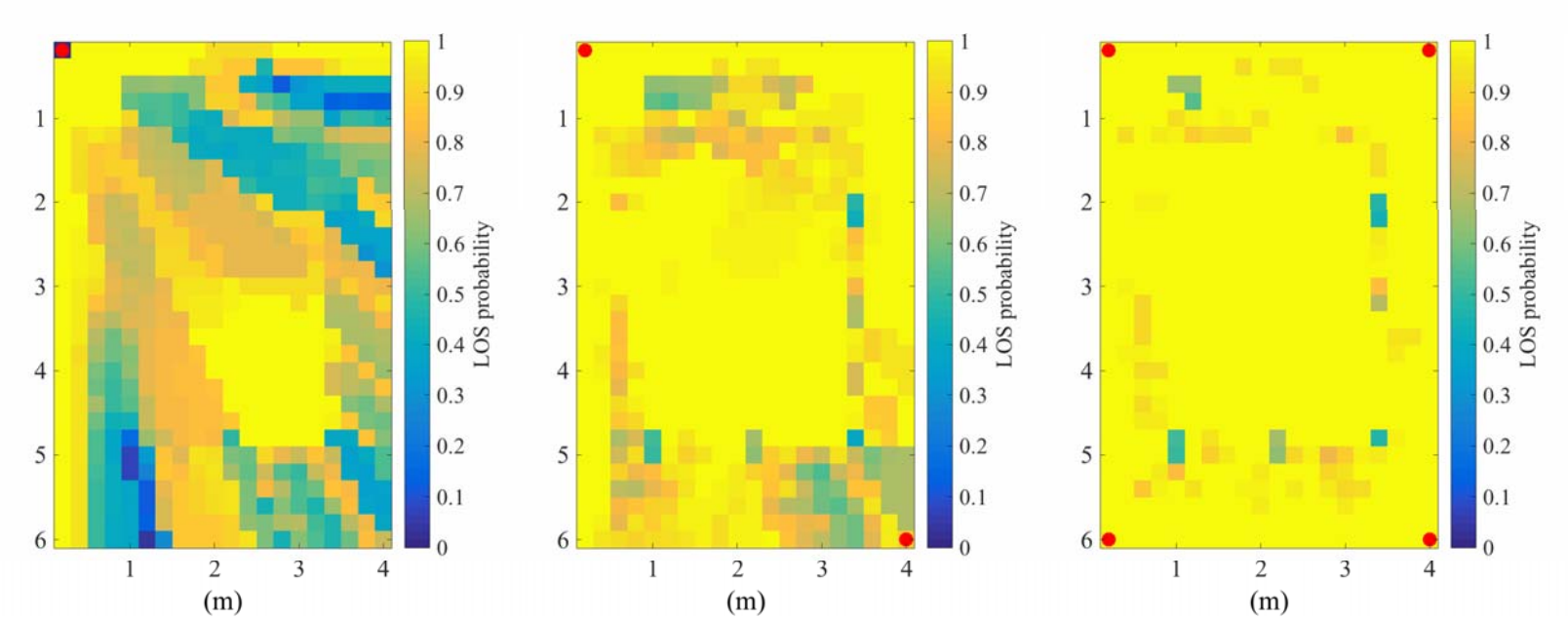
LOS Probabilities with DAS

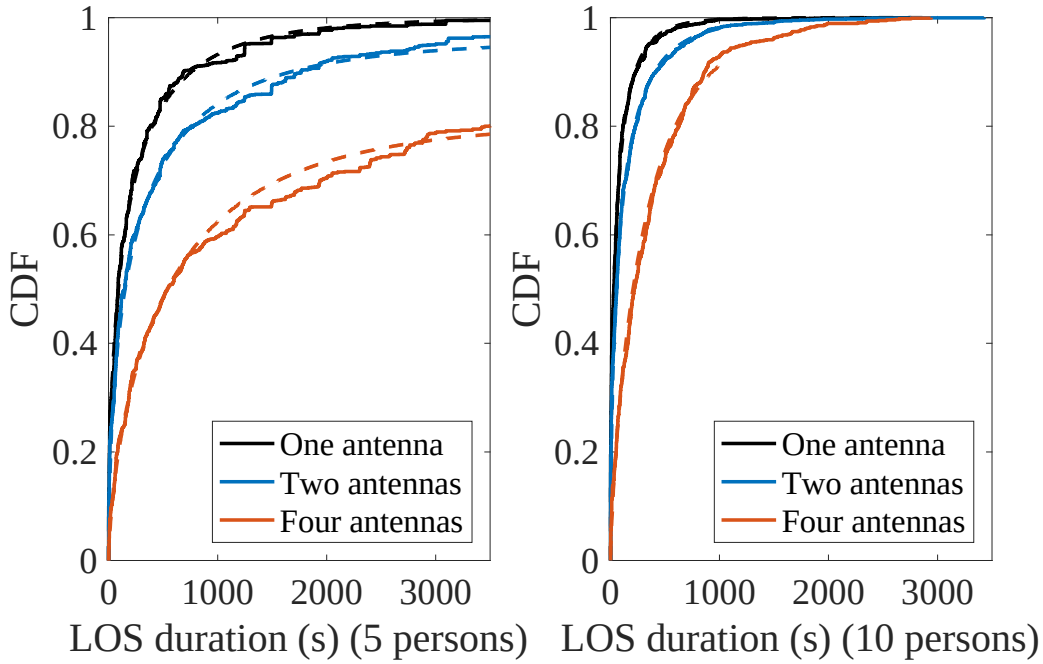


One antenna Two antennas Four antennas

The simulation is carried out with 10 people.

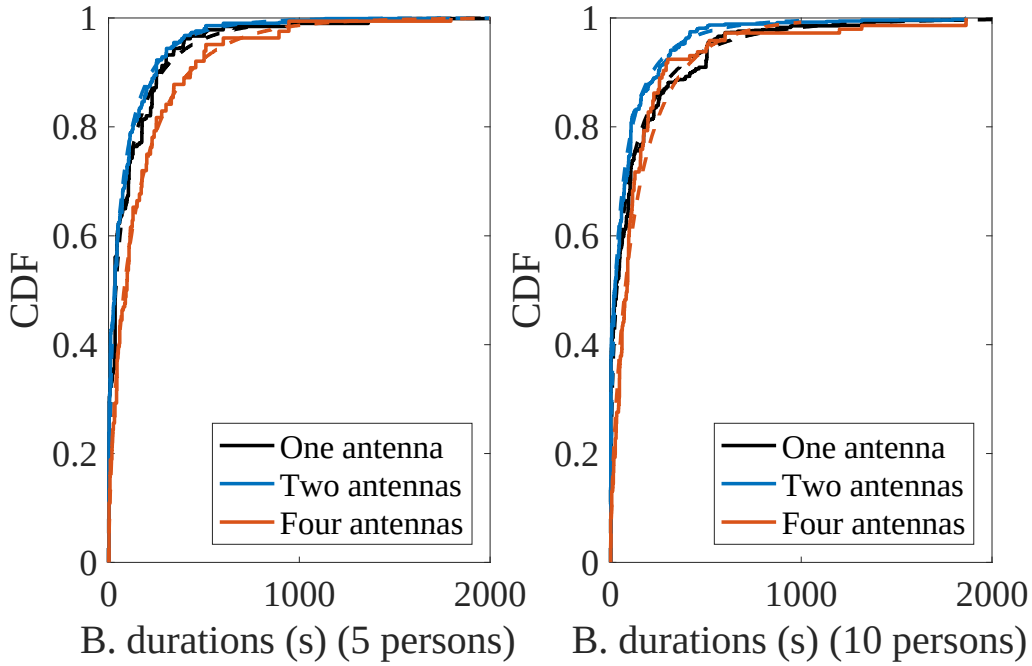
DAS improves the availability of the LoS path.

Cumulative Distribution Functions (CDF) of LOS duration



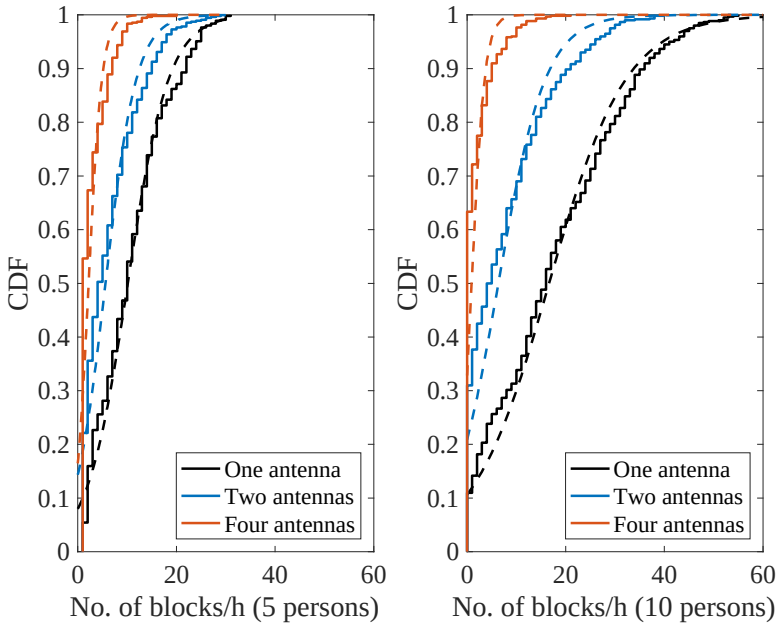
- The CDF of the LOS duration (solid lines) can be approximated by the Weibull distribution (dahsed lines).
- The LOS duration is longer with more antennas.

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 (dahsed 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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- 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.