Modeling the human induced 60 GHz channel dynamics

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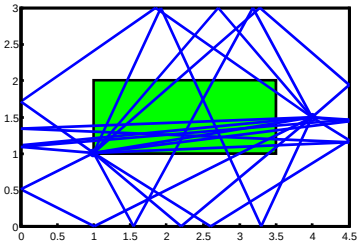
Abstract

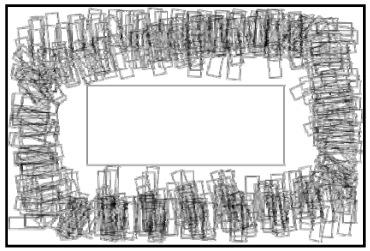
The support of people motion with blocking of signal paths (channel dynamics) is currently an open issue in the TGad channel model [1]. To overcome this we present simulations of the time-variant 60 GHz channel based on ray tracing, a random walk model and a diffraction model. The results could be easily included in the channel model document [2] as a further statistic.

Methodology

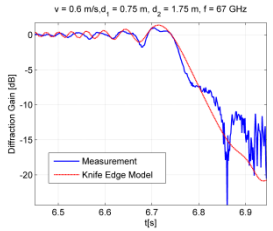
Ray Tracing

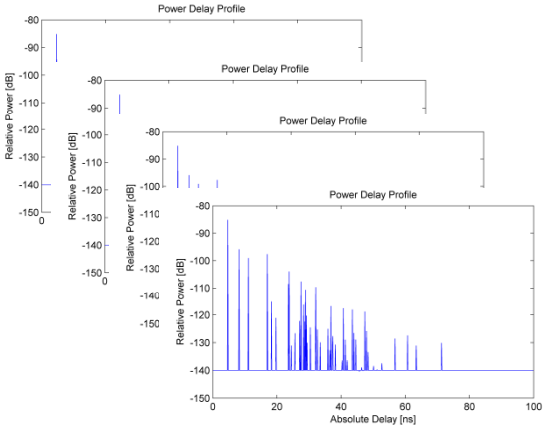


Random Walk Model

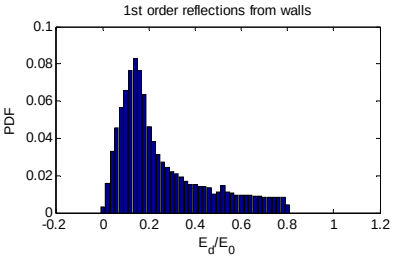


Diffraction Model



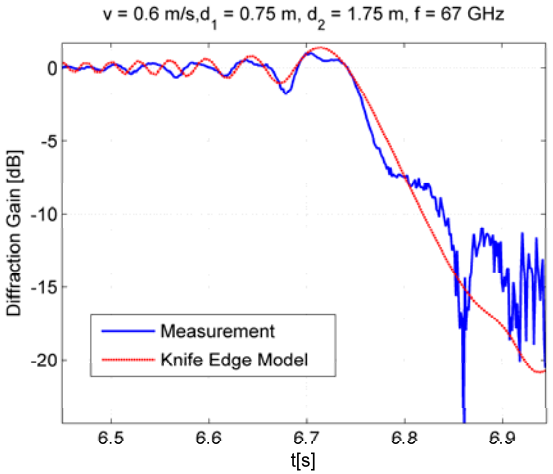


Set of **time variant channel realizations**

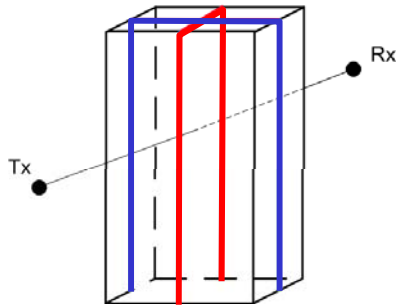


Channel Statistics

Diffraction Model



Verification of Model by Measurements from [3]



Multiple Edge Model

- **Assuming Person as „Multiple Edges“**
- **Electric field strength calculation based on Fresnel Integral:**

$$\frac{E_d}{E_0} = \frac{(1+j)}{2}\int_{\upsilon}^{\infty} \exp(-j\pi t^2)dt$$

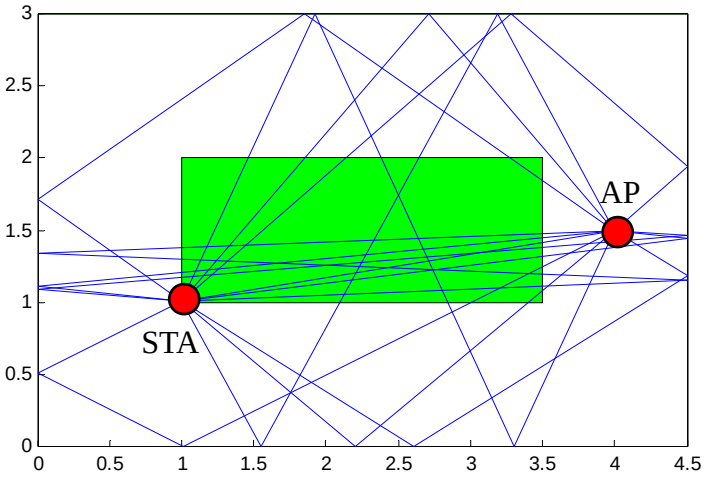
$$mit\,\nu = h\sqrt{\frac{2(d_1+d_2)}{d_1 d_2}}$$

- **Loss:** $G_d(dB) = 20\log\left|\frac{E_d}{E_0}\right|$

- **Good agreement between this simple model and measurements**

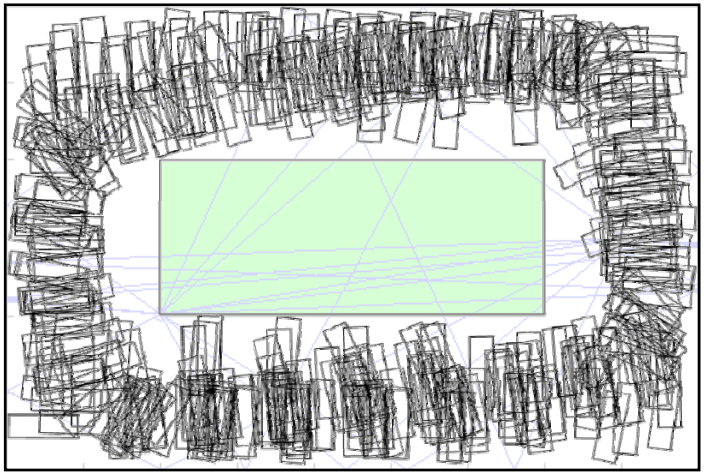
Ray Tracing Simulations

- **STA-AP Scenario from [2]**
- **AP position fixed**
- **STA positions uniformly distributed on the table**
  - Simulated:1071 STA positions
- **Result:**
  - Each ray represents one cluster (cf. [2])
  - 1071 CIR for the static scenario
  - Categorized Rays (Table 2 from [2])
    - LOS
    - 1st order
    - 2nd order



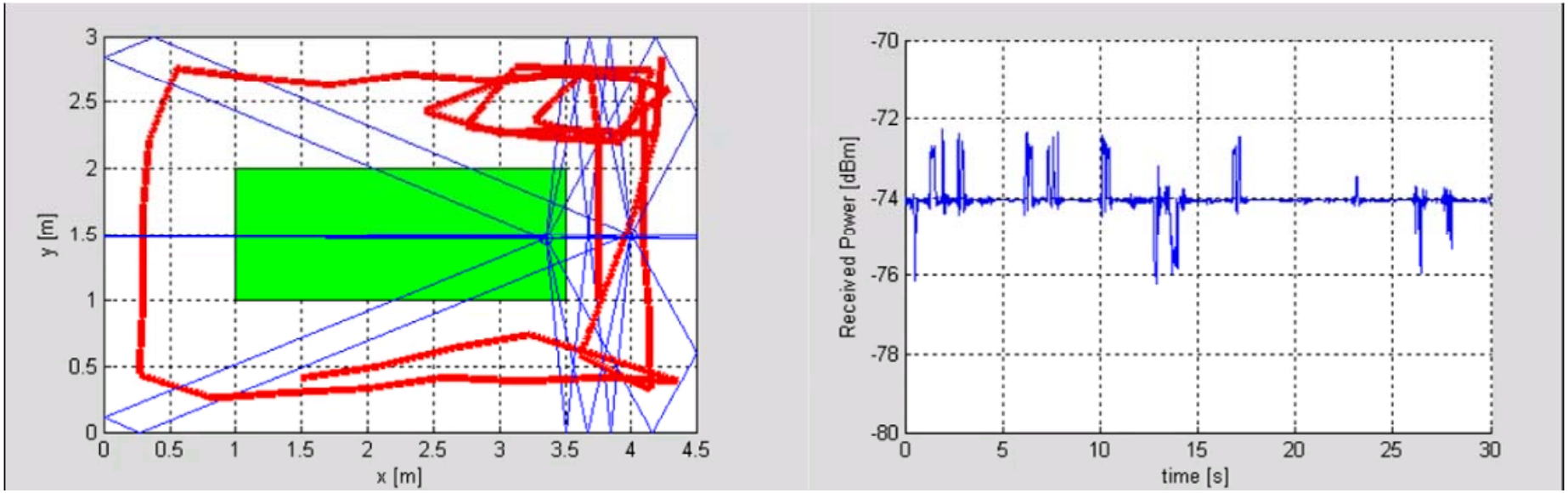
Random Walk Model

- **Simulation Parameters**
  - 1 Person walking around the table
    - Random Walk with preference direction
  - Speed v =1m/s
  - Step size: 60 cm
  - Person assumed as cuboid:
    - 0.45m x 0.15m x 1.70m
  - Time resolution: 10 ms
  - Simulation Time: 30 s
  - Apply diffraction model to the ray tracing results

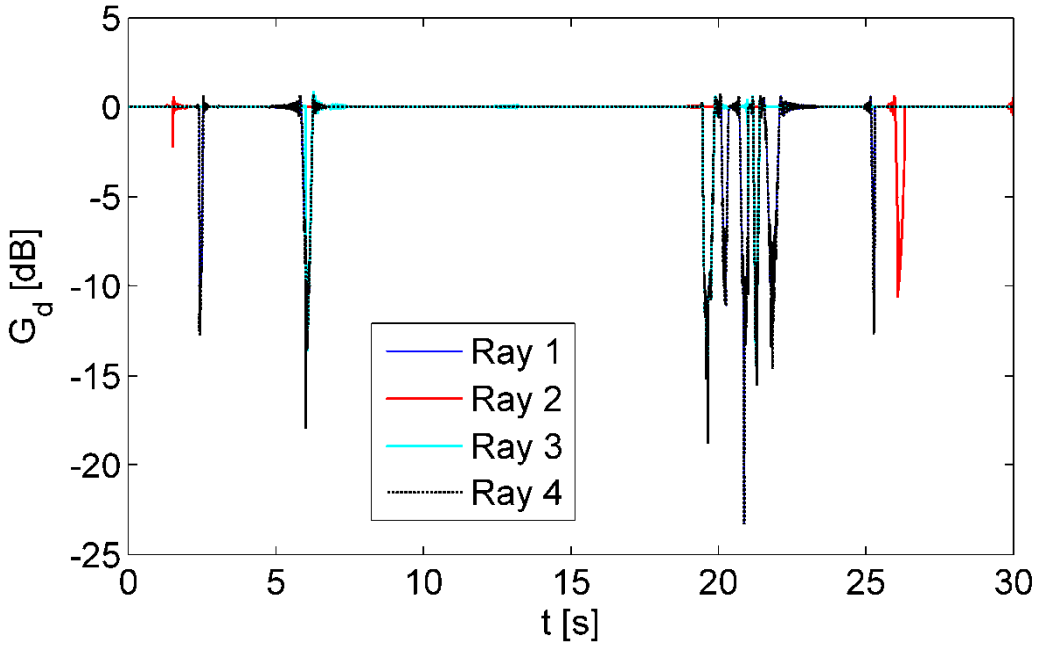


→3001 different time-variant CIRs for each of the 1071 STA positions

Simulation Example for Random Walk



Example Results



Temporal variation of the diffraction Gain of the four 1st order reflected rays for a fixed STA position on the table

Statistics

1. Number of blocked clusters

- Based on pure „blockage approach“
- Full blockage if ray intersects person
- 2 categories (1st & 2nd order)

2. Blockage probabilities for single clusters

- Based on diffraction model
- Full blockage if ray is attenuated by more than 2 dB
- 2 categories (1st & 2nd order)

3. Amplitude distribution

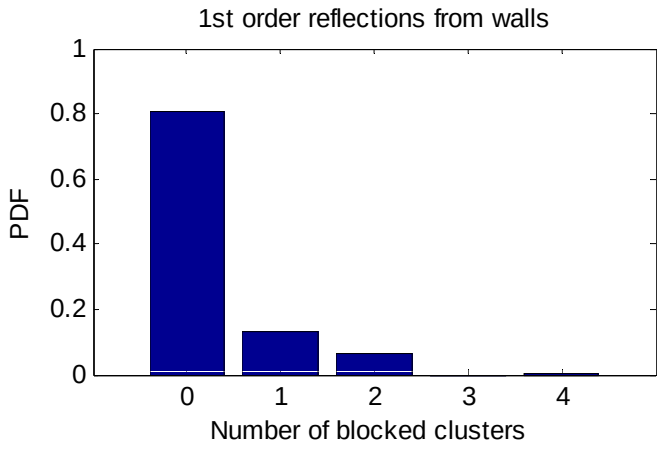
- Based on diffraction model
- Attenuation due to diffraction

Number of blocked clusters - 1

- 1071 x 3001 = 3,214,071 channel realizations
- In 99.99 % of the realizations the LOS link was NOT blocked!

- 1st order reflections from walls

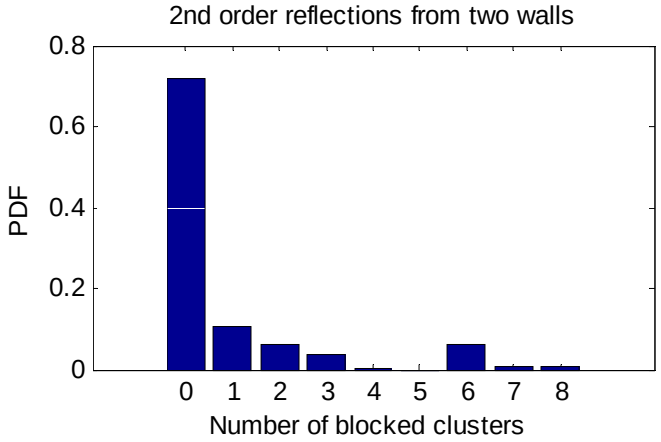
Number of blocked Clusters	Probability
0	80.4 %
1	13.2 %
2	6.4 %
3	0 %
4	0 %



Number of blocked clusters - 2

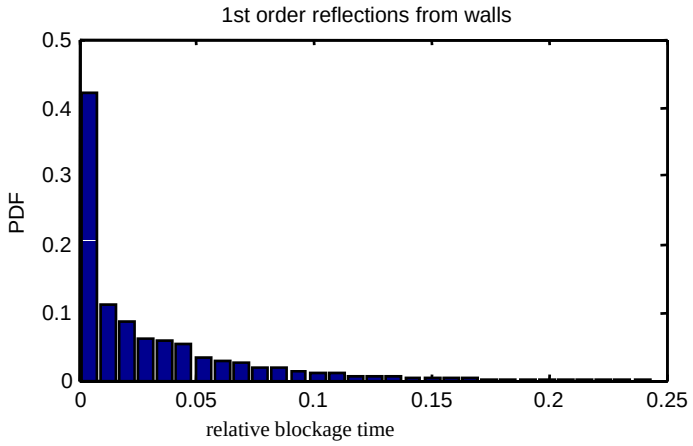
- 2nd order reflections from two walls

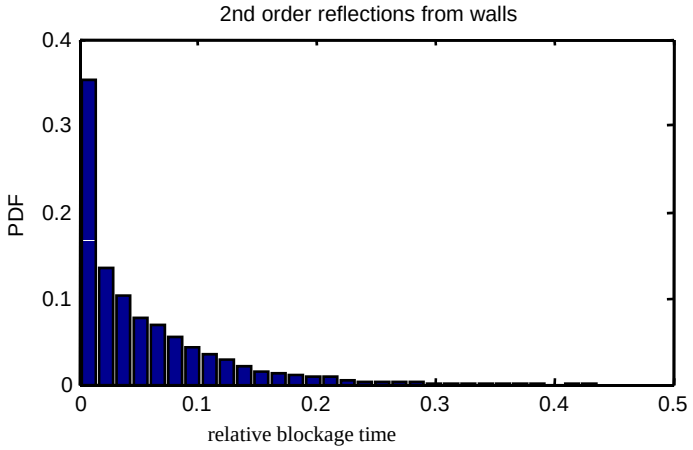
Number of blocked Clusters	Probability
0	71.6 %
1	10.5 %
2	6.2 %
3	3.8 %
4	0.3 %
5	0 %
6	6.4 %
7	0.7 %
8	0.5%



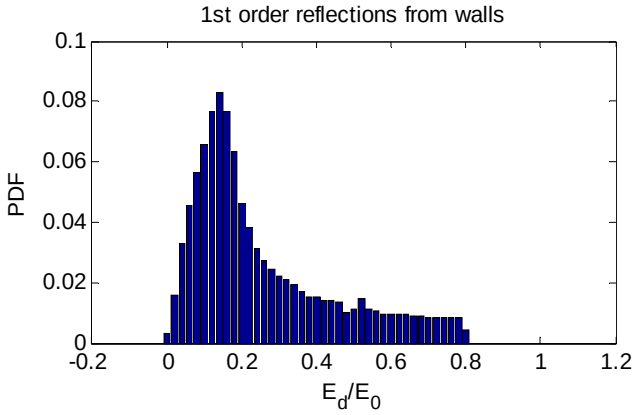
Blockage Rate of single clusters

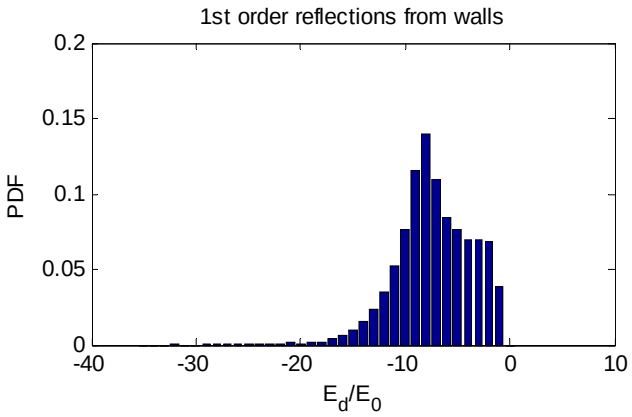
- The blockage rate of single clusters is calculated as the ratio of the duration of blockage and the simulation time (relative blockage time)
- In 99.99 % of the realizations the LOS link was NOT blocked!
- For the four 1st order reflections and the eight 2nd order reflections pdfs are given:

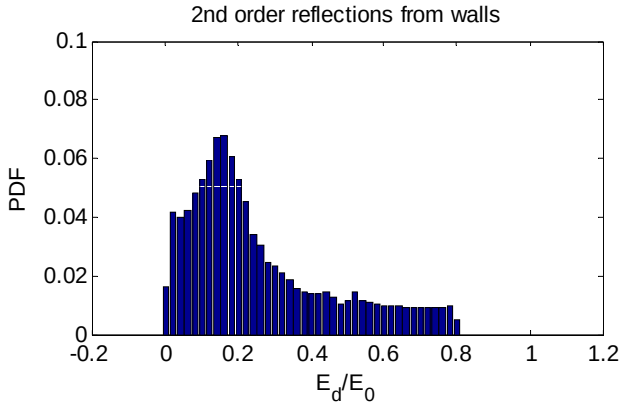


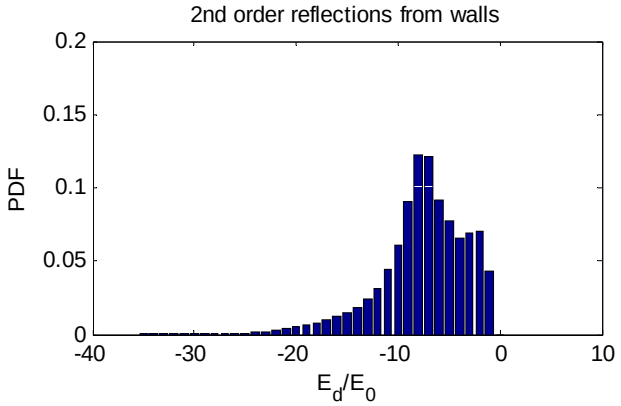


Amplitude distribution of attenuated paths









- Only attenuated paths taken into account (E_d/E_0 <-2 dB)
- Otherwise the amplitude distribution would be nearly Dirac shaped at E_d/E_0 =1 (0 dB), because the single path is not blocked most of the time

Conclusion

We propose to introduce the channel dynamics into the TGad channel document based on the presented simulation results. From this data it is possible to extract statistics about the total number of blocked clusters, about the blockage rate of single clusters or about the amplitude distribution of single clusters. These statistic can be included in the channel model in an adequate way.

References

- **[1] *E. Perahia:* TGad Task Group Document Open Items IEEE802.11-09/1108r0, October 2009**
- **[2] *A. Maltsev et al.:* Channel Models for 60 GHZ WLAN Systems, IEEE802.11-09/0334r3, July 2009**
- **[3] *M. Jacob et al.:* Human Body Blockage - Guidelines for TGad MAC Development, IEEE802.11-09/1169r0, November 2009**