Mitigating People Blockage by Angular Diversity at Millimeter Wave 5G Bands

Miguel Riobó, Manuel García Sanchez, Iñigo Cuiñas, Isabel Exposito
Dept. Teoría do Sinal e Comunicacións, atlanTTic
Universidade de Vigo
Vigo, Spain
miriobo, manuel.garciasanchez, inhigo, iexpositop@uvigo.es

Jo Verhaevert, Rob Hofman
IDLab, Department of Information Technology
Ghent University/imec
Ghent, Belgium
Jo.Verhaevert, Rob.Hofman@UGent.be

***Abstract*—A measurement campaign was carried out in order to characterize the channel response when people are passing between transmitter and receiver in the 5G Frequency Range 2 and beyond (40 GHz and 60 GHz). We also studied the possibility of using angular diversity to compensate for the resultant fading. After analyzing the data, interesting results are obtained: fading values over 25 dB were measured at both bands; the level crossing rate is very similar in value and distribution at both frequencies, and the average duration of the resultant fadings is almost double at 60 GHz. It was also observed that the fading depth seems to be related to the stature of the person obstructing the radio link. A deeper fading is observing with taller individuals.**

Keywords*—*attenuation; narrowband; propagation; diversity

I. Introduction

The fifth generation of mobile communications (5G) is just around the corner and will require higher data rates and lower latency times. There is no doubt that a very important part of the new services will be used in indoor environments, where the antennas are located very close to each other. The possibility of people passing between the end antennas will lead to a radio link that can be considered challenging at best, if not unstable.

In order to develop a diversity technique able to mitigate or even eliminate deep fading points, it is necessary to know how people interrupt the line of sight (LoS) and hence affect the performance of the system. With this objective, a campaign of narrowband measurements was carried out, and results are presented in this paper. In contrast, some studies focused on the effect of the people on the attenuation of the radio waves around WiFi frequencies [1] [2]. The most similar study is presented in [3], where the effect of people on the signal is characterized at different bands.

II. Measurement Setup

Measurements were performed with the intention to simulate a radio link for the 5G Frequency Range 2 in an indoor environment. One transmitting and two receiving antennas were used. The transmitting antenna was directive with a beamwidth of 20º, with an amplifier connected to it when working at 40 GHz. On the other hand, the receiving antennas were omnidirectional, amplified in the case of the measurements at 60 GHz and passive at 40 GHz.

The transmit antenna and the two receiving ones were placed in a large corridor, as depicted in Fig. 1. The heights were 1.2 m and 2.5 m above ground level for the transmitting and receiving antennas, respectively. Then, the linear distance between the transmitting and each of the receiving antennas was 3.09 m. The receiving omnidirectional antennas were made by Flann Microwave, models: MD249-AA and MD249-AC for the 60 GHz and 40 GHz measurements, respectively. The transmitting horn antenna used at 40 GHz was also a Flann Microwave model 23240-20, whereas it was a Q-par QSH25F20 at 60 GHz.

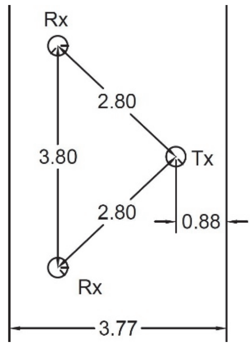


Fig. 1. Zenithal view of antennas' collocation. All dimensions are in meters.

All antennas were connected to a four port Rohde & Schwarz ZVA67 vector network analyzer (VNA) configured in time sweep mode, transmitting by port 1 and receiving by ports 2 and 3, measuring both S_{21} and S_{31} parameters. During the chosen sweep time of 20 s, the VNA sampled 20,001 and 2,001 points, at 40 GHz and 60 GHz bands, respectively. Thus, the sampling rates were 1 kHz for the former and 100 Hz for the latter.

A standard test was carried out, repeated at both bands. Two different persons passed at walking speed, one at a time, between the transmitting and receiving antennas. Person 1 was 185 cm tall and person 2, 173 cm. When each person interrupted the LoS, a deep fading was observed in the channel response.

III. Results

After data were gathered, both qualitative and statistical analyses were performed. The Level Crossing Rate (LCR) and the Average Fading Duration (AFD) were computed [4]. LCR is obtained by counting how many times the signal crosses a defined threshold per unit of time. On the other hand, AFD represents the mean time the measured signal is below each of those thresholds. Threshold values were selected from −30 dB to 2 dB in steps of 0.1 dB.

A. 60 GHz results

The maximum fading produced by the tallest person was −28.3 dB and −30.0 dB for parameters S_{21} and S_{31}, respectively. The shortest person induced fading events of −10.9 dB and −13.5 dB for S_{21} and S_{31}, respectively. Thus, the radio channel responses corresponding to the tallest person crossing show deeper fading events than those produced by the shortest.

LCR analysis shows higher number of crosses per second when the tallest person blocks the LoS, at the lower thresholds. Besides, the AFD caused by the tallest person are higher than the ones produced by the shortest.

B. 40 GHz results

Measurement results at 40 GHz show similar trends, with longer and deeper fading events caused by tallest person. The maximum depth of the fadings is −27.7 dB for S_{21} and −25.6 dB for S_{31} when the tallest test person passed by, whereas for the shortest one, the values are −25.5 dB and −12.3 dB, respectively.

Regarding the LCR when the tallest person blocks the channel, there are more crosses per second in the lower thresholds. Again, values for AFD are higher when computed from data gathered with the tallest person.

C. Spatial Diversity

Since measurements involved two radio channels, with two different receiving antennas, it could be possible to apply spatial diversity to improve the signal level. As described in [5], several methods are available; we applied the Signal Selection (SS). For each received time sample, the largest amplitude between both channel responses is selected:

$$D(t) = max\{S_{21}(t), S_{31}(t)\} \quad (1)$$

being t be the temporal instant, $D(t)$ the signal generated through diversity and $S_{21}(t)$ and $S_{31}(t)$ the channel responses. The results of the diversity algorithm are plotted in yellow and labelled as "Combination" in Fig. 2, in the 40 GHz case with the tallest person passing by. Fig. 2a shows a channel response, free of fading, when selecting the best channel, as one channel compensates the fading in the other. Diversity effectiveness is even evident in LCR and AFD: both parameters are always zero until the threshold value of 0 dB.

IV. Conclusion

This paper presents a study of the fading produced by test persons crossing an indoor radio link at 40 GHz and 60 GHz. Very deep fadings have been found. It stands out that the level crossing rate is very similar in value and distribution at both frequencies, and that the average duration of the resultant fadings is almost double at 60 GHz. To compensate for this, a diversity technique is proposed and analyzed with good results. Diversity reduces the number of fadings and its depth or even cancels them completely, ensuring a better signal level than when only one receiving antenna is used.

As the walking speed was similar for both test persons, we guess that the corresponding statures are related to the fading deep and duration. In fact, the duration of the fadings shows that their behaviors at 40 and 60 GHz can be correlated.

Acknowledgment

This work was supported by the Spanish Government, Ministerio de Ciencia, Innovación y Universidades (project TEC2017-85529-C3-3R), Xunta de Galicia (project ED431C 2019/26), atlanTTic Research Center and the European Regional Development Fund (ERDF).

References

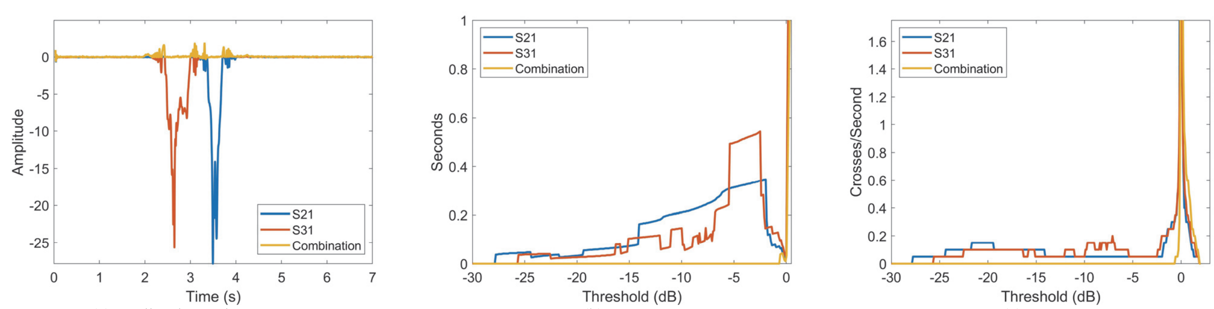
[1] M. Klepal, R. Mathur, A. McGibney, and D. Pesch, "Influence of people shadowing on optimal deployment of WLan access points," in IEEE 60th Vehicular Technology Conference, 2004. VTC2004-Fall. 2004, vol. 6, Sep. 2004, pp. 4516–4520 Vol. 6.

[2] J. C. Rodrigues, J. Valim, B. D. Tarso, S. G. C. Fraiha, H. Gomes, A. A. Neves, and G. P. S. Cavalcante, "People and furniture effects on the transmitter coverage area," in 2006 IEEE Ninth International Symposium on Spread Spectrum Techniques and Applications, Aug 2006, pp. 391–395.

[3] M. Nakamura, M. Sasaki, and Y. Takatori, "Human body shadowing at 26.4 and 66.5 GHz in an indoor environment," in 2018 IEEE International Symposium on Antennas and Propagation USNC/URSI National Radio Science Meeting, July 2018, pp. 757–758.

[4] D. Parsons, The Mobile Radio Propagation Channel. Wiley, 2000

[5] M. G. Sanchez, A. V. Alejos, and I. Cuinas, "Indoor radio reception at 60 GHz: Fading mitigation using diversity techniques," IEEE Transactions on Antennas and Propagation, vol.57, pp.2934-2939, 2009.



(a) Radio channel response (b) AFD (c) LCR

Fig 2. Results at 40 GHz when the tallest person is crossing.