Induced Effects of Moving People in an Indoor Radio Channel at sub-6 GHz 5G Bands

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***Abstract*— A deep knowledge of radio propagation is necessary before deploying wireless networks. In indoor environments, when people are moving, experimental analysis is needed, as many elements are difficult to model with a deterministic simulation tool. Thus, before deploying 5G systems at the 3.5 GHz band, insights on the effect of people moving in the indoor channel are required. This contribution describes the results of a measurement campaign considering different conditions. For analyzing the results, box plots of measured attenuations due to the people moving are compiled. Both the speed of the people and their concentration seem to influence the narrowband parameters of the radio channel. However, the position of the people seems to provide fewer effects on the radio channel.**

Keywords — indoor; measurement; propagation; people

I. Introduction

A new generation (the fifth) of wireless communication is arriving and its deployment requires a good knowledge of radio wave behavior, among other technical solutions and understandings. This contribution gives the experimental results of the effect of people moving within indoor radio channels at 3.5 GHz band. This band has interest because of its use for fifth generation (5G) systems [1]. The people involved would obstruct the path between transmit and receive antennas in different ways, transforming the line of sight (LoS) conditions into obstructed line of sight (OLoS). Similar measurement campaigns were made, in the past, at other frequency bands, reporting i.e. decrements of around 1.3 dB when people are moving freely at 5.7 GHz [2], and observing an increment of attenuation variability when people are near [3].

The results of this study, done at 3.5 GHz, suggest changes in received power when the radio link is obstructed by people moving. Whereas the location of individuals seems to have limited influence, the speed and the amount of people involved in the experiment result to be more determinative, and they must be considered by radio planners.

II. Measurements

We performed measurements after tailoring an automated system for controlling the measurement instrument. A vector network analyzer (VNA) was intended to gather the attenuation variations during short time periods, with and without people moving in between transmitting and receiving antennas. The selected environment was a corridor, as it allows forcing people to cross between both antennas when moving from one side to the other. Two biconical omnidirectional antennas were set up at the same height, located at a distance of 3.5 m of each other, perpendicular to the axis of the corridor, close to each lateral wall.

Once the antennas were placed, the four port Rohde & Schwarz ZVA67 VNA measured the S_{21} parameters at sequences of 25 seconds on zero-span mode, tuned at 3.5 GHz. We gathered some bursts of channel responses in a quiet situation, without people moving, to have static references. Then, people were forced to cross the LoS in a choreographed way, being the formation side-by-side in all situations, whereas the VNA gathered bursts of OLoS channel responses.

III. Results

Each measured channel response has been subtracted with the mean value when no people were crossing, in order to obtain the net difference in received power. Based on the fluctuation of these differences, we evaluate a boxplot which shows how much variation is present in the channel when people are crossing. The box plot height corresponds to the Inter-Quartile Range (IQR), which represents half of the measured data and it is hence a measure of the spread of data around its median value. Besides that, also indicates the presence of values at larger distances of this median. The obtained results are explained in the following subsections.

A. Effect of crossing speed

To check the effect of the speed of people movement, we forced one person to cross in between both antennas at three different speeds, labeled from 1 to 3 in increasing numbers: speed 1 is the slowest (walking speed) and speed 3 is the fastest (march speed). In all cases, people were not allowed to run. Figure 1 contains the box plots obtained from this experiment, where we can observe that the presence of people always induces some attenuation independent of the walking speed. The attenuation induced by one person moving resulted to be between 1 and 2 dB, which is an additional attenuation to be considered related to the analysis of an empty indoor environment. The difference in IQR for the boxplots is highly dependent on the crossing pace of the people: when crossing at a slower pace, the attenuation affects more measured samples, which will result in a larger IQR.

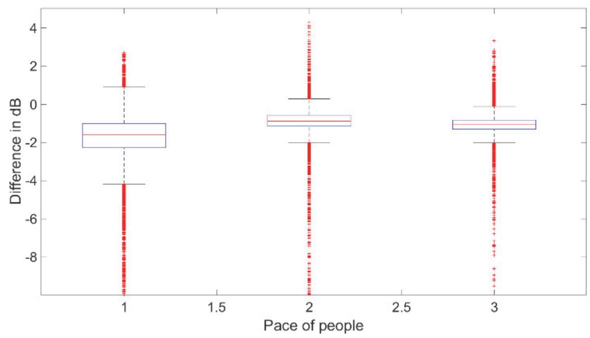

Fig. 1. Box plots of induced attenuations depending on the pace of the people moving (being 1 the slowest and 3 the fastest speeds)

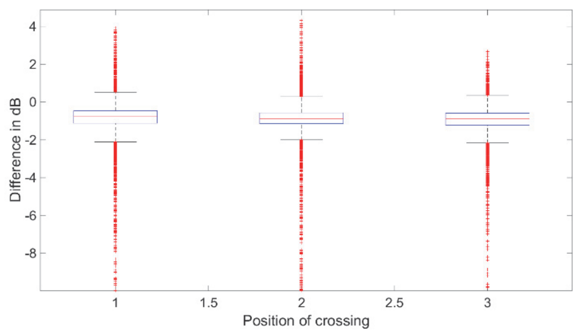

Fig. 2. Box plots of induced attenuations depending on the position of the person moving (being 1 the closest to the receiving antenna and 3 the closest to the transmitting antenna)

B. Effect of crossing geometry

In order to analyze the influence of the crossing position, people were asked to cross the LoS path close to the receiving antenna, in the middle, or close to the transmitting antenna. The resulting boxplots are plotted in figure 2. Generally speaking, we could consider that the attenuation is, in median, independent of the position of the obstacle related to the transmitter or to the receiver at this 3.5 GHz band. This result is interesting as the location of the antennas in a final deployment would be independent of the expected preferred paths of people moving within the environment where the 5G system is installed.

C. Effect of the amount of people

The amount of people crossing the LoS of the radio link is also an interesting property to investigate. This experiment consisted in forcing people to cross the wireless link individually or in groups of two, three or four persons, organized in a line parallel to the wireless link: this means that one, two, three or four people crossed the link at the same time. Results are depicted in figure 3. One can see slight changes going from one to four people, although the median attenuations seem to be very similar. This leads to the conclusion that the amount of people crossing is of importance regarding the attenuation of the channel. Then, network planners must take into account the expected number of people moving within the environment for where they are intending to deploy the radio network in order to define the transmitted power at each area.

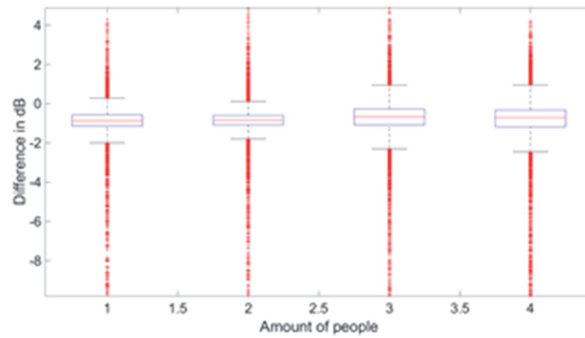

Fig. 3. Box plots of induced attenuations depending on the amount of people obstructing the LoS

IV. Conclusion

This contribution presents a large measurement campaign focused on the effect of people moving within radio links in an indoor environment at the 3.5 GHz band, one of the assigned frequency bands to be used in 5G systems in the near future.

It has been found that the speed of people affects the channel: although median induced attenuations are always between 1 and 2 dB, the spread around median grows with the lowest speeds. This suggest to use additional attenuations to correct the estimations provided by simulation tools. The position of the people related to the antenna locations seems to have almost no influence on the radio channel performance. This is interesting, as network planners do not have to think about the main movement routes within the indoor environment when planning the different access points. The amount of people affects more to the variability around median attenuation than to the own attenuation values, which simplifies the task of the planners.

The insights and the values provided in this paper can be used in future developments of new communication systems as guard values or to improve results obtained by simulation, in order to develop better designs for radio networks at 3.5 GHz.

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