MODELING OF DIRECTIONAL RADIO LINKS AND THE ACCURACY OF 5G LINK BUDGET ESTIMATION

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The main objective of this dissertation is the assessment of accuracy of 5G radio link budget estimation from the perspective of joint modelling of directional antenna beam pattern and angular spread phenomenon, due to impact of this estimation on the efficiency of 5G network planning and optimization.

First are clarified the definitions of nominal antenna pattern (as measured in anechoic chamber) and effective antenna pattern (as determined in scattering environment). Afterwards presented are simulation results of 5G network performance, which indicate significant overestimation if nominal antenna patterns are assumed during evaluation instead of effective antenna patterns. This part is concentrated on radio link budget for serving and interfering downlink (DL) signals in millimeter-wave cell and indicates methods for its accurate calculation. Additionally, a method for improvement of DL signal to interference plus noise ratio (SINR) by optimization of effective antenna pattern is proposed and evaluated. This method is based on the patented proprietary algorithm, which matches the geometry of antenna array to the azimuth and zenith angular spread in the given channel. In the consequence the effective antenna pattern, understood as a spatial filter of multipath components, is optimized and its effective antenna gain is maximized.

The next study evaluates for 5G the accuracy of methods for assessment of radio frequency (RF) electromagnetic field (EMF) exposure inherited from previous systems. It is presented that legacy methods may lead to significant overestimation of the maximum RF EMF exposure associated with 5G base station (BS) in scattering environment if nominal antenna pattern is assumed instead of effective antenna pattern. Therefore, a simple solution is proposed to improve the accuracy of RF EMF exposure assessment, which is indicated in the latest version of standard 62232 defined by International Electrotechnical Commission (IEC). Proposed solution is based on closed-form formulas, which allow to extrapolate the maximum exposure by calculation and

comparison of effective antenna gains. Obtained values of RF EMF exposure are more accurate than estimated based on nominal antenna gains and at the same time do not require comprehensive system-level simulation with 3D channel model.

By the example of Citizens Broadband Radio Service (CBRS) it is presented how the accurate modeling of antenna pattern may improve performance of radio resources distribution in spectrum sharing environment. Obtained simulation results allow to assess the accuracy of interference evaluation and channels distribution between CBRS devices (CBSD) if centralized controller for spectrum access system (SAS) does not have enough knowledge about effective antenna pattern. It is also indicated that for the assumed scenario of CBRS network implementation the mutual interference between each pair of CBSDs can be significantly underestimated, which in consequence leads to insufficient co-existence conditions, if nominal antenna pattens are used by SAS instead of effective patterns. Therefore, a proposal for improvement of standards relevant for CBRS networks is made.

The final study allows to compare different approaches for joint modeling of antenna pattern and angular spread phenomenon in scattering environment. The concept of effective antenna pattern is compared with multi-elliptical propagation model (MPM) approach. This comparison is enabled by the use of common input data. Comparable simulation results, obtained from both approaches for selected simulation scenarios, allow to conclude that MPM model ensures good accuracy without the need for full 3D channel modeling in time-consuming and computational power-consuming statistical simulations.

Findings and conclusions of all studies included in this dissertation are aligned with the thesis stated in its introduction and can be considered as a noticeable contribution to the current state of the art.