NED UNIVERSITY OF ENGINEERING AND TECHNOLOGY

ANNOUNCEMENT

Doctoral Dissertation Oral Defense

Abstract

Uplink Performance Analysis of Millimeter Wave in Heterogeneous Cellular Network

by

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Millimeter wave (mmwave) spectrum potentially offers significant improvement in the capacity of the future cellular network to support higher data rate requirements for futuristic applications. However, mmwave systems have certain design challenges such as directional communication and susceptibility to blockages. Therefore it is critically important to properly model and analyze the behavior of mmwave systems. This work investigates the design of an uplink mmwave cellular network and develops mathematical models that represent the network performance.

The first contribution of this research is development of an analytical model for urban outdoor mmwave cellular network to characterize the impact of network parameters such as base station (BS) density, load per BS, system bandwidth and power control factor on system performance metrics such as signal-to-interference-and-noise ratio (SINR) coverage probability, rate coverage probability and area spectral efficiency (ASE). The developed framework incorporates blockage effect due to buildings by employing a distance-dependent exponential line-of-sight (LOS) probability function and separate path loss exponents for LOS and non-LOS (NLOS) paths. One of the critical aspects of uplink performance characterization is to accurately model the interference seen at the BS. By modeling the interferers as non-homogeneous Poisson point process (non-HPPP), the analysis takes into account the spatial correlation that arises due to the use of multiple access scheme and power control, between the BSs and interfering user equipment (UEs). The results based on the developed model illustrate accurate network coverage estimates for sparse to dense network deployment. Based on the findings, an optimum BS density value at which the SINR coverage probability, as well as ASE, is maximized can be determined.

As a second contribution of this thesis, NLOS coverage performance of mmwave cellular network is examined including the effect of blockage in the propagation environment. The presence of blockage can significantly impact the LOS coverage of mmwave cellular network, raising concerns for the viability of mmwave NLOS links. It has been demonstrated unequivocally by experimentations that acceptable rates can be obtained through the NLOS path, in case of LOS obstructions. Based on the fact, that the blockages in the environment lead to an exponential attenuation term in the link budget expression, this work employs stretched exponential path loss model (SEPLM) that is deemed appropriate to define the presence of various blocking environments as a function of path loss parameters. Results demonstrate the importance of NLOS links which yield sufficient coverage and ASE in medium to sparse obstructive environment, whereas in a highly obstructive environment the achievable coverage probability and the ASE is relatively low.

As a third contribution, the impact of dynamic blockage (moving vehicles or humans that obstructs LOS path for a particular duration) on the mmwave communication in an open space scenario is investigated. An important aspect for mmwave communication is the performance degradation by the presence of human blockers as well as the user‘s body. Increased blockage frequency and longer blockage durations cause service interruptions degrading the user‘s quality of service. It is observed that the proper selection of SINR threshold is critically important to obtain better coverage performance in the presence of self-body blockage and human blockers in the surroundings. Results show that as compared to small cell radii, large communication ranges are less affected by the human density. However, the coverage probability at low cell radii can be considerably improved by increasing the height of BS.

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