# PERFORMANCE ANALYSIS OF TERAHERTZ COMMUNICATION ENABLED NETWORKS

## ABSTRACT

Channel propagation in the THz band is highly susceptible to various propagation losses including molecular absorption, blockages caused by walls and humans, path loss, and interference, resulting in restriction on THz network coverage. However, it remains viable for an indoor environment when the Line-of-Sight (LOS) path is available. The constraint on THz network coverage highlights the need for the coexistence of multi-tier (MT), multi-band (MB) heterogeneous networks (HetNets). Typically cellular networks employ two distributed cell association schemes namely Reference Signal Received Power (RSRP) and bias-based Cell Range Expansion (CRE). In the downlink of MT networks, different Access Points (APs) transmit with different powers, which can cause a traffic load imbalance, overloading APs with higher transmit power while leaving APs with lower transmit power underutilized. CRE has emerged as the solution to provide a better cell load balancing by adding a bias, to increase the strength of low transmit power APs.

This project focuses on the analytical modeling of a single-tier THz network and MT, MB HetNets using stochastic geometry. The project has been carried out in three parts: firstly the performance of a single-tier THz network has been investigated while considering human and wall blockages for an indoor environment. RSRP-based cell association scheme is employed for single-tier THz network. The proposed framework is classified into probabilities of LOS and Non-Line-of-Sight propagation caused by human blockages. The generalized expression for uplink coverage probability (UCP), average spectral efficiency, and mean interference power with comparison to the densities of THz APs (TAPs) and human blockages have been derived. The impact of the uplink network performance of the THz network has been analyzed for different network and environmental parameters. Secondly, a system model for MT, MB HetNets including THz, Sub-THz, and mmWave tiers has been developed. The user association probabilities of the three tiers have been derived by considering different environmental conditions and various network parameters. The impact of the downlink network performance of the HetNets has been analyzed under different environmental conditions which include free space and suburban zones. This investigation establishes the significance of network and environmental conditions in particular the impact of CRE bias and antenna array sizes on the utilization of THz tier for serving the indoor user. Thirdly, the impact of the uplink network performance of the MT, MB HetNets by considering human blockages and different environmental conditions has been analyzed. The impact of network parameters such as CRE bias and different antenna array sizes have also been investigated. The model has been analytically tested for various performance parameters, such as SINR, UCP, and average spectral efficiency. To validate the derived analytical expressions Monte Carlo simulation has been performed.

The results highlight the target to improve the load management of APs, where the indoor users are being intentionally served by indoor TAPs. These system models find promising applications to enable eMBBPlus networks, where the users are located in an indoor environment and can fully exploit the benefits of the THz tier. Moreover, this investigation establishes the significance of environmental and network conditions in

particular the impact of CRE bias, antenna array sizes, and blockages effect on the utilization of THz tier for serving the indoor user. The results indicate that the system model enhances coverage and reliability by facilitating both indoor as well as outdoor wireless communication.

The THz band plays a vital role in 6G networks. The vision of 6G networks is to improve the performance of data rate and latency limitations. This improvement may result in ubiquitous connectivity. It can become the next frontier of high data rate communication. THz frequency band is expected to improve and provide performance benefits to applications that may not function optimally if deployed using 5G technologies. Some of such applications include but are not limited to remote surgery, haptic and holographic communication, etc. Applications like remote surgery are envisioned to transform healthcare services. The above-mentioned applications necessitate a very high data rate (up to 1 Tbps), and extremely low latency (as low as 100 μs) to meet real-time communication requirements, which are targeted to be achieved using THz communication technology under the 6G standard. Haptic communication offers promising services in smart homes or buildings by employing tactile feedback. Moreover, holographic communication, which enables distant users to represent their presence, operates in 3D space with audio that can mimic various physical attributes and requires more bandwidth (up to 100 GHz), which is not supported by 5G technology enablers. Hence, the bandwidth-hungry, low latency, and high-reliability requirements of applications and use cases discussed above warrant the deployment of THz communications infrastructure, particularly for indoor network deployments.