Comparative Study on mmWave and Terahertz Hotspot Performances

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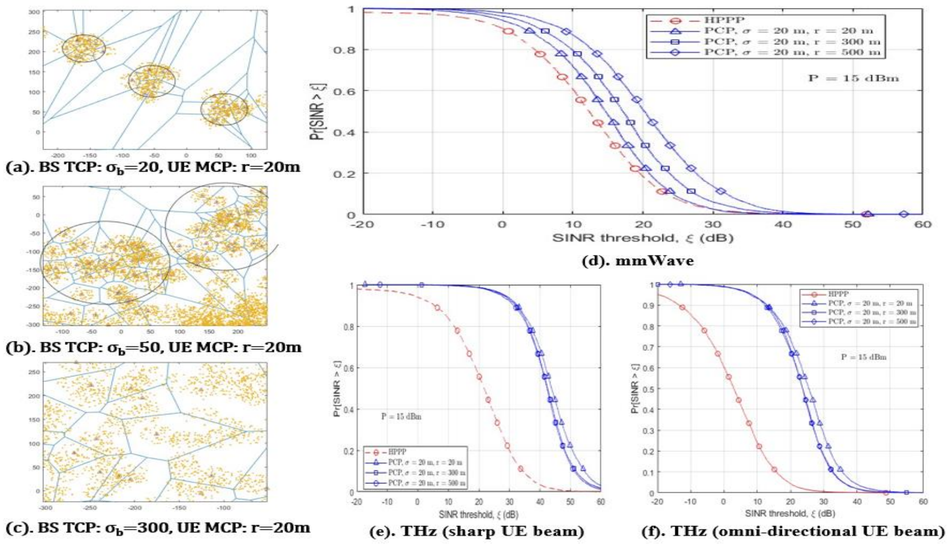
Abstract— Millimeter wave (mmWave) technology has been instrumental in the development of 5G networks, and as we anticipate the evolution to 6G mobile communication, the frequency band above 100 GHz, specifically the Terahertz (THz) band, emerges as a defining characteristic. The THz band shares many attributes with mmWave albeit with heightened nuances. Challenges within the THz spectrum include reduced antenna aperture size, leading to diminished per-antenna power output, and the additional complexity of atmospheric absorption, further compounded by signal blockages like mmWave. Moreover, while the homogeneous Poisson Point Process (HPPP) has traditionally modeled the distribution of base stations (BSs) and users, it has limitations in capturing the intricate spatial configurations encountered in real-world deployments. The Poisson cluster Process (PCP) can capture both non-uniformity and hotspots forming or coupling in the positions of BSs and the users. This research undertakes a comparative evaluation of mmWave and THz performance across diverse network topologies.

Keywords—6G, mmWave, THz, Hotspot, Poisson Cluster Process



- BSs form hotspots where UEs cluster around each BS following Thomas Cluster Process (TCP) and Matérn Cluster Process (MCP), respectively. For all cases, UE cluster size around parent point BS remain same.
- With the increase in cluster size of BSs, it approaches HPPP except that inter BS distance is larger than baseline HPPP. Due to larger separation of BSs, interference is diminished and hence, SINR is higher than baseline.
- In mmWave, where BS antenna gain is smaller, bigger BS hotspot leads to higher SINR as the interference from neighboring BSs is not as prominent as in THz.
- In THz, where BS antenna gain is larger, bigger hotspot also means overall inter-cluster BSs getting closer. So, interferences are coming from all directions (360˚) besides high antenna gain. Hence, SINR decreases but at a margin. THz omnidirectional UE beam performs worse than sharp UE beam due to interference.
- For THz with sharp UE beam as well, with increase in BS cluster size, the beam is more likely to be interfered because the BSs from other clusters (360 ˚ around the user) are getting closer. Hence, SINR decreases.

[1] N. R. Olson, J. G. Andrews and R. W. Heath, "Coverage and Capacity of Terahertz Cellular Networks With Joint Transmission," *IEEE Trans. on Wireless Commun.*, vol. 21, no. 11, pp. 9865-9878, Nov. 2022.

[2] T. Bai and R. W. Heath, "Coverage and Rate Analysis for Millimeter-Wave Cellular Networks," *IEEE Trans. on Wireless Commun.*, vol. 14, no. 2, pp. 1100-1114, Feb. 2015.

[3] C. Saha, M. Afshang and H. S. Dhillon, "Poisson cluster process: Bridging the gap between PPP and 3GPP HetNet models," *Information Theory and Applications Workshop (ITA),* pp. 1-9, San Diego, CA, USA, 2017.