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# UAV-assisted 5G Networks for Optimised Coverage Under Dynamic Traffic Load

*Iftikhar Ahmad[†], *Jaspreet Kaur, Hasan T Abbas, Qammer H Abbasi, Ahmed Zoha, Muhammad Ali Imran and Sajjad Hussain

James Watt School of Engineering, University of Glasgow, United Kingdom. †(i.ahmad.3@research.gla.ac.uk)

*Authors made an equal contribution.

*Abstract*— **Cellular communication researchers and engineers are both interested in the potential use of unmanned aerial vehicles (UAVs) as aerial base stations. In comparison to terrestrial communications or systems based on high-altitude networks, on-demand wireless systems using low-altitude UAVs can be deployed faster, can be reconfigured more easily, and will likely have better communication channels due to short-range line of sight links. The goal of this paper is to evaluate the use of UAVs in next-generation wireless networks, specifically as a flying base station. Ray-tracing simulations are used to simulate the coverage of a UAV-aided base station (UAV-BS) in a scenario with a fixed base station at the University of Glasgow, UK. The results imply that the UAV-BS will be of tremendous benefit to 5G network communication, such as capacity expansion in metropolitan regions, better coverage in rural areas, and network densification.**

## I. INTRODUCTION

The enormous growth of high-performance mobile devices such as smartphones, tablets, and Internet of Things (IoT) devices has increased the demand for high-speed wireless access. As a result, conventional wireless cellular networks have reached their capacity and coverage limits, requiring the development of new wireless technologies to address the problem [1]. Because of their wide variety of applications, Unmanned Aerial Vehicles (UAVs) have recently caught the interest of operators and the research community as a possible option for creating secure wireless communication [2][3].

Among the many uses for UAVs; high-speed wireless transmission is expected to play a role in future communication systems. Indeed, UAV-assisted wireless communications is a possible alternative for giving wireless connectivity to devices that lack infrastructure coverage due to severe shadowing in mountainous terrains or damage caused by natural catastrophes to infrastructure [4].

The main problem that wirelesses communication networks face in this regard is a lack of capacity for such unexpected demand, so various solutions, such as millimeter-wave communications, massive multiple-input multiple-output (mMIMO), and network densification, have already been introduced with the goal of capacity enhancement. However, there is still an opportunity for capacity expansion, particularly in scenarios involving unusually large crowds, such as music concerts, sporting events, fairs, and other events that occur seldom. In such circumstances, a crowd gathers around a hotspot (i.e., the event location) and puts pressure on the existing cellular network infrastructure, which is typically not equipped to handle such unusual events. For these types of applications, a pop-up solution is necessary, and UAV-assisted wireless networking has been proposed as a possible option. Each UAV is equipped with a small cell base station and is deployed on-demand in a specific location to provide pop-up connectivity [5]. This paper presents a brief experimental assessment of ray-tracing simulation for a 5G network supported by UAVs with the aim is to assess UAVs in 5G networks.

## II. METHODOLOGY

Ray-tracing simulation is a way for modeling the propagation of an RF signal and has a lot of potential for assessing channel characteristics and innovative radio technology. In many cases, ray tracing can give a reliable technique of describing the mmWave channel. In this article, Remcom Wireless Insite (WI) [6] simulation application is used as a ray-tracing model method to apply and examine the functional aspects of radio transmission and wireless communication systems. A small cell scenario of the University of Glasgow (UofG) in Glasgow, Scotland, UK campus was set up in WI with a fixed base station James Watt School (JWS) and one flying base station (UAV-BS). The layout of the university campus was obtained from a third-party application (open street map) with the help of Remcom, shown in Figure 1. A grid is deployed at a specific location with receivers for a less crowded scenario and approximately 1200 receivers for a crowded scenario, each 1m and 0.5m apart, respectively. The array was designed to be 4x4 with both vertically and horizontally polarized antennas, totaling 32 elements for 3.7 GHz. The fixed BS is down tilted, while the UAV-BS antenna was placed 90° tilted towards the ground at a height of 100m. The transmission power of the JWS is 49dBm and the frequency is 3,750MHz with a bandwidth of 100MHz. In contrast, over the UAV we installed a half wave-dipole antenna on the sinusoid with a transmission power of 30dBm on a frequency of 2000MHz with a bandwidth of 10MHz. The conceptual model is illustrated in Figure 2, while the parameters for the simulations are given in Table 1.

TABLE 1. SIMULATION PARAMETERS.

| **BS Name** | **Down-tilts and Azimuth** | **Transmission power** | **Frequency** | **Bandwidth** |
|---|---|---|---|---|
| JWS | 15°, 190° | 49 dBm | 3,750MHz | 100 MHz |
| UAV-BS | 90°, 190° | 30 dBm | 2000MHz | 10 MHz |

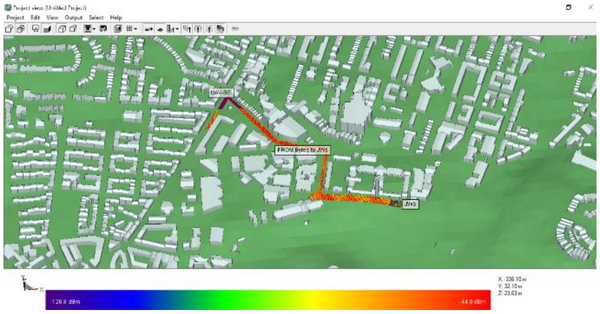

Figure 1. University of Glasgow Ray tracing scenario with Mobile Users, Base Station and UAV-BS.

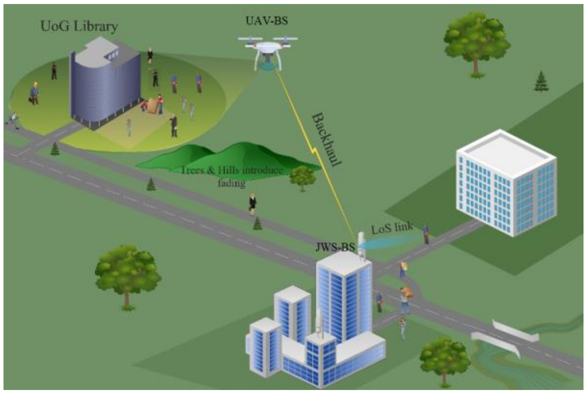

Figure 2. The Conceptual Model.

## III. SIMULATION RESULTS

For comparative analysis, we simulated less crowded and crowded scenarios and evaluated the impact of connectivity offered by UAV-BS on the average received signal strength. The results shows that when JWS doesnot provide power to user at a specific location i.e. from receiver 500 to the last receivers which are away from the JWS the UAV-BS pop-up and provide power to the user in shdowed areas (unserved users). The results indicated that UAV can be helpful in a congested area where the number of mobile users are high and the power is low or unavailable. The output of the results for the simulation are shown in Figure 3.

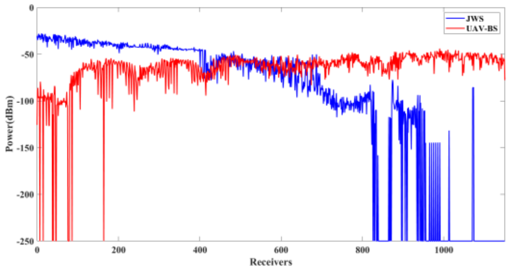

Figure 3. Received Power in a crowded scenario.

The simulation data can be retrieved and used to analyze MIMO performance using beamforming techniques and estimating received power, SINR, and throughput. At the transmitter side, we are using maximum ratio transmission (MRT) beamforming and at the receiver end, we have used receiver diversity in terms of Selection Combining (SC), Equal Gain Combining (EGC), and Maximal Ratio Combining (MRC) [7]. In comparison to no-beamforming, using beamforming techniques increased throughput by about 70% on average in our case by deploying UAV-BS as a flying base station at a congested location. The result shows that there is a significant difference in throughput between no-beamforming with beamforming as shown in Figure 4.

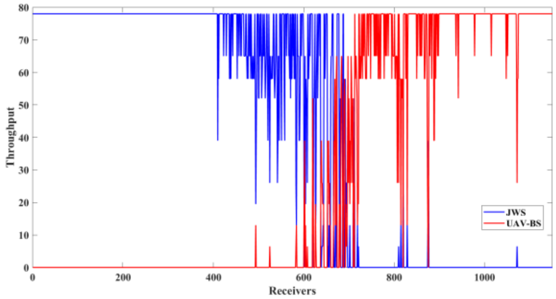

Figure 4. Throughput with Beamforming.

## IV. CONCLUSION

In this paper, we used ray-tracing simulation to evaluate UAV-aided wireless communications. in comparison to fixed BS, this study demonstrated the benefit of using UAV-assisted networks for improved coverage. Furthermore, we simulated two scenarios and report the efficacy of our proposed framework in terms of received power. The study then includes multiple performance scenarios (received power) to determine the usefulness of UAVs in wireless communication. Similarly, in comparison to no-beamforming, our data demonstrate an overall 70 percent increase in throughput when beamforming techniques are used.

## REFERENCES

[1] M. Mozaffari, W. Saad, M. Bennis, Y. H. Nam, and M. Debbah, “A Tutorial on UAVs for Wireless Networks: Applications, Challenges, and Open Problems,” IEEE Commun. Surv. Tutorials, vol. 21, no. 3, pp. 2334–2360, 2019, doi: 10.1109/COMST.2019.2902862.

[2] Y. Zeng, R. Zhang, and T. J. Lim, “Wireless communications with unmanned aerial vehicles: Opportunities and challenges,” IEEE Commun. Mag., vol. 54, no. 5, pp. 36–42, 2016, doi: 10.1109/MCOM.2016.7470933.

[3] S. Hayat, E. Yanmaz, and R. Muzaffar, “Survey on Unmanned Aerial Vehicle Networks for Civil Applications: A Communications Viewpoint,” IEEE Commun. Surv. Tutorials, vol. 18, no. 4, pp. 2624–2661, 2016, doi: 10.1109/COMST.2016.2560343.

[4] M. Kishk, A. Bader, and M. S. Alouini, “Aerial Base Station Deployment in 6G Cellular Networks Using Tethered Drones: The Mobility and Endurance Tradeoff,” IEEE Veh. Technol. Mag., vol. 15, no. 4, pp. 103–111, 2020, doi: 10.1109/MVT.2020.3017885.

[5] W. Khawaja, O. Ozdemir, and I. Guvenc, “UAV air-to-ground channel characterization for mmWave systems,” IEEE Veh. Technol. Conf., vol. 2017-Septe, no. I, pp. 1–5, 2018, doi: 10.1109/VTCFall.2017.8288376.

[6] “Remcom.” https://stores.modularmarket.com/remcom/digdel_login.php (accessed Feb. 01, 2022).

[7] J. Kaur, O. R. Popoola, M. A. Imran, Q. H. Abbasi, and H. T. Abbas, “Improving Throughput For Mobile Receivers Using Adaptive Beamforming,” in 2021 1st International Conference on Microwave, Antennas \& Circuits (ICMAC), 2021, pp. 1–4.