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RESEARCH ARTICLE

Positioning Optimization of UAV (Drones) Base Station in Communication Networks

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Abstract Unmanned aerial vehicles (UAV) and cellular networks are growing closer to being integrated in the realm of wireless communications, which will improve service quality even further. In this study, we investigate a wireless communication system in which two types of base stations—in the air and on the ground—serve separate groups of users. We analyze the effect of the aerial base station (ABS) height and transmit power on the system's downlink and uplink data rates while accounting for the reciprocal interference between the Aerial and terrestrial communication lines. The findings demonstrate that in many cases the best ABS altitude and transmit Power are either the highest or lowest values attainable. The distance between the ABS, the ABS user (AU), and the terrestrial base station user, among other factors, may affect how well they all communicate (TU). In this article we will discuss the following topics: unmanned aerial vehicle (UAV), terrestrial base station (BTS), transmit power optimization (TPO), interference (I), downlink (DL), and uplink (UL).

Keywords: Drones, Communication Networks, Positioning Optimization, UAV.

Introduction

Due to advantages like on-demand deployment and strengthened aerial-ground communication linkages, communication provided by unmanned aerial vehicles (UAVs) is a viable technology for future wireless communication networks [1]. As a result, there has been a considerable increase in the research community's interest in addressing some of the most pressing concerns of UAV-enabled communication, including trajectory Design, coverage analysis, and positioning optimization [2-4]. UAV-enabled mobile relaying systems were investigated in [2], where a unique framework was suggested to optimize both the UAV's trajectory and its transmit power. The optimal placement of the UAV was determined in [5-10] in order to guarantee that the intended area would be covered. In [6], the authors suggest a method for designing UAV itineraries that will reduce the time required to complete a multicasting operation. In [4], the authors optimized the trajectory (time-variant placement) and transmit Power of a communication system between numerous UAVs in the presence of UAV-based interference in a rural setting, assuming a constant UAV height. Independently, for coverage enhancement purposes in urban areas, the authors of [6] and [7] investigated 3D UAV positioning without taking interference into account. This paper [3] independently investigated the optimal UAV altitude and Beamwidth without interference concerns. The coverage area and UAV altitude were investigated by the authors of [5], who evaluated the downlink operation of a UAV existing alongside an underlying device-to-device (D2D) Communication network. In order to transfer data to a receiver without being seen, a UAV's altitude and power have been optimized [11]. There is work done on UAV placement optimization in [12], where a UAV is used as a relay between a transmitter and a receiver while the system is subject to interference. This paper [13] uses a two-dimensional (2D) Sequential approach to find the minimum number of UAVs required to cover a given area.

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This paper examines the optimization of UAV altitude and transmit Power under interference influence in both uplink and downlink operations, which is different from many solutions on standalone UAV placement. In specifically, we think of a scenario in which an unmanned aerial vehicle (UAV)-mounted aerial base station (ABS) and a traditional Terrestrial base station (TBS) coexist, each catering to a different kind of customer (TU). We make the assumption that users can only associate with their assigned BS and not with either the ABS or the TBS. Downlink communication between the AU and TU is disrupted by the interference caused by the TBS and the ABS as a result of frequency reuse. While the TU and AU introduce interference into the uplink communication, it is mostly experienced by the ABS and TBS. It is only the data rate between the ABS and the AU that is considered here, as the uplink data rate between the TU and the TBS is independent of the ABS's altitude and transmit power. We discuss the intriguing trade-off in optimizing ABS altitude versus Its transmit power under the aforementioned mutual interference scenarios, looking at both the downlink and uplink data rates for the system. For a given ABS transmit Power, it makes sense that lowering the ABS's altitude would boost the bi-directional Desired signal power between the ABS and the AU and reduce the bi-directional harmful interference between the ABS and the TU, provided that the channel was initially configured for clear line-of-sight (LoS) communication. However, at a certain ABS altitude, boosting the ABS's transmit power enhances both the ABS's ability to send the intended signal to the AU and its ability to cause unwanted interference for the TU. Our findings reveal a striking dissimilarity in the behavior of downlink and uplink data rates in relation to the ABS altitude and transmit power. There are many cases where the optimal ABS altitude and transmit Power are the extremes, depending on factors like the distances between the ABS, the AU, and the TU. We see in the outcomes that our conclusions hold true even in the presence of several users. The remaining sections of this work are structured as follows. Section II Introduces the system model. In parts III and IV, we focus on optimizing the downlink and Uplink data rates. In Section V, we provide the numerical results, and in Section VI, we draw conclusions.

Model Design

How to Best Place Two CSs in the UBS Based on Throughput and Delay Objectives To further understand the tradeoff between sum-rate maximization and average Delay reduction, we focus on the example of a UBS with just two CSs while the WiFi AP is absent. We assume a Distance d separates the two CSs, as seen in Figure 1. The UBS will always be located at a height of H = 40 m, but its horizontal position will change depending on the distance x from the first CS, where 0xd. The licensed bandwidth (B) is fixed at 4 MHz, and the two CSs each get 2 MHz of spectrum. The power level of UBS transmissions is P = 10 dBm. The loss of the standard route (shown by 0) is 50 dB.

All all, the white Gaussian noise is 100 dB below full strength. Thus, 0 means 60 dB. There is a 1 Mbit limit on packet size. Figure 2 displays the ideal UBS Position for maximizing the cumulative rate and minimizing the average delay while optimizing for d, as determined by a thorough search of the space represented by x. Delay minimization takes into account two scenarios: one in which both CSs have an equal influx of traffic, and another in which one CS experiences twice as many packets per second as the other. In order to maximize the total rate, a clear bifurcation can be seen in the curve (see Figure 5). If you have a d of up to around 80 m, the sweet spot for your UBS is halfway between the two CSs (x = d/2). As d increases, the optimal UBS Location moves towards one of the two CSs, giving the curve a hyperbolic shape in this region. When traffic arrival rates are equal, the best UBS location is in the middle of the road between the two CSs since this results in the smallest average delay. In contrast, when traffic arrival rates are not uniform, the ideal UBS Position moves toward the CS with the greater rate of arrival. In conclusion, these Results show that the optimum UBS placement is notably different when delay minimization is considered as the design aim, as followed in this research, compared to other purposes, such as sum-rate maximization, which has been widely investigated in the Literature. Next, we demonstrate that when there are more than two CSs present and the AP is in the picture, the UBS placement issue becomes more difficult and must be handled in conjunction with other Design factors (problem 11).

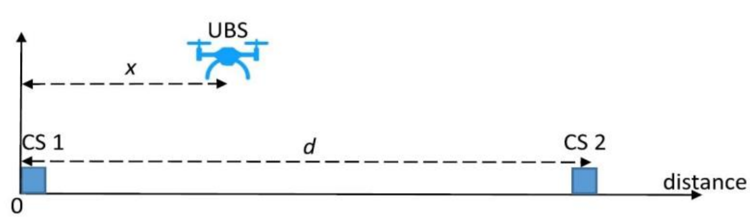

Figure 1. Distance d separates the two CS

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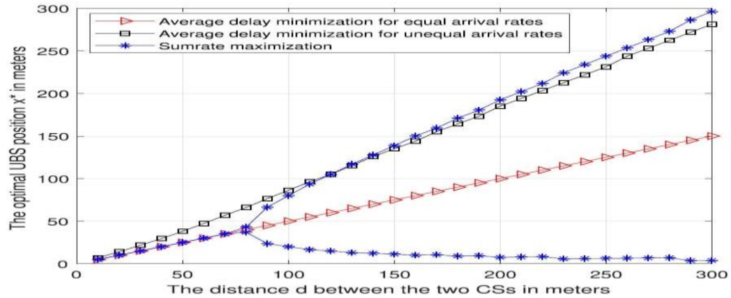

Figure 2. The ideal UBS Position for maximizing the cumulative rate and minimizing the average delay while optimizing for d

Mavic Air 2

Almost 2.5 years after the release of the original Mavic Air, DJI officially announced the small Mavic Air 2 drone, which features a better camera that provides the user with better Imaging capabilities,[14-16] as well as relying on a new technology for wireless Communication, and the small drone that can be relied upon to shoot provides 34 minutes of flight time before the need to charge the battery again, and a Bet. Both (2.1) and (2.2) and (2.3). The Mavic Air 2 drone costs $1,000. The new MavicAir2 has the following features:

- A 1/2.3-inch, 48-megapixel sensor camera.
- Allow for 4K video and stills.
- To allow for 8K fast-motion video recording.
- Flying time is estimated at about 34 minutes.
- 240 minutes of usage time is possible with the best controller before a recharge is required.
- Using a brand-new kind of communication, pilots may now talk to their control room from as far as 10 kilometers away.

Figure 3. Mavic Air 2 (drone type used in test signal)

Camera at Mavic Air 2

The tiny DJI Mavic Air 2 has a camera similar to the ones used in smartphones, which record 12-megapixel photos with Full-resolution photographs, but with a larger sensor and wider aperture (f/2.8). Dji Said Mavic Air 2 also enables taking accelerated 8K movies and can record 4K video at 60 frames per second (with HDR support when recording 4K video at 30 frames per second), as seen in Figure 4. [17].

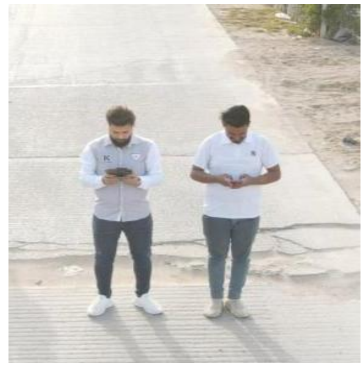

Figure 4. Distance drone from user

Supporting Smart Photo, which combines AI viewer recognition techniques with Hyper Light and HDR technologies for the best possible images in a variety of scenes, the new Mavic Air 2 is also equipped with HEVC (High Efficiency Video Coding) video recording, allowing the user to record higher quality, smaller videos that take up less space. Hyper Dynamic Range (HDR) enhances photographs and adjusts exposure in bright lighting, while Hyper Light enhances low-light images to deliver better pictures with less noise. DJI has improved or concentrated on tracking people and objects from the Mavic Air 2 camera, allowing you to focus on a person, object, or something constantly moving, like a moving car or someone riding a bike during filming, and giving it the advantage of capturing short panoramic videos quick Shots in more than one Different situation easily, as well as supporting hyperlapse 8K accelerated Video recording in more than one Different mode or method. According to DGI, the new Mavic Air 2's Cousin 2.0 communication system enables video recording at distances of up to 10 kilometers [18].

Considering the potential of real-time video streaming Supporting 2.4/5.8 GHz dual-frequency communication and seamlessly switching between them to deliver the highest connectivity quality, the company claims this helps eliminate interference and boosts aircraft performance in challenging settings, all while recording in 1080p at 30 frames per second. DGI has upgraded the Mavic Air 2's obstacle avoidance capabilities by installing new light sensors that enable the aircraft to recognize its surroundings from all three directions (front, back, and bottom), as well as providing more light to enhance visibility. The company has also enhanced the Mavic Air 2's APAS navigation or flight systems, which now rely on an advanced map service to provide smooth and reliable tracking in order to avoid obstacles in a wide variety of flight scenarios. However, water resistance is not supported by the Mavik Air 2 [19].

Remote Control

The remote control for the Mavic Air 2 has been modified by DJI to be more ergonomic in the user's hand, to have a battery life of 240 minutes before needing to be recharged, to have a new clip for connecting the smartphone more quickly and simply, and to have built-in antennae. [20-23] The height of the drone and its interaction with the wind are shown on the far left of the screen, counting up from the bottom.

The Outcome of Experiments

A Possible At-Work Scenario

At first, we attached the grab bar method of connecting 4G-LET to the Mavic AIR 2 as illustrated in Form (5) the drone was then lifted to an appropriate altitude by the controller, predicated on the outcomes of the experiments. According to the criteria established by the speed test software, we quantify the findings. Plus, download.

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Figure 5. 4G-LET on Mavic AIR2

You may evaluate your internet connection speed in three different scenarios: One or two individuals compute Internet speed, and the Internet speed is determined by shifting the user(s) or drone(s) by one or two meters (horizontally or vertically, depending on the quality of the data). The last step is to input the data into Excel and draw a curve for each individual circumstance. Some specific examples will be given later on. The plane's altitude remained constant. The controller has an appearance. At first we connected 4G-LET on The Mavic AIR 2 by grab bar as shown in Form (5)

A Possible First-Case Situation

The user in this case is standing at a fixed distance of 3 meters from the plane, with the plane soaring at an angle of fall with the user and the user and the plane (45°). The height of the aircraft, however, is variable, beginning at 2 meters above the user's head and increasing by 2 meters in each test until it reaches a maximum height of 22 meters, as depicted in the Figure 6 below.

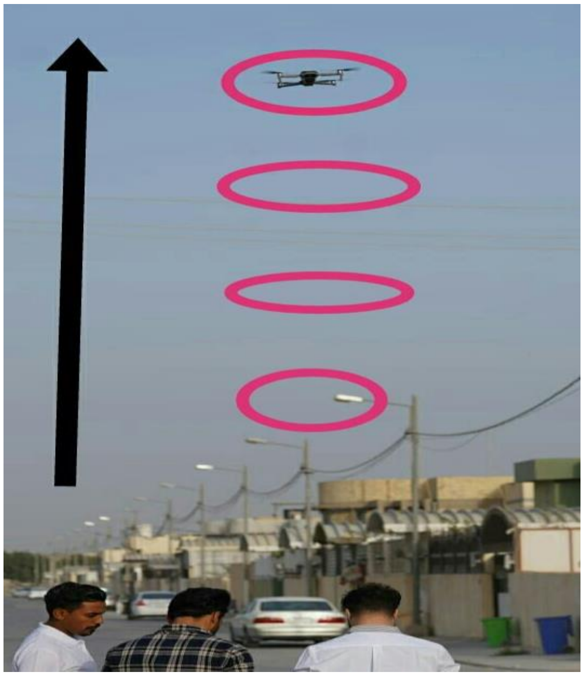

Figure 6. Distance between the Mavic AIR2 and User

Results from the internet speed calculation are shown in Table 1; they are used to determine the optimal location of AIR for the future work of the drone's operational level.

Table 1. Internet speed depending on the height of drone (vertical)

the distance of the user from the drone is fixed and at an angle of all 45	the height of the drone from the ground	internet speed
3 m	2	6.8
3m	4	10.1
3 m	6	11.6
3m	8	6.6
3 m	10	9.3
3m	12	1.3
3 m	14	7.5
3m	16	5.6
3m	18	3.7
3m	20	2.1
3m	22	0.7

First Case Overview and Conclusion; Overall Plan

Since the line-of-sight communication component is greater in this medium distance, the best results or the maximum internet speed are achieved not when the drone is at the lowest height but rather at an average height between the highest and lowest height recorded at it (see Figure 7). In the last section of the first example, we provide some computational findings validated by means of a program.

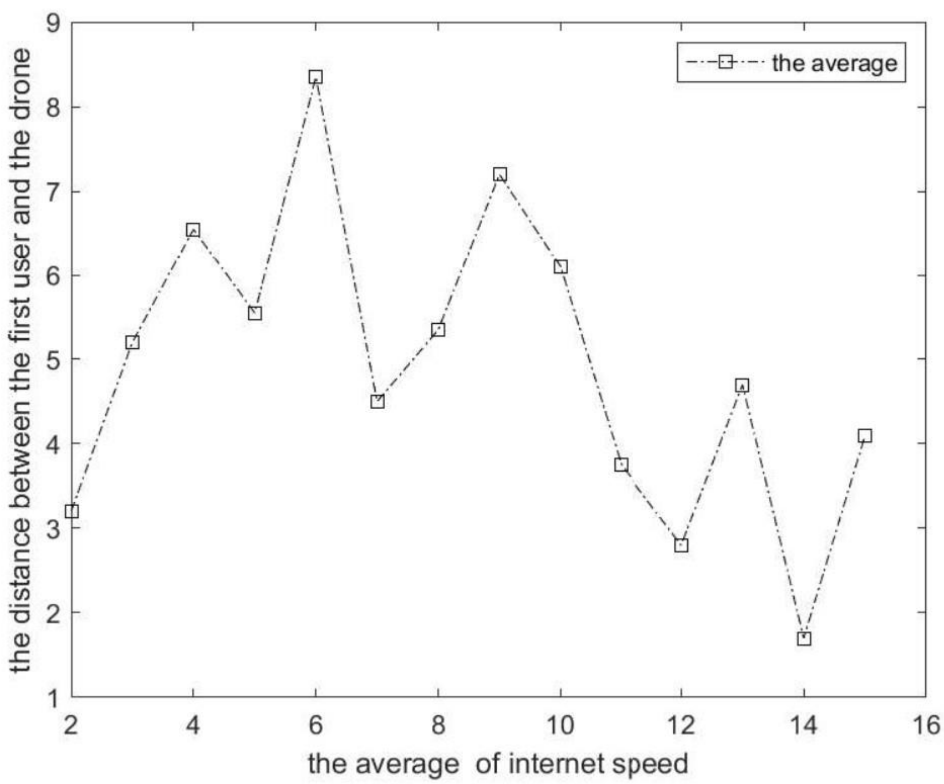

Figure 7. Internet speed depending on the height

The Second Case Scenario

Aircraft in this situation have a set height of (5) meters above ground. The internet speed was determined for a range of user-drone separations, from 0 to 16 meters. The range of user-drone separations began at 0 meters and increased by 2 meters at the start of each test. We also provide some more details in the image below: In Figure 8, the black line represents the path taken by the horizontal drone, while the green line represents the path taken by the user.

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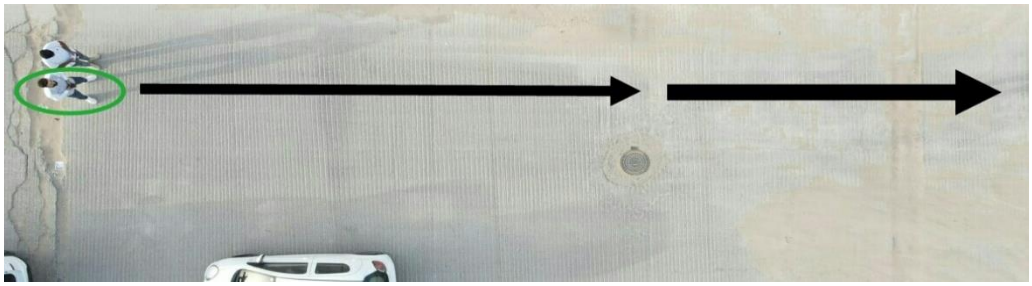

Figure 8. Internet speed test under various levels

The findings of our Internet speed calculation application are shown in the accompanying Table 2 we will input these results or numbers into an Excel software, from which we will ultimately extract the Internet speed curve and draw our conclusions.

Table 2. Internet speed depending on the distance of drone (horizontal)

the height of the drone from the ground	the distance between the done and the user (m)	internet speed
5m	0	2.1
5m	2	2.6
5m	4	3.7
5m	6	5.9
5m	8	9.3
5m	10	15.7
5m	12	17
5m	14	13.8
5m	16	9.4
5m	18	11.2
5m	20	5.1
5m	22	1.7
5m	24	0.9
5m	26	1.1
5m	28	0.75

Conclusion and Summary of the Second Case, as well as the Scheme

Since the line-of-sight communication components are stronger in the first scenario, the best outcomes arise when the drones are at a medium distance from the user (as shown in Figure 9), contrary to what could be predicted. The average distance is thus far because at this hour, obstructions like trees, buildings, and towers are avoided.

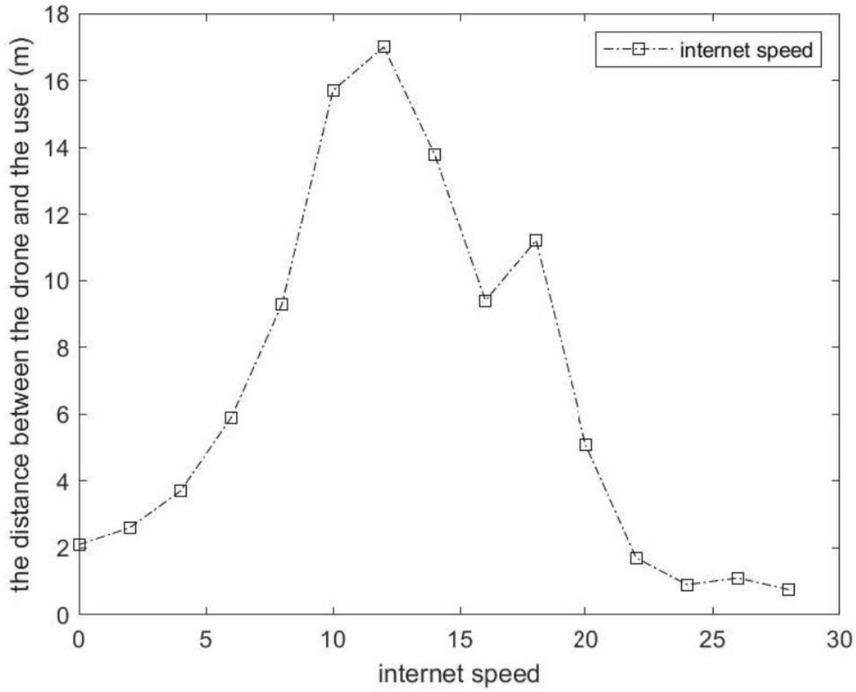

Figure 9. Internet speed depending on the distance

Third Case Scenario

The presence of two users distinguishes this scenario from the preceding one. We set the height of the drone to 5 meters, put it 2 meters over the head of the first user, and "fixed" the distance between the users at 15 meters before I began moving it horizontally by one meter at a time. It then sped towards the second user, passing over his head at a distance of 2m before crashing on the ground. We determined the average of all users by adding and dividing by 2/ordered values. The following diagram illustrates a few key points for your perusal: the black line represents the distance between the first user and the second user, as represented by the green circles; the pink hue represents the position of the drone as it moves between the first and second users. A representation of this is shown in the image below (10)

Figure 10. One drone and two users

The findings of our Internet speed calculation application are shown in the accompanying Table 3, and we will input these results or data into an Excel software before extracting the Internet speed curve and drawing our conclusion.

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Table 3. Internet speed depending on the distance (horizontal) and height (vertical) of drone

the distance between users	the distance between the first user and the drone	the height of the drone is fixed	the average of internet speed
15	2	5	3.2
15	3	5	5.2
15	4	5	6.55
15	5	5	5.55
15	6	5	8.35
15	7	5	4.5
15	8	5	5.35
15	9	5	7.2
15	10	5	6.1
15	11	5	3.75
15	12	5	2.8
15	13	5	4.7
15	14	5	1.7
15	15	5	4.1

Conclusion and Summary of the Third Case, as well as the Scheme

Figure 11, which shows that the middle results are the highest, suggests that users will have the fastest average internet speeds when the drones are placed in the middle of the distance between them. This is because the signal will be the strongest for both users in this scenario.

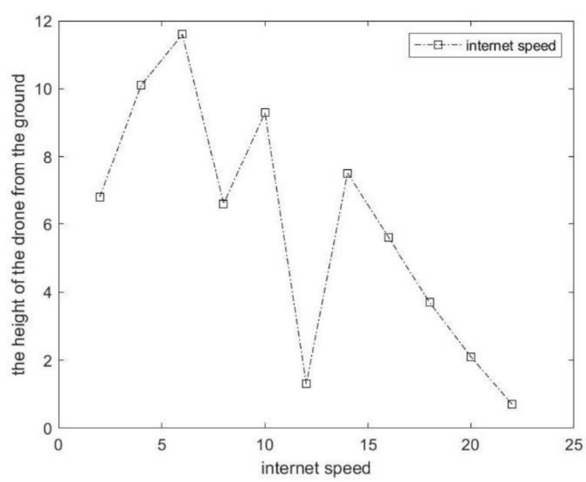

Figure 11. Internet speed depending on the distance and height

Conclusion

According to the data and results in the previous analyzes, the possibility of the signal preference and the strength of the connection was not possible in its proximity or distance from the source, through the analysis of the first case in the height of the transmitter from the user, vertical height and horizontal stability, the signal strength was obtained in select (13) meters from the user. In the second case, we note the signal is strong if horizontal change and the vertically fixed, best signal was in (14) meters from the user. But in the latter case, the signal source is mobile with respect to height and distance (horizontal and vertically) and it was the best result for each user in the middle, as shown in Figure 10.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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