ENERGY EFFICIENT DRONE BASE STATION PLACEMENT ALGORITHM FOR COMMUNICATION

K. KALAISELVI[1], J.M. NISHA[2]

[1]Assistant Professor, Dept. of Electronics and Communication Engineering, Govt. College of Engineering, Tirunelveli.
[2]PG Scholar, Dept. of Communication Systems, Govt. College of Engineering, Tirunelveli

---***---

Abstract - Drone Base Stations (DBSs) can provide maximum wireless coverage for the ground users. In order to serve the number of ground users using minimum required transmit power an energy efficient drone base station placement algorithm is proposed in this paper. We obtain the optimal drone position by decoupling the deployment problem in the horizontal and vertical dimension. The Drone Base Station can be placed according to the maximal coverage for the purpose of power savings. It gives better signal strength to the edge users. The simulation results show that the significant reduction in the transmitting power. The number of active users with respect to time in the cellular network can also be obtained. From the DBS to the minimum horizontal distance of the edge users is proportional to the optimal drone altitude.

***Key Words*: Drone Base Station, Wireless Coverage, Optimal Drone position.**

1. INTRODUCTION

Wireless communication involves transmission of information between two or more points without using any physical medium. Communication between two or more devices by using a wireless signal can be done by means of wireless communication technologies and devices. The transmitted distance can be anywhere between a few meters (for ex: TV remote control) and thousands of kilometers (for ex: radio communication). It can be used for cellular telephony, wireless access to the internet, wireless home networking and so on. The devices used for wireless communication may vary from one service to another and they may have different size and shape. Wireless communication systems also provide different services like Satellite communications, Global Positioning System (GPS), Radio communication, Infrared Communication, Paging and Radio Frequency Identification (RFID).

1.1 UNMANNED AERIAL VEHICLE

Drone is also known as unmanned aerial vehicle (UAV), is an aircraft without having a human pilot. UAVs are a component of an unmanned aircraft system (UAS). UAS include a UAV, a ground-based controller, and a system of communications between the two. The flight of UAVs can be operate either by a human operator using remote control or autonomously by onboard computers. The use of UAVs such as drone is growing rapidly across many domains. In wireless network, drones can be used as base stations. Drones can support reliable, cost-effective, and high data rate wireless communications for ground users due to their flexibility, agility, and mobility. There is a need to supplement the limited capacity and coverage capabilities of existing cellular networking infrastructure major public events such as Olympic games that generate a substantial demand for communication. Drone-based wireless communication is an ideal solution for such scenarios. Drones can be used in agriculture in order to check the condition of their crops. Instead of spraying the entire field with the chemical it enabling the farmer to spot a problem area. So, it could help lowering the cost of chemical. For football national championship and the Super Bowl. AT&T and Verizon are planning to use flying drones to boost the Internet coverage. To provide reliable and cost-effective wireless connectivity drones can be used as flying base stations.

1.2 DRONE BASE STATION

In the field of next generation networks, Drone-assisted communication is one of an emerging technology. Drones equipped with small base stations, known as drone base stations (DBSs), having the considerable attention [1] [2]. Drones can be used as flying base stations in wireless network. The drones move within the cell that reduces the distance between the Base Station and the serving users. The decreasing Base Station to user distance result in better received signal strength for all users. For enabling wireless connectivity in other key scenarios such as public safety, and Internet of Things (IoT) scenarios drones can play a key role. Optimal placement of drones, path planning, resource management, control, and flight time optimization are the number of challenges to effectively leverage drones for wireless networking applications. In particular, the service time can be minimized that contains both the transmission time and the control time. They are needed to control the movement and orientation of the drones.

Fig: 1 Drone Base Station

To this end, we minimize the transmission time, by optimizing the drones' locations, as well as the control time that the drones need to move between these optimal locations. First, we determine the optimal drone spacing for which the array directivity is maximized in order to minimize the transmission time. Next, we optimally adjust the locations of the drones according to the position of each ground user, based on the given derived drone spacing. During the control time period the drones must dynamically move between the derived optimal locations in order to serve different users. To minimize the control time of quad rotor drones, we determine the optimal speeds of rotors such that the drones can update their positions and orientations within a minimum time. In this letter, we propose an optimal placement of DBS energy efficient algorithm to serve a set of ground users.

By decoupling the horizontal dimension from the vertical dimension the optimal drone position problem can be formulated. Simulation results show significant reductions in transmit power of the DBS. The number of active users with respect to time in the cellular network can also be obtained. From the DBS to the minimum horizontal distance of the edge users is proportional to the optimal drone altitude.

2. SYSTEM MODEL

By a wide sector of mission critical users, such as the public safety agencies including police forces and fire fighters the recent developments in broadband wireless communication technology gives in terms of capability and reliability has led an emerging rapid adoption. If networks are dishevel due to a natural disaster such as flood, earthquake or tsunami, making the need for finding a rapid and cost-effective temporary recovery solution an important necessity, with the increasing dependency on such broadband networks, the total failure of public services would be massive.

The use of LTE (Long Term Evolution) for realizing the downlink data and uplink control. When transmitting data to and from the UAV, we study the impact of interference and path loss by means of measurements and simulations. Considered the two scenarios in which UAVs act as either base stations transmitting in downlink or UEs transmitting in uplink. Their impact on the respective downlink and uplink performance of an LTE ground network is analyzed in [1]. Both measurements and simulations are used to quantify such impact for a range of scenarios with varying elevation, separation from the base station, or UAV occurrence. It is concluded that when LTE enabled UAVs are introduced, interference is going to be a major limiting factor and that strong technical solutions will have to be found.

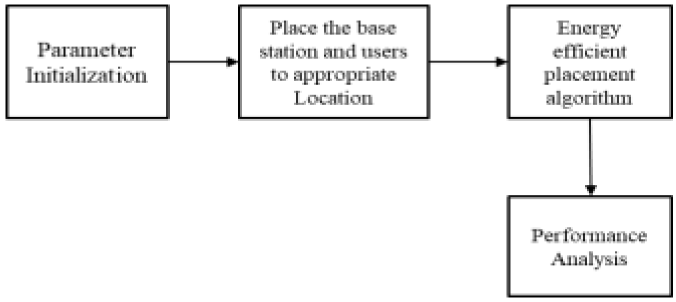

Fig: 2 Block Diagram

3. METHODOLOGY

DBSs are highly crucible for various scenarios. In case of an enormous incident, the ground base station may be of congestion due to an considerable temporal increase in the number of users. It is impossible from economical interpretation to invest in the ground substructure for a relatively short time period. For this reason, a DBS can be used. Let (xi; yi) represent the location of the unserved user i. Several models have been proposed for air to ground links. Here we use the model proposed in [3]. The air to ground communication links are mainly LoS or NLoS links. The probability of a LoS connection between user
i and the DBS is given by [3]

$$P_{LoS}(r_i, h) = c_0(\frac{180}{\pi}\tan^{-1}(\frac{h}{r_i}) - 15)^{d_0} \quad (1)$$

Here c0 and d0 are environmental constants, h is the drone altitude, and ri is the horizontal distance of user i from the DBS. The probability PNLoS(ri; h) of an NLoS connection between user i and DBS is 1 - PLoS(ri; h).

In air to ground links, two types of radio propagation modes, named as free space propagation and urban space propagation. The free space propagation results in the free space path loss, which of user i can be calculated as

$$20\log(\frac{4\pi f_c d_i}{c}) \quad (2)$$

where fc is the carrier frequency, di is the distance of user i from the DBS and c is the speed of light. The urban space propagation results in the additional path loss and depends on the corresponding connection between user i and the DBS. Let $\eta_{LoS}(r_i,h)$ and $\eta_{NLoS}(r_i,h)$ be the additional path losses for LoS or NLoS connection between user i and the DBS. The average path loss between user i and the DBS can be calculate.

$$PL_A(r_i,h) = 20\log(\frac{4\pi f_c d_i}{c}) + P_{LoS}(r_i,h)\eta_{LoS}(r_i,h) + P_{NLoS}(r_i,h)\eta_{NLoS}(r_i,h). \quad (3)$$

The $\eta_{LoS}(r_i,h)$ and $\eta_{NLoS}(r_i,h)$ obey different Gaussian distribution

$$\begin{aligned} \eta_{LoS}(r_i,h) &\backsim (\mu_{LoS}, \sigma^2_{LoS}(r_i,h)) \\ \eta_{NLoS}(r_i,h) &\backsim (\mu_{NLoS}, \sigma^2_{NLoS}(r_i,h)) \end{aligned} \quad (4)$$

where the means μ_{LoS} and μ_{NLoS} are constants given and depend on the environment.

Standard deviations $\sigma^2_{LoS}(r_i,h)$ and $\sigma^2_{NLoS}(r_i,h)$ are functions of ri and h.

A concept that has been endorsed by the Homeland Security Bureau in USA as the Deployable Aerial Communications Architecture [4] envisions the recovery of critical communications for first responders within 12-18 hours. Radio Frequency (RF) planning should be achieved for the target area that can produce an evaluation for the (i) the required number of Aerial Base Stations, (ii) the optimum altitude of the platforms, and (iii) the expected service level. The International Telecommunication Union (ITU-R) in its recommendation document, is suggesting a standardized model for urban areas, based on three simple parameters and that describe to a fair extent the general geometrical statistics of a certain urban area of which the RF signal propagates. According to Rayleigh probability density function, a scale parameter that describes the buildings heights distribution can be given by

$$P(h) = \frac{h}{\gamma_o^2}\exp\left(\frac{-h^2}{2\gamma_o^2}\right) \quad (5)$$

where (h) is the building height in meters. In order to determine the minimum required transmit power, first we have to find out the transmit power Pt of the DBS and it can be described as

$$P_t = P_r(e) + PL_A(r_e,h), \quad (6)$$

Where $P_r(e)$ represent the received power of the edge users. r_e is the horizontal distance of the edge users. $PL_A(r_e,h)$ is the average path loss. Then find the minimum required transmit power Pm of the DBS and can be transformed as

$$\begin{aligned} P_m = \min P_t &= \min(P_r(e) + PL_A(r_e,h)) \\ &= P_{th} + \min(PL_A(r_e,h)). \end{aligned} \quad (7)$$

There exists a point of minimum value, for a given horizontal distance of the edge users from the DBS and a particular environment, where y and x coordinates of the point represent the minimum average reduction in power density of the edge users and the corresponding drone altitude respectively. Moreover, both the minimum average path loss of the edge users and the corresponding drone altitude decreases, as the horizontal distance of the edge users from the DBS decreases. This leads us to dissociate the optimal drone position in the horizontal and vertical dimensions. Providing the minimum horizontal distance of the edge users from the DBS, we firstly find the optimal horizontal position of the DBS. In fact, for a given user issuance, this problem is a minimum coverage circle problem and can be formulated as:

$$\min_{x_H, y_H, r_e} r_e$$

subject to:

$$\begin{aligned} &\sqrt{(x_i - x_H)^2 + (y_i - y_H)^2} \le r_e, \ \forall i \in \mathbb{C}, \\ &x_{lower} \le x_H \le x_{upper}, \\ &y_{lower} \le y_H \le y_{upper}, \end{aligned} \quad (8)$$

where subscripts (·)lower and (·)upper denote respectively the minimum and maximum allowed values for xH and yH. The problem (8) is a second order cone optimization problem and can be solved using the software MATLAB/CVX. Let (x∗, y∗) and rmin be the optimal horizontal position of the DBS and the minimum horizontal distance of the edge users from the DBS respectively, then (x∗, y∗) and optimal horizontal position of the DBS can be obtained by solving the problem (8).

Here h′ and h′′ are the drone altitudes providing the coverage radius rmin. If the drone elevation is h′ or h′′, the wireless coverage radius of the DBS is rightly equal to rmin, for the DBS at our optimized horizontal position (x∗, y∗). As a result, the average path loss of the edge users is rightly equal to the maximum allowed average path loss PLMAX that the users can tolerate. If the drone elevation is lower than h′ or higher than h′′, the corresponding wireless coverage radius of the DBS is smaller than rmin, causing the edge users uncovered. As a result, the average path loss of the edge users exceeds the threshold PLMAX. Thus for a given rmin, the placement problem in the vertical dimension can be formulated as:

$$\min_{h} PL_A(r_{\min}, h)$$

subject to:

$$h' \leq h \leq h''. \quad (9)$$

The problem (9) can be solved using the software MATLAB. Let h_{opt} be the optimal drone altitude, and h_{opt} can be obtained by solving the problem (9). Thus we can obtain that $P_m = P_{th} + PL_A(r_{min}, h_{opt})$. Our proposed algorithm is obtained by solving the problem (3), (8) & (9).

For predicting the air-to-ground path loss between a low altitude platform and a terrestrial terminal a statistical propagation model is used. The prediction is based on the urban environment properties, and is dependent on the elevation angle between the terminal and the platform in [5]. This method having high path loss but reduces traffic overload. For Low Altitude Platforms a statistical generic Air-to-Ground RF propagation model is provided in this paper, that can substantially facilitate the planning efforts of airborne wireless services. Since the RF planning can be performed based on the merely simple urban parameters, rather than they depending on site-specific 3D-models that are unlikely to be easily available and updated. The air-to-ground path loss revealed a clear tendency towards two distinct propagation groups.

4. Result and Discussion

In this work the Macro Base Station is placed in the cell. Next the number of Femto cells, number of Macro Users and the number of Femto Users are allocated. Number of buildings are also represented in terms of (x, y) coordinates.

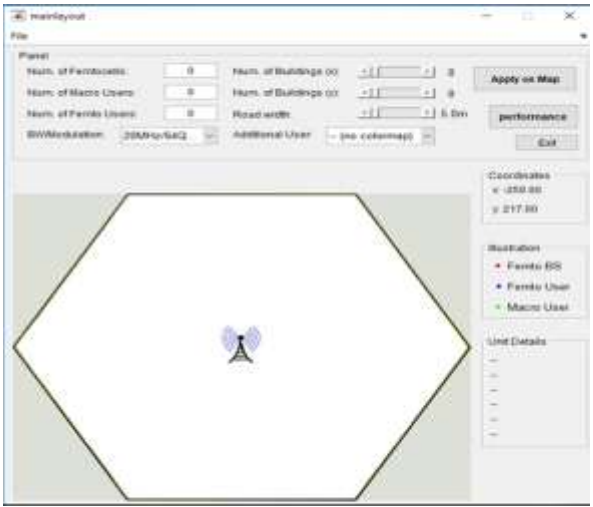

Fig: 3 Placing the macro Base Station

Based on the allocated values the Hexagonal cell is subdivided into smaller cells. One of the most notable conditions in an urban environment is the layout and

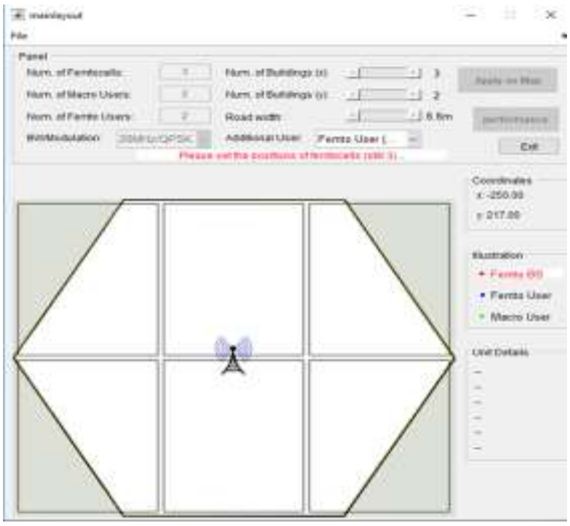

Fig: 3 Splitting of Hexagonal Cell

conditions in an urban environment is the layout and characteristics of the buildings. The number of buildings are represented in terms of (x, y) coordinates. Based on the values that are mentioned in the coordinates, the hexagonal cell is subdivided. The vertical position of the drone at the altitude providing maximal coverage, and optimized the horizontal position of the drone maximizing the number of covered users while using minimum transmit power.

An optimal placement of DBS energy efficient algorithm is used to serve a set of ground users. To decrease drone-BS movements to save more on battery and increase flight time and to reduce the channel variations, the robustness of the network is examined as how sensitive it is with respect to the users displacement. Our investigation also shows that only a small percentage of the total served users would be in outage when the users move. This highlights the robustness of the proposed algorithm against the modest movement of users.

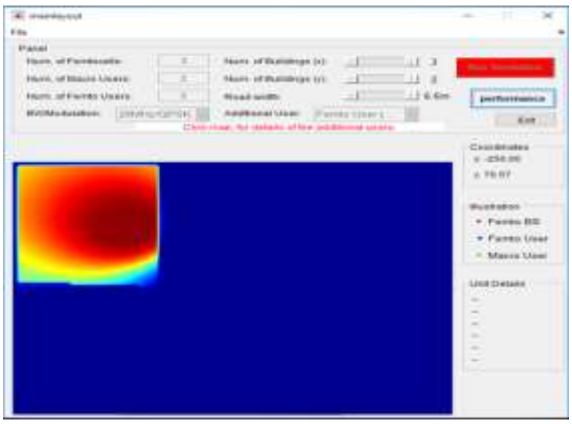

Fig: 4 Efficient placement of DBS

From Fig: 4, we conclude that the efficient placement of Drone Base Station. The area highlighted with red colour can denote the efficient placement of DBS. A UAV would be able to discover only nearby users with a fixed position and also it needs to find all potential users for serving to optimize its-self positioning.

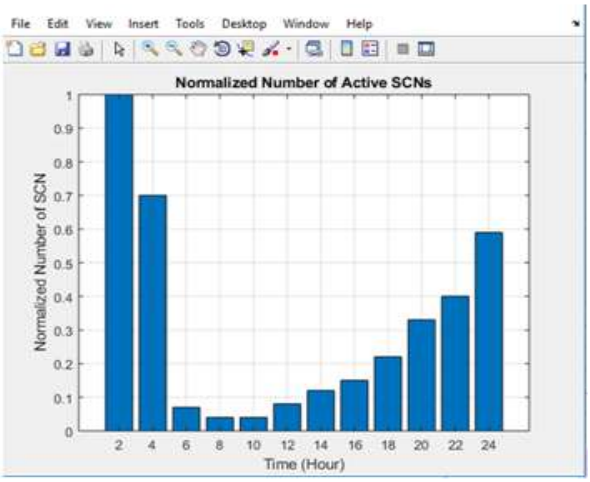

Fig: 5 Normalised number of SCN Vs Time

Fig: 5 show that the Normalised Number of Active SCNs. SCN is the Small Cellular Network. It denotes the active number of users with respect to time in the cellular network. Average delay corresponding to the exponential power profile. It is the spread of time over which the signal energy is received at the receiver, it can be denoted in Fig: 6.

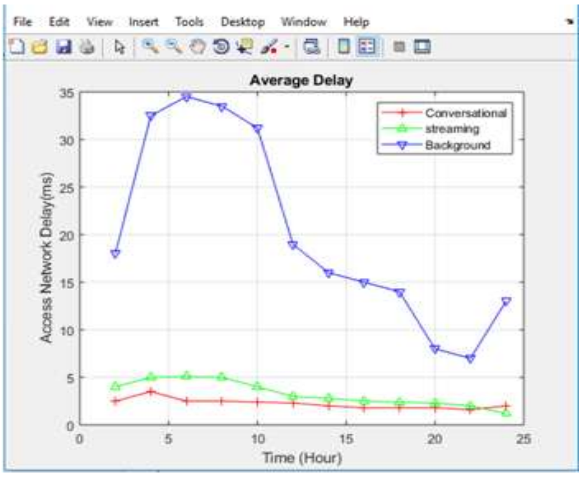

Fig: 6 Average delay Vs Time

The analysis in the Fig: 7 show that the power consumption is better for the proposed method compared to the existing technique. For the purpose of minimum required transmit power this proposed algorithm is used. The distance between the serving users and the Drone Base Station is reduced for the purpose of power consumption.

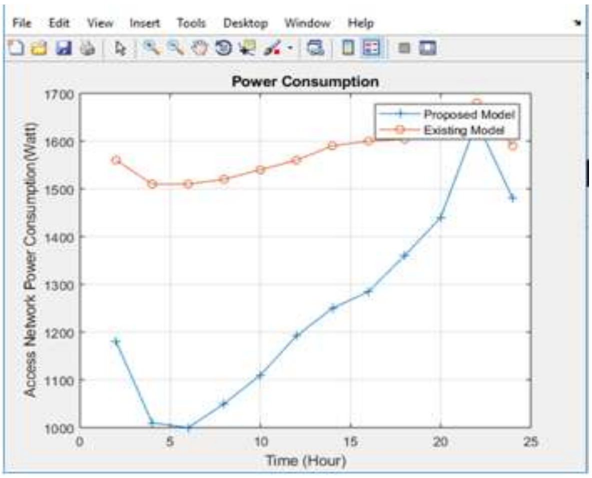

Fig: 7 Power Consumption Vs Time

The advantages of the proposed method are Reduces energy consumption by placing the drone base station effectively, High data rate, Reliable & Quality of Service, Cost-effective.

5. CONCLUSION

In this paper, an energy efficient placement algorithm for a DBS is presented. That serves a set of ground users, using minimum required transmit power. We obtain the optimal drone position by decoupling the deployment problem in the horizontal and vertical dimension. The Drone Base Station can be placed according to the maximal coverage for the purpose of power savings. It gives better signal strength to the edge users. The simulation results show that the significant reduction in the transmitting power also analyse the performance of the proposed method.

REFERENCE

[1] S. Chandrasekharan, K. Gomez, A. Al-Hourani, S. Kandeepan, T. Rasheed, L. Goratti, L. Reynaud, D. Grace, I. Bucaille, T. Wirth, and S. Allsopp, “Designing and implementing future aerial communication networks,” IEEE Communications Magazine, vol. 54, no. 5, pp. 26–34, May 2016.

[2] I. Bor-Yaliniz and H. Yanikomeroglu, “The new frontier in RAN heterogeneity: multi-tier drone-cells,” IEEE Communications Magazine, vol. 54, no. 11, pp. 48–55, November 2016.

[3] A. Al-Hourani, S. Kandeepan, and A. Jamalipour, “Modeling air-to-ground path loss for low altitude platforms in urban environments,” in 2014 IEEE Global Communications Conference, Dec 2014, pp. 2898– 2904.

[4] Z. Xiao, P. Xia, and X. g. Xia, “Enabling UAV cellular with millimeterwave communication: potentials and approaches,”

IEEE Communications Magazine, vol. 54, no. 5, pp. 66–73, May 2016.

[5] B. V. D. Bergh, A. Chiumento, and S. Pollin, "LTE in the sky: trading off propagation benefits with interference costs for aerial nodes," IEEE Communications Magazine, vol. 54, no. 5, pp. 44–50, May 2016.

AUTHORS:

1) J.M.Nisha, PG Scholar, Department of Communication Systems, Government College of Engineering, Tirunelveli.

2) K.Kalaiselvi, Assistant Professor, Department of Electronics and Communication Engineering, Tirunelveli.