Energy Aware Drone Enabled Base Stations Deployment in Flying Adhoc Networks

Saqib Majeed[1], Syed Amad Hussain Shah[1], Kashif Sattar[1], Saleem Iqbal[2,*], Ghulam Mustafa[1], Ali Raza Bhangwar[3],

[1]UIIT, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan
[2]Department of Computer Science, Allama Iqbal Open University Islamabad, Pakistan
[3]Department of Software Engineering, QUEST, Nawabshah, Pakistan
[*]Corresponding author: saleem.iqbal@aiou.edu.pk

Abstract

The demand for Wireless Networks has increased rapidly for downloading and uploading all types of data, which is due to the inefficiency and high cost of infrastructure based cellular Networks. Unmanned Aerial Vehicle (UAVs) is the reliable solution for improving efficiency, latency redundancy, business, and troubleshooting problems on a high scale. Although, the deployment of UAVs to meet user demand in any environment or region is quite thought-provoking. This deployment not merely provides the only the coverage area, but also provides the capacity balancing and accommodation of extremely populated areas. In this research, the suggested solutions show significant achievements in terms of energy proficiency related to the fixed and dynamic drone base station system. We propose FSO (free space optical) communication system and evaluate three feasible algorithms for separate dynamic repositioning of drone base stations in terms of communicational energy. In MATLAB, the simulation result shows 20 percent of communicational energy consumption improvement can be obtained deprived of adversely affecting any other factor of the drone.

Keywords—Energy Efficiency, Drone, UE, Selfmotivated Deployment, Communicational Energy.

✦

1 Introduction

In this development era, the demand for Wireless Sensor Networks increased rapidly for the collection of Data and provision of more services, cause of infrastructure based cellular Networks, inefficiency, and cost-effective. So, Unmanned Aerial Vehicle (UAVs) is a reliable solution for improving proficiency, and increasing throughput and cost. UAVs are deployed in any environment and region according to the requirement of the user. Hereby, a self-healing and neural base cost function approach is used to control the high traffic and user demand in a particular area. Hence, a competent approach and mechanism are required to solve interface and topology problem. Furthermore, the basic purpose of UAV deployment is, to improve the lower transmit delay through a cost function-based multiple UAVs deployment model is presented and also provides an algorithm for area mapping (for UAVs). However, these models use density and cost functions and by using this model better capacity, throughput reliability, and longtime connectivity could be achieved. Although, wireless users expect full coverage anytime, anywhere and such expectation has quadrupled, especially during disasters. So, to meet such expectations, different technologies were used [1].

According to the research, large power transmitters were formerly used for remote communication, but such communication systems require high power consumption. Although, the ad hoc / mesh wireless network is another alternative to traditional networks that can connect to the last mile. However, these networks are difficult to manage because they do not have a central entity and, in this case, routing (frequent path interruptions) and resource management become more complex. Moreover, these networks cannot meet the user expectations at the fullest for fast content delivery due to

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the nature of multiple jumps. According to the limitations mentioned above, mobile networks offer the advantage of increasing the capacity of users, reducing energy consumption, increasing reach, and seamless connectivity. The following subsection describes the application and versatility of cellular networks[2].

Hence, the drone can fly in any unfavorable terrestrial zones (earthquake, flood, etc.) and in case of any sudden collapse of the ground base station, it can be placed as a temporary base station for the supply of uninterrupted communication services to the linked networks. For this purpose in the recent past, the DaaG algorithm was used, which has majorly contributed to message planning, data transfer, and path adjustment.

The wireless communication system is committed to users providing highly approachable connectivity without infrastructure coverage. An intelligent-based cost function approach is used to control the high traffic and user demand in a particular area. These models used density and cost functions. The basic purpose of UAV deployment is to improve scalability, latency redundancy, better capacity, and efficient control with northbound and southbound communication. However, in the heterogeneous transmission (front haul and backhaul) due to different networks, many aspects like UAV placement, load balancing, reliability, and longtime connectivity could be possible. The UAVs could be easily deployed in the required area to provide the fastest rescue coverage and better channel characteristics. However, in recent few years, the usage rate of drones has increased in various domains like military, civilian, and commercial because domain usage of UAVs can reduce the cost of infrastructure, provide reliability and pilot lassies, etc. There are two main types of UAVs. In the first type, the fixed using a drone has high speed and heavy play load. On the other hand, rotary-using drones have limited mobility and payload.

According to the research, in traditional mobile networks, the number of users increases over time and later on becomes the reason for network congestion. However, there are two types of traffic jams. The former is practically stable at peak times, can be predictable, and can lead to significant revenue losses if not resolved. Hence, such a type of congestion requires an expansion of capacity. However, the second type of bottleneck is unpredictable and short-lived and its impact on income may be negligible such type of congestion cannot justify an increase in capacity.

Although to cope with this situation, different alternatives have been proposed in the literature, based on permanent or temporary solutions. Whereas, the permanent supply of solid microcells, zoning, and sectorization is the most important techniques. However, in momentary situations where the number of users increases suddenly, likewise a massive crowd in a protest or a stadium, the mechanism of borrowing strings is applied in such situations. Although, channel extraction is limited to the minimum required for the removal of the neighboring cell and the fact that it is not used in the adjacent cell. According to the situations mentioned above, a temporary solution, such as transient microcells is proposed. Hence, these limitations could make it ineffective in reconfiguration and movement. Therefore, an easy-to-use system at all times for uninterrupted communication is required. In addition, microcellular solutions based on UAVs have been used to limit temporary solutions based on soil [3], [4]. Such solutions are also under study to increase coverage in 5g networks. These antenna base stations are deployed using drones. Such drone base stations can continuously adjust their directions of movement to provide a better QoS to mobile users. This research is based on the best location for the drone near provide better on-site service to users.

Eventually, User Equipment (UE) is increasing day by day so, the demand for internet connections is dynamically increased in the present network. Although, placement problems occur for proper and efficient deployment of UAVs. In this paper, a self-healing neural model network and matrix complexion in the form of adjacent and isolated cells for achieving the optimum utilization of UAVs has been proposed. This provides an n x n matrix approach and a proper method for the deployment of UAVs at low energy consumption, memory, and cost. For the deployment of UAVs basically, two network techniques are used Backhaul (unidirectional) and Fronthaul (Umbrella form). The network model consists of microcells having the number of base stations Nb, and capable of maximum UE connections. Where E is some User Equipment, A is an area divided into D subdivisions based on two algorithms 1) is for isolated cell identification and 2) is for UAV deployment.

In general, drone base stations can help the ground base stations by providing a high data rate when there is a downlink in the area and need excessive space and time. In such a situation, excessive demand occurs in an unpredicted manner. However, one of the very important problems in drone base stations is to be energy efficient placement of drones, in which place a drone can transmit its signal as long as requirement is because when the altitude of a drone is low its transmission power is limited, and require less energy, and when the altitude is high and covering a large area for transmission required more energy utilization. Moreover, in this study, we are concentrating on the issue of the drone base station and require to find an ideal settlement for the drone to utilize the energy of the drone base station efficiently.

Whereas there are two types of energy consumption by drone base stations, one is infrastructural energy consumption and the other is communicational energy. However, we focus on communicational energy gain by proposing FSO (free space optical) communication system and evaluate three feasible algorithms (explained in Methods and techniques) for separate dynamic repositioning of drone base stations in terms of communicational energy to achieve 20 percent of communicational energy consumption gain.

The remaining paper is described as section II a Literature review, section III a Proposed Methodology, section IV results and discussions and section V is about the conclusion.

2 Literature Review

Recently, numerous pieces of training have been carried out in the area of drone location, as this can offer a better substitute for the erection of transitory cells on non-complementary cell sites. Additionally, parameters affecting drone placement are the main aspects that can brutally affect network presentation, these parameters are user density, energy, spectral energy and placement approaches including centralized and distributed, their intensity and applicability in literature are discussed in Section 2. This section highlights the findings of the literature and discusses the reasons to enhance further research in this field. According to the research, an integrated hardware and software architecture designed for use on mini UAVs or microUAVs in the hazardous cloud [3] conditions to operate as a flexible payload (less than 30 kg) and mission controller. However, the proposed drones consist of a modified standard isolated control cell for autonomous flight, ground imagining, and burden transmission. In [5], they envision cooperative transmission communication techniques to reduce the energy ingestion of battery-operated powered native nodes to better utilize the rare energy of the battery during communication. On the fly to effectively communicate with the Low Height Platform, an origin node analyzes its options for forwarding to LAP and routed connections over a variety of possible forwarding links in the network. In [6], [7], the authors propose an optimal performance allocation mechanism to minimize failures, maximize volume or maximize the average signal-noise ratio.

Whereas, it's already discussed that there are many suggestions given in this area. However, many of them have inspired our work on several points, but there are differences in network patterns, objectives, and methods. In [8], the problem is a high traffic demand and a lower connection speed, for this problem the proposed model is the demand-based network model with several UAVs. During this development period, the demand for wireless sensor networks increased after data collection and the provision of more services, resulting in infrastructure-based cellular networks, inefficiencies, and profitability. Unmanned Aerial Vehicles (UAVs) are the trusted solution to improve efficiency, and overall costs and increase capacity.

Thus, there were many aspects of drone base stations, which have already been considered and studied by many researchers likewise the role of drone base stations in cellular network coverage. In many aspects, drone base stations are used as temporary micro cells construction. The solution of optimal height for a drone can be optimized by using multiple algorithms which can increase spectral efficiency.

In [9] author proposed two structures, the first one is statistical and the other one is an analytical structure, the first structure is statistical for enumerating the performance of UAV station deployment and the systematic structure is designed for optimization. Although, the aim is to place UAV base stations that cover a maximum denser area are served with a minimum number of drone base stations. To achieve this, improvement in the quality of services for users is required. Consequently, to find the best placement for drone base stations mostly heuristic algorithms were used such as particle swarm optimization. Whereas, different types of obstacles like buildings and other substances cause reflection but as the drone increases its altitude the path loss declines and the line of slight probability increases.

The different drone placement is found in the literature, and more research is underway to provide UAVs for wireless coverage. However, existing work on UAV networks describes the deployment problem to provide fast radio coverage. According to this limitation, we are conducting research on the rapid deployment of UAVs in heterogeneous networks. In practice, UAVs are limited in scope and can only serve those users under the radar very closely. Before serving the connected users, each UAV needs the travel time or deployment time to reach its final position. Therefore, the delay depends on the distance to its first operating position, the speed, and the operating altitude. As described in different types of UAVs, three different tasks have heights, radius, speed, and endurance. For example, there are two types of network cells: a macro and a micro base station. We will discuss the base station for micro drones in this article. Thus, in microUAVs, the altitude is generally less than 300 m / s, the radius is between 1 and 5 km and the endurance is about 60 minutes.

Subsequently, by considering this heterogeneity of UAVs and focusing on the communication scenario dominated by LVs to cover the entire target area, we explore two issues of rapid deployment. Firstly, the aim is to reduce the delay and maximum availability of all UAVs for the sake of fairness.

Secondly, the consideration is to minimize the overall deployment time to account for effectiveness. Of course, the min-max optimization problem occurs in disaster or war zone situations where we are very concerned that the user is delaying the provision of services in the target region. In [10], the initial position of the drone is the center of disaster management. The starting point of the first drone is in the center and the other drones take into account the same deployment scheme from left to right.

Repositioning of drone, repositioning related to changing the position of the drone during the services. The percent for accurate drone rapidity, altitude, and consumer traffic model and even not affecting drone energy consumption. In a real atmosphere, more than one drone cell is required, and there are two types of distributed algorithms [11] for the whole network area. While repositioning drones and other different factors also need to be of concern, two important factors are [12] time division multiple access (TDMA) and [13] frequency division multiple access (FDMA).

There are two types of communication in drones, the first one is drone to drone and the second is drone to ground. Drone to ground channel applications with piloted aircraft are well understood but drone to ground channels are more complex in a practical environment. Dissimilar channeled airplane systems where ground sites are typically in an open area and have long antenna towers, in DBS to ground channel [15] are complicated in the operational environment. Because LoS are expected in such channels [13] in most scenarios and the drawback is this sight can be blocked by obstacles like buildings, ground, and the environment. Low altitude [16] UAV to ground channels also create several multipath components due to consideration, smattering, and diversion by elevation or ground external. Another model Rician Fading Model [18], [19] also considers for air to ground communication. Air-to-air frequencies may have even more Doppler effects [20]. As a drone, counterparts are grounded because of the potentially high relative speed between drones. These channel properties have a direct impact on frequency assignment [21,22] for UAV-to-UAV connections. A high relative speed between the drones with advanced occurrence in the millimeter wave band results in an unnecessary Doppler shift.

Multi Drone Placement, the writers in [9] debated finding the user denser position for installing several UAV cells to provide facilities for the ongoing number of users. The number of drone base stations depends on two types of constraints, one is no of users and the other is the coverage area or total area. So firstly, we describe user denser areas where how many minimum numbers of drone BS are required to satisfy the user demand and to provide some set of target quality of services. We aim to find the least no of UAV BS to provide the service to the user in the region.

Table 1 represents an overview of the most appropriate correlated mechanism on a) Drone Placement including (i) initial placement and (ii) repositioning b) parameters (i) user density (ii) energy constraints (iii) bandwidth division c) multiple drones and d) placement approaches (centralized and distributed). These are described as follows:

Hence, the temporary use of microcells in the affected / overcrowded areas is dependent on the location of battery-powered drone base stations. So, the optimal location of these base stations, which consume less power, is a tiring task to provide optimal spatial coverage with the best number of consumers.

However, geographic coverage with the optimal number of users is necessary, but placement also affects the variation in transmission power. In this case, the non-constant power supply leads to a shorter transmission time for the drones.

In addition, this requires frequent replacement of drones to ensure uninterrupted and continuous operation. Whereas, this could further complicate the scenario and could have serious consequences for network performance in the form of switching latency and service interruptions caused by drone UAV switching. Therefore, a solution is needed to optimize drone placement to extend airtime and reduce the number of switches.

3 Proposed Methodology

We considered efficient Fronthaul communication between DBS and user equipment for prolonging battery life. We used FSO (free space optical) system approach for a large number of mobile users. FSO

TABLE 1: Summary of some recent literature

Reference	**Drone Placement**		**Drone Parameter**			**Multiple Drones**	**Placement Approach**	
	Initial	**Reposi -tioning**	**User Density**	**Energy**	**Spectral Efficiency**		**Centralized**	**Distributed**
Terrestrial Cooperation and Energy-Efficient Transmissions to Aerial-Base Stations (2014)		✓		✓	✓		✓	
Deployment of Multiple Unmanned Aerial Vehicles for Optimal Wireless Coverage (2016)		✓	✓			✓	✓	
Dynamic Base Station Repositioning to Improve Performance of Drone Small Cells(2017)		✓	✓		✓		✓	
Drone Empowered Small Cellular Disaster Recovery Networks for Resilient Smart Cities (2016)	✓		✓			✓		✓
Fast Deployment of UAV Networks for Optimal Wireless Coverage (2018)	✓		✓			✓		✓
Placement of 5G Drone Base Stations by Dala Field Clustering(2015)		✓	✓		✓		✓	
Environment-Aware Deployment of Wireless Drones Base Stations with Google Earth Simulator (2018)	✓		✓			✓		✓

system is considered a promising candidate for front back-hauling of the data gathered by the drones and user equipment. One free space optical frequency can deal with terabytes of data per sec throughput. The range is large and excess-free (very dense reuse), with Insignificant components. We have used different approaches for calculating energy and other aspects of the requirement. The approaches we have used are equal to the bandwidth frequency, least buffer first, and nearest user first.

Fig. 1 shows the architectural overview of free space optical and demonstrates the communication of the drone base station in cellular networks with the ground base station and end devices. It also shows end-to-end communication between drones the drone. One

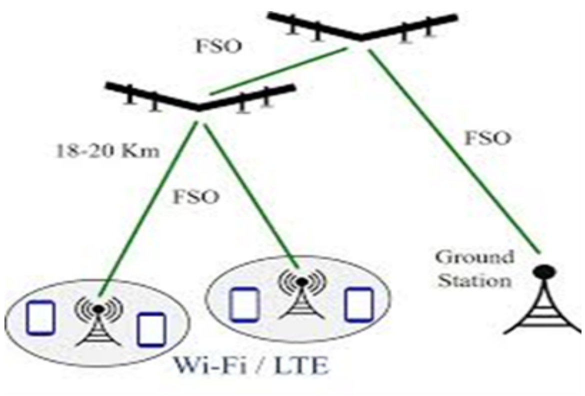

Fig. 1: FSO drone Cellular communication Architecture

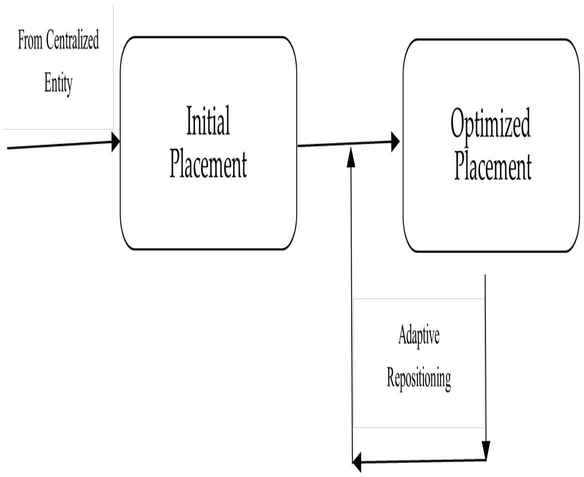

Fig. 2: Proposed Block Diagram

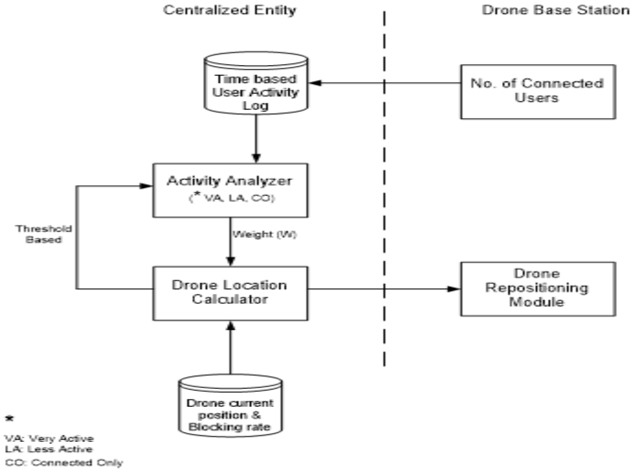

Fig. 3: Activity Aware Drone Placement flow diagram

free space optical frequency can deal with terabytes of data per sec throughput. The range is large and excess-free (very dense reuse), with Insignificant components. Different approaches are used for calculating energy under the FSO communication network. In Shannon's capacity theorem, there is active user i at distance d and energy in bytes per second per joule, which is formulated as:

$$\phi_i(d) = log2(1 + C_i\ route(d)/P_i) \tag{1}$$

Where Pi is power in Watts represents all noise power the warm air noise power and the equipment noises.

$$P_i = 10(-174 + \delta ue/10).(a_i).10 - 3 \tag{2}$$

Therefore, in this research work accurate calculation of user density will be done by monitoring the user activity log. To efficiently utilize the drone resources, the maintenance of the activity log will be performed in a centralized manner. Figure 2 represents the flow of the proposed approach.

Three different approaches will be used in the free space optical algorithm, first one from those is in which complete bandwidth is assigned to those users who have the minimum amount of data to be sent on each interval. Second is in which the whole bandwidth assign equally among all the users. When the transfer of a request is done, the amount of shared bandwidth is shared equally among the remaining loads. In the third approach, drones assign complete services to those users who are close in distance to the drone with respect to decibels per meter square. All those users who early request a time for service will be selected. The drone will provide services to selected users and repeat the decision-making process at each round or time slot.

The communication energy relay indicates the broadcast power and the transmission time, described as follows:

$$E_{comm} = P_{tx}.t_{communication} \tag{3}$$

Communication energy optimization which is in bit per second per joule is defined as the ratio of the number of total transmitted bits over total communication energy.

$$CEO = P^{u-1}|R(u)|S(bit)/E(comm) \tag{4}$$

Where CEO is Communication Energy optimization and $|R(u)|$ shows no of requests of consumers u during process time, and $S(bit)$ shows packet size request.

4 Results and Discussion

The maximum network transmission range against the number of UAVs in the network is simulated in Matlab. In fig. 5 the initial position of the drone in the allotted area is shown:

In fig. 5 drone base station shows the initial position which is the base point, from where the drone will incorporate its flight. And according to the density (no of users) of sites updated his position.

3D view of the drone base station shows the final position concerning altitude in fig. 6. Minimum altitude shows the starting point of the drone and the final altitude shows the point of placement where the area is user opaque.

Fig. 7 shows the integration of the drone base station with the ground base station, and it describes the position of users and the initial position of drones and their position will change where the user density is high accordingly.

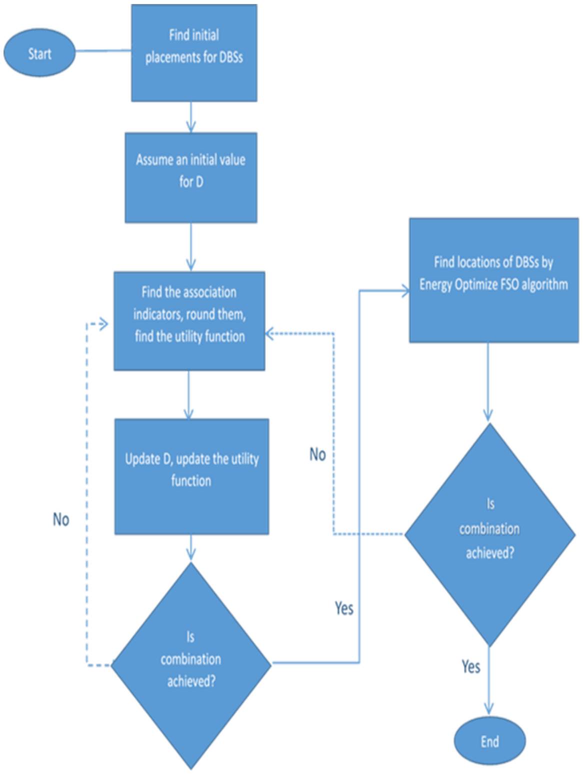

Fig. 4: Methodology Flow Chart

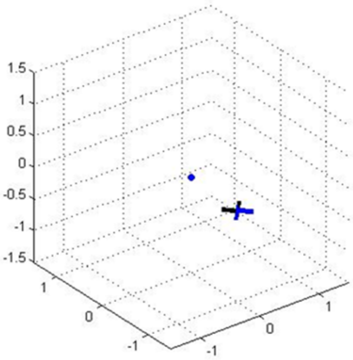

Fig. 5: 3-D Initial Altitude of Drone BS

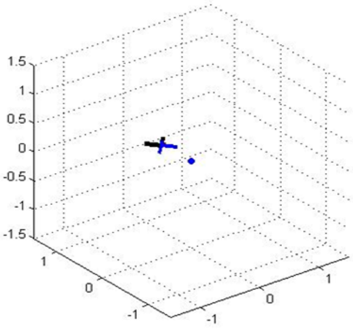

Fig. 6: Final Altitude of DBS

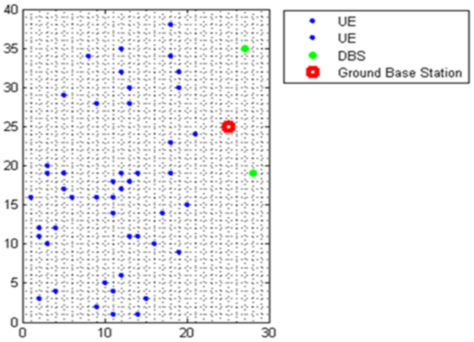

Fig. 7: Initial Position of DBS w.r.t GBS

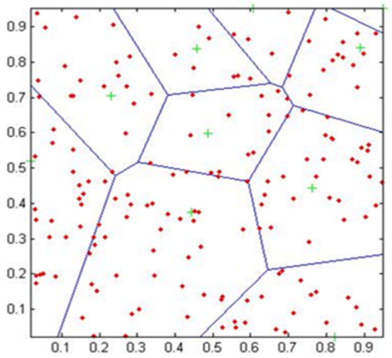

Fig. 8: Cluster range of DBS

5 Results

The proposed algorithms show significant energy efficiency gains compared to the BS scheme of the fixed drone.

In the above three approaches, the result shows the communicational energy. The final result shows how much energy saving is in each algorithm in comparison.

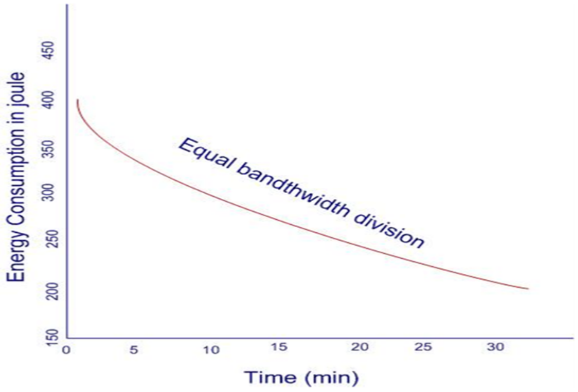

Fig. 9: Result of First Approach

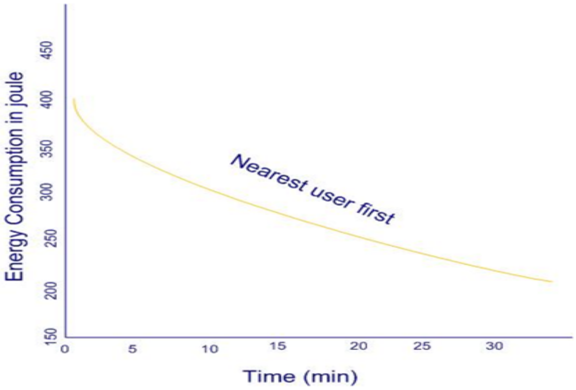

Fig. 10: Result of the Second Approach

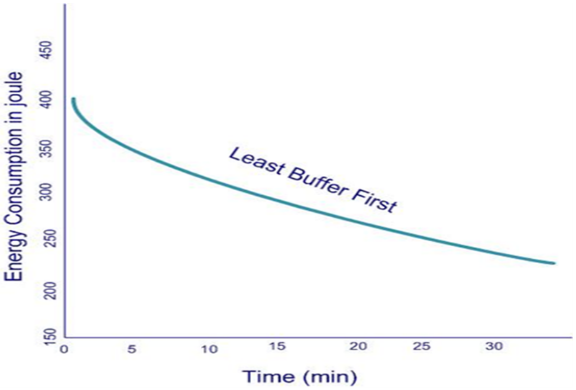

Fig. 11: Result of the Third Approach

6 Conclusion

In this research, the proposed algorithms provide significant energy efficiency gains over the BS fixed drone system. Hereby, we proposed and evaluated three possible algorithms for the separate dynamic repositioning of drone base stations in terms of communication energy. So, the result shows that it is possible to gain 20% of the energy consumption of communications without compromising the spectral efficiency of the drone. Moreover, the result shows that the key finding is that the closest and lowest buffer user policies provide performance comparable to that of the same bandwidth allocation strategy. Furthermore, at higher speeds, the BS drone can get closer to consumers in less time and transmit data at an advanced speed. Moreover, the result can be illustrated by the element that the distribution of bandwidth to all lively users reduces the average communication energy. Hence, the least buffer first approach is one of the best algorithms to get the best power consumption for communication. Finally, future work for research is to make intelligent routing protocols for improving the time expiration and performance of flying adhoc networks according to different scenarios.

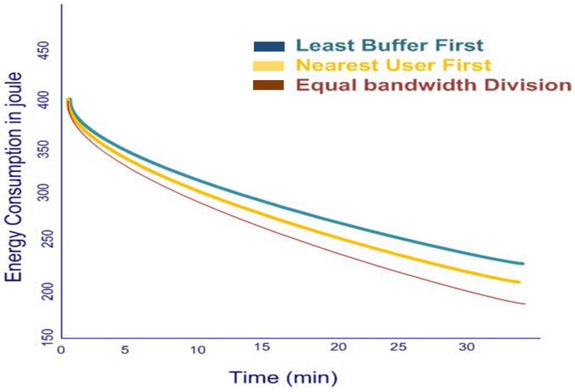

Fig. 12: Results Comparison

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