Arabian Journal for Science and Engineering
https://doi.org/10.1007/s13369-021-05985-x

RESEARCH ARTICLE - SPECIAL ISSUE - FRONTIERS IN PARALLEL PROGRAMMING MODELS FOR FOG AND EDGE COMPUTING INFRASTRUCTURES

Check for updates

Positioning of UAV Base Stations Using 5G and Beyond Networks for IoMT Applications

Taher M. Ghazal[1,2]

Received: 22 April 2021 / Accepted: 11 July 2021

Abstract

5G and Beyond 5G networks (B5G) face the greatest obstacle to ensure accessibility with all categories of users. A significant part of the emerging wireless networks will greatly facilitate connectivity, and cooperation in high-speed communications from Unmanned Aviation Vehicles (UAVs) is expected. UAV has excellent features such as versatile delivery, simple line of sight (LOS) connecting, gradual independence and connectivity architecture speeds, and fixed framework communication systems. Given that many UAVs can achieve specific coverage for surface user terminals (UTs), one problem is how they can be implemented optimally. According to critical constraints, the implementation task was shaped as minimization, including the numbers of UAVs and the optimization of their network load: UAV should form a secure network structure and sustain links with the specified base stations (BSs). The challenge has been split into subtasks to address this problem of optimization with a core framework. The Unified Greedy Quest Algorithm for the Internet of Medical Things (UGQA-IoMT) algorithm is used for telemedicine applications and achieves a minimum number of UAVs and optimal places. The algorithm proposed refers to various scenarios in which UAVs are installed by themselves or with the set BSs, irrespective of the UT deployment. The performance gains in mean SNR of −3 dB, network load stability ratio of 99.89%, and coverage ratio of 97.5% are validated in coherent simulations of the proposed methodology for the real-time implementation.

Keywords UAV · 5G and beyond · IoMT · UGQA · Base station

1 Introduction to B5G and UAV

The landscape of the future fifth-generation (5G) radio connectivity networks is supposed to link all effortlessly and worldwide, contrasting with present fourth-generation cellular networks. 5G networks support a minimum 1200-fold volume, 150 billion wired, wireless devices, and differentiated availability, bandwidth, and energy parameters [1]. The Internet of Things (IoT), the popularity of the upstream 5G and beyond 5G (B5G), has sparked an increase in mobile data services. According to the most recent estimate, global mobile internet traffic is expected to hit 1.6 zettabytes/mo by 2028. The new infrastructure would face high demands regarding efficiency and a heavy workload due to the higher investments in capital and operating expenses. Heterogeneous networks (HetNets) have made early attempts to satisfy these rising demands (i.e., deploy different small cells) [2].

Conversely, terrestrial networks' implementation is commercially unfeasible and daunting in unforeseen or emergency circumstances (such as disaster relief and utility rehabilitation) and complicated, unpredictable settings. To address this problem, sophisticated heterogeneous networking was deemed an innovative career framework for facilitating [3] real usage situations in wireless communication, i.e., enhanced mobile broadband (eMBBs) with high-speed bandwidth, Consistent, Reduced Delay (CRD), and massive Machine-Type Communications (mMTC).

For example, UAV may be vital to network services recovery in a catastrophe area, improve public health and safety systems, or other emergencies where CRD is necessary. The IoMT has become a collection of medical equipment and applications that can use networking technologies to link healthcare information systems. For example,

✉ Taher M. Ghazal
ghazal1000@hotmail.com

1 Skyline University College, Sharjah, UAE

2 Universiti Kebangsaan Malaysia (UKM), Bangi, Malaysia

connecting patients to their doctors and allowing medical data to be sent via a secure network can minimize needless hospital visits and the load on health care systems. IoMT, or Internet of Medical Things, demands a lot of data, a lot of speed, a lot of battery life, and dependable connectivity. With its ultrafast capabilities, 5G meets these criteria and facilitates IoMT for human health applications such as diagnosis and therapy. UAV-aided eMBB can be seen as a significant addition to the 5G mobile networks [4]. UAVs are also an integral part of cellular technology in 5G and B5G. The UAV's simplicity and dynamic topology make it widely available to various applications and needs in diverse fields [5]. Low-altitude UAVs have been used widely in IoMT applications, particularly in emergency ambulance services. In addition, UAVs can be used to provide surface network connectivity in heavy traffic demand and overloaded circumstances in the perspective of wireless communication as an aerial communication network (for example, flying primary stations (BSs) or cell relays) by the mounting of transceivers [6].

UAV's can be employed as airborne portals in a wide range of applications, including the supply of freight to the defense, usually known as cellular UAV's [7]. However, most current work is limited to UAVs as facilitators of mobile communications [8]. UAVs are fitted with navigation systems or dedicated sensors in most modern scenarios. They can enable a wide range of low-altitude monitoring, post-disaster evacuation, logistical application, and communication support. Besides, a colony of UAVs that build Fly Ad Hoc Networks (FANETs) [9, 10] has been technically developed and tested in field studies to enable broadband access networking in vast areas.

This article summarizes the critical contributions given as follows.

(1) Modeling of IoMT framework in 5G network
(2) Introduces the framework for positioning of UAV BSs to the IoMT applications
(3) Design for two different wireless channel
(4) Design strategy for network bi-link in a theoretical and statistical manner
(5) Unified Greedy Quest Algorithm for Internet of Medical Things (UGQA-IoMT) algorithm for positioning of UAV BSs
(6) Validation of the proposed methodology through discussion on experimental analysis

In all cases where UAV is installed alone and to support the current grounded BSs, the proposed UGQA algorithm will effectively address the positioning issues of BSs on-demand.

This article's remaining part can be systematized: Sect. 2 examines the associated study on 5G and Beyond Networks for IoMT Applications. Section 3 describes the Unified Greedy Quest Algorithm for the Internet of Medical Things (UGQA-IoMT) algorithm for positioning UAV BSs. Section 4 offers the outcomes and analysis by using the proposed UGQA-IoMT model. Concluding remarks, limits of the current learning, and the possibility for further enhancement have been provided in Sect. 5.

2 Related works on 5G and Beyond Networks for IoMT Applications

The latest drone interaction review has examined a range of engineering challenges, including specification of results, organization's strategic goals, 3D installation, user collaboration, and wireless UAVs. For example, in [11], the authors suggested an architecture designed to optimize wireless coverage in locations and the number of drones. The study carried out in [12] examined the optimum 3D usage of UAVs to maximize the number of land users protected by the QoS requirements. In [13], the authors suggested a wireless networking system for a broad ground network for multiple drone-strategic BS's positioning. In the previous research on UAV ground station installation, however, drone UTs are not recognized. In work in [14], the cell assembly in the UAV-supported grounded communication protocol was also delayed-optimized.

The study in [15] examined the best user/UAV interaction to increase heterogeneous UAV wireless network's performance. The project in [16] suggested using UAVs as an aerial ground station and deploying data to create a new hybrid cellular network structure. With the developed framework, a dual optimization of the client segmentation, the bandwidth distribution, and the UAV trajectory maximize the minimum throughput from the network environment. In [17], the researchers reported improving the land usage by optimizing the relationship between devices and drones and allocating the mobile spectrum broadband service. The study in [18] suggested a new method to cell association that maximizes overall data from drone-BSs with minimal flight durability provided to ground users. Conversely, earlier research in drone communications on users is restricted to land users and does not take 3D aircraft users into account.

Furthermore, previous studies do not investigate delay, a core parameter in 3D UAV communications networks (for instance, coordination, calculation, and backhaul). While a range of studies has been done on drone-UEs linked to the cellular [18], it has not considered the use of drone-BSs to serve drone-UEs. In [19], the researchers compared the harmony of drone UTs and broadband services on the ground and identified the ground station range's accuracy. The study in [20] suggested a path optimization strategy for drones to minimize their delay in contact and conflict with IoMT applications. The authors in [21] have analyzed drone-UE's base station coverage accuracy communicating with terrestrial base stations. The researchers reported a pathway technical architecture in [21] to minimize a UAV-mission UT's duration. Additionally, in the hopping chance and average attainable throughput, the authors characterized the success of drone- UTs in uplink contact with ground BSs. However, current experiments on mobile UAVs do not use airbase stations to facilitate reduced delay and efficient drone-UT connectivity [16].

Effective utilities are exchanged during the interaction with the framework with various products, including smartphones, computers, wearables, and detectors. The IoMT can enhance device's remote performance and reliability, accuracy, and economic benefits under the current network architecture [22]. IoMT delivers applications that support only brief information and long battery duration in addition to high speed and secure connectivity. For IoT, 5G network or equipment networking and power must be usable, bandwidth demand, and frequency spectrum. American businesses plan to rise to 357 billion dollars in 2019 if they spend 232 billion dollars on IoMT facilities and revenues this year [23]. In pandemic crisis handling, a 5G-enabled UAV-to-community offloading system was presented in [24]. The transmission rate, atomicity of jobs, and speed of UAVs were all factors in the formulation of a system throughput maximization issue. The mixed-integer nonlinear program was split into two subproblems by loosening the transmission rate requirement. They created a community-based latency approximation method to control the planned auction bidding and an average throughput maximization-based auction algorithm to decide the trajectory of UAVs. Within one community, a dynamic task admission method was used to tackle the task scheduling subproblem. Since targets are sparsely scattered throughout many different locations, an increase in the number of drones needed to monitor them does not necessitate an increase in the number of drones needed to monitor them. The authors in [25] suggested that the visible range of drones would rise instead, resulting in a reduction in drones. In the IoT age, a cost-effective framework for the appropriate deployment of drones to monitor a collection of static and dynamic targets was developed.

Much of the works do not deliberate the UAV associates with the immobile BSs, which are essential for fixed wireless networks. In brief, in current results, the UAV implementation issue has not been studied in the IoMT framework's mobile networks. Using all UAV situations, the UAVs are deployed alone for the fixed BSs. To reduce the number of used UAVs and optimize the load balance, deployment has been formulated because of the energy and resource constraints. There are two key restrictions on configuration: UAVs should form a stable communication infrastructure and keep linked with the defined BSs.

3 Unified Greedy Quest Algorithm for Internet of Medical Things (UGQA-IoMT) Algorithm for Positioning of UAV BSs

The objective of this paper is to allocate minimal UAVs to support as many IoMT devices as feasible. Furthermore, the load balancing between UAVs must be optimized for consistency, given UAVs' power limitations. In other terms, it should be reduced the variation of the quantity of UTs assisted between UAVs. In this case, the two-tier system biconnection and minor boundary of assisted IoMT were taken as significant factors. The amount of UAVs and the consignment equilibrium were jointly optimized by resolving several horizontal UAV coordinators.

Figure 1 illustrates the medical appearance of IoMT in the 5G network in the future. The biological samples, vital signals, and tracking information are obtained from the patients, and these data have been transported to the health guide or physician through routing networks. They can access the patient data remotely and give critical feedback or treatment. The patient must provide a legitimate identity that offers connectivity to any computer that benefits from that access when scanned and connected. Digital technological developments are critical to the fast growth of the Internet of Medical Things (IoMT).

3.1 Modeling of System

Figure 2 depicts the framework for positioning of UAV BSs for IoMT applications. Three types of contact artifacts in the situation under discussion are outlined in Fig. 2: (1) Designated BSs, (2) UAVs, and (3) the user terminals (UTs). Due to operational prerequisites or topography constraints, UTs are unequally distributed on the ground. They can consist of any on-ground terminals, including mobile phones, body sensors, IoMT-connected devices, and so on, transmitting information via their local cellular network. However, in the cellular network, coverage loops, BS overloads, and malfunctions will occur where UTs request the wireless service's urgent recovery. The correct fault detection system, such as the optimal detector, will detect such anomalies.

Interestingly, UAVs can be used quickly to provide these UEs with wireless connectivity services. First, both UAVs and static BSs build a solid infrastructure framework to support the surface UTs in interests in cooperation (AoI). Static BSs can be unified UAV administrators, where all UT data can be obtained from the UAVs. Both UAVs and UTs are fitted with omnidirectional antennas because they have a strategic location in high-mobile conditions to send and receive commands.

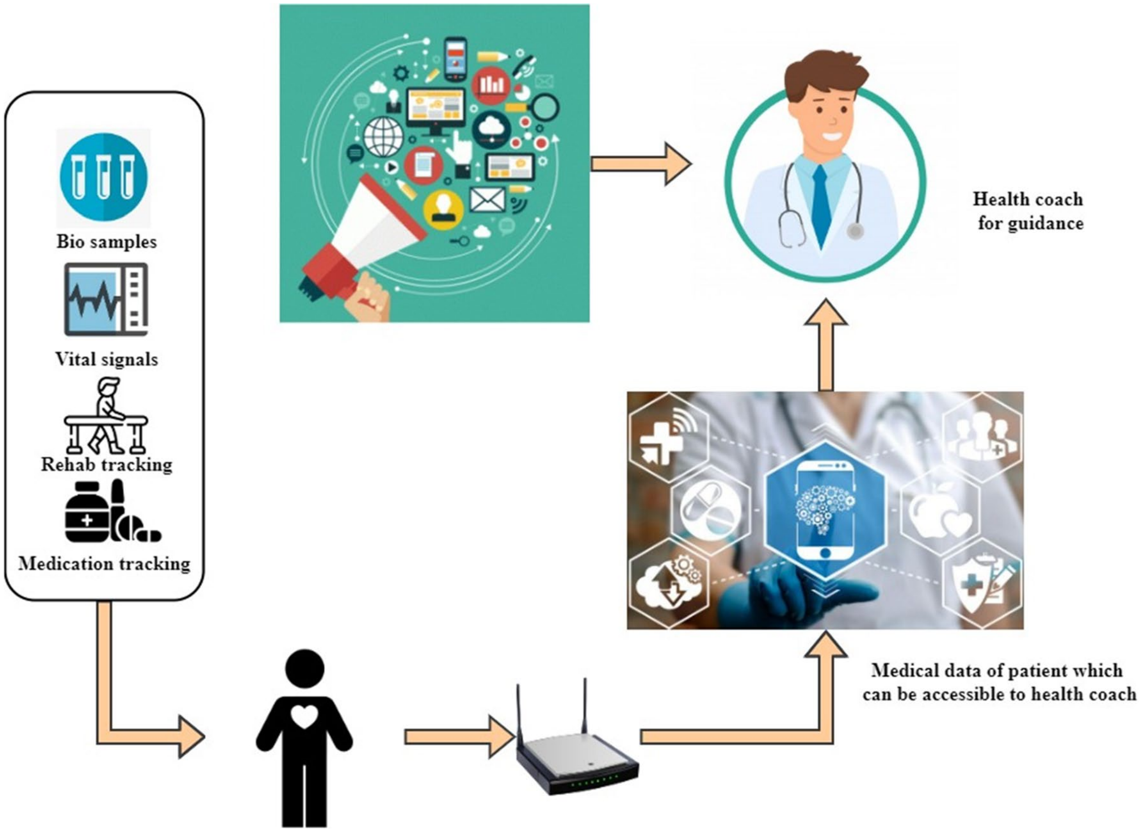


Fig. 1 IoMT framework in 5G network

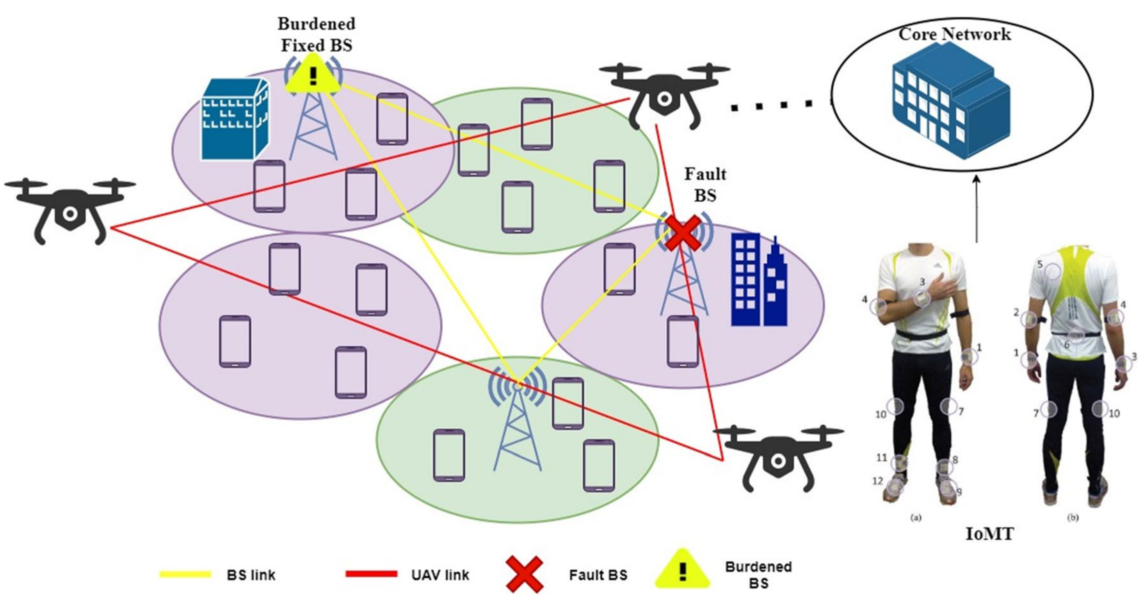


Fig. 2 Framework for positioning of UAV BSs to the IoMT applications

3.2 Modeling of the Wireless Channel

There are two types of channel available.

(i) Space to Space (S2S)—existing among UAVs, between UAV and BS.
(ii) Space to Terrestrial (S2T)—existing between UAV and UT, BS, and UT.

3.2.1 Space to Space (S2S)

Given the free space where the elevated UAVs and BSs interact, the streams are controlled mainly through the LOS link. The loss in the channel between UAV_a and UAV_b can therefore be constructed as free space propagation loss.

$$FL_{\mathrm{LOS}}^{\mathrm{a,b}} = 20logDt_{\mathrm{a,b}} + 20logF_0 + 20\log\left(\frac{4\pi}{v}\right) \quad (1)$$

where $Dt_{\mathrm{a,b}}$ is the remoteness among UAV_{a} and UAV_{b}, F_0 is the carrier frequency existing among UAVs and between UAV and BS, and v is the velocity of light in free space. Here it has been concluded that the transmitting capacity and the reception responsiveness in the backbone network between UAVs and BSs are symmetrical. Therefore, this article's maximal contact range is calculated because of the transmitting capacity of UAVs and BSs.

3.2.2 Space to Terrestrial (S2T)

Given the dynamic land geography of UTs, space to terrestrial channels is generally modeled upon integrating the LOS and non-LOS elements with their likelihood of success. The path loss between UAV_{a} and UT_{c} has been denoted as

$$PL_{\mathrm{a,c}}(dB) = P\left(LOS, \propto_{\mathrm{a,c}}\right) \times FL_{\mathrm{LOS}}^{\mathrm{a,c}} + \left(1 - P\left(LOS, \propto_{\mathrm{a,c}}\right)\right) \times FL_{\mathrm{Non-LOS}}^{\mathrm{a,c}} \quad (2)$$

$P\left(LOS, \propto_{\mathrm{a,c}}\right)$ is the likelihood of having a LOS link between UAV_{a} and UT_{c} with the angle of elevation denoted by $\propto_{\mathrm{a,c}}$. $FL_{\mathrm{LOS}}^{\mathrm{a,c}}$ and $FL_{\mathrm{Non-LOS}}^{\mathrm{a,c}}$ are the free space propagation loss between UAV_a and UT_c along the LOS and non-LOS path, respectively.

$$P\left(LOS, \propto_{\mathrm{a,c}}\right) = \frac{1}{1 + \gamma \exp\left(-\delta\left(\propto_{\mathrm{a,c}} - \gamma\right)\right)} \quad (3)$$

γ and δ are constants that are based on the surroundings. $FL_{\mathrm{LOS}}^{\mathrm{a,c}}$ and $FL_{\mathrm{Non-LOS}}^{\mathrm{a,c}}$ are the free space propagation loss between UAV_a and UT_c along the LOS and non-LOS path, respectively. They can be denoted as

$$FL_{LOS}^{a,c} = 20logDt_{a,c} + 20logF_0 + 20\log\left(\frac{4\pi}{v}\right) + \rho_{LOS} \quad (4)$$

$$FL_{Non-LOS}^{a,c} = 20logDt_{a,c} + 20logF_0 + 20\log\left(\frac{4\pi}{v}\right) + \rho_{Non-LOS} \quad (5)$$

where $Dt_{\mathrm{a,c}}$ is the remoteness among UAV_{a} and UT_{c}, F_0 is the carrier frequency existing between UAV and UT, and v is the velocity of light in free space. $\rho_{\mathrm{LOS}}$and$\rho_{\mathrm{Non-LOS}}$ are the extra path loss suffered to free space path loss in LOS and non-LOS, respectively.

UAVs use the same spectrum band as BSs to serve UTs. All layers controlled by UAVs and BSs have an inter-carrier intervention. If the signal-to-noise power Ratio (SNR) obtained by the UT_{c} from UAV_{a} (or BS_{a} is above the threshold indicated by Δ, UT_{c} is included, and the broadcast rate and quality of sservice (QoS) are provided by UAV_{a} (or BS_{a}). The SNR is determined by

$$\varepsilon_{\mathrm{a,c}} = \frac{P_{\mathrm{a,c}} C_{\mathrm{a,c}}}{\sum_{b \neq a} P_{\mathrm{a,c}} C_{\mathrm{a,c}} + N_0} \geq \Delta \quad (6)$$

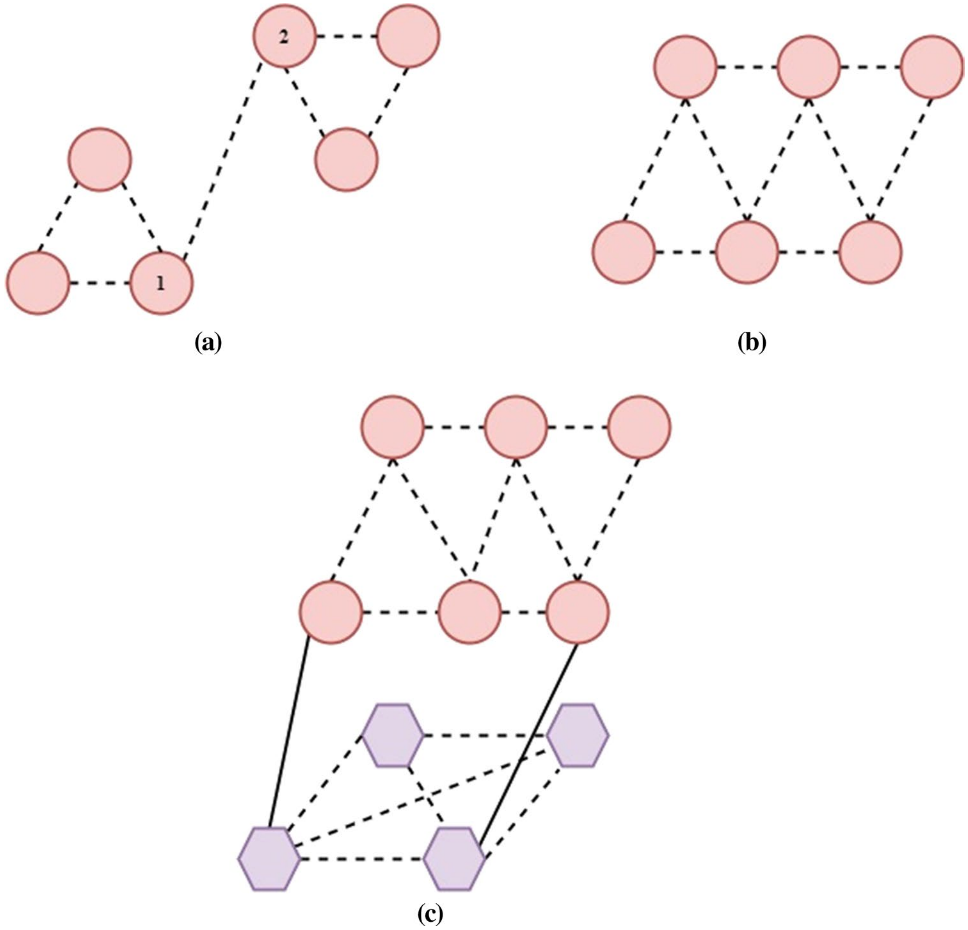
where $P_{\mathrm{a,c}}$ is the transmitted power between UAV_{a} and UT_{c}, $C_{\mathrm{a,c}}$ is the gain of the wireless channel and N_0 is the power of the additive white Gaussian noise (AWGN).

3.3 Linking of Networks

Figure 3 depicts the UAV management bi-links (the circles represent UAVs, IoMTs, and the hexagons signify static BSs) with the bi-link unit, two-connected, single-tier network, and Two-connected, two-tier networks. The node biconnecting and isolated information island preventing issues have been established, meaning that each UAV has two neighbors. A single and multi-hop connection links all UAVs, as seen in Fig. 3a. If one of the UAV crashes, there is always a minimum of one path between two UAVs left, so a bi network topology is said to be linked. As shown in Fig. 3b, this one-tier network communication is designated here (i.e., seeing the UAV link).

As shown in Fig. 3a, all nodes are bound to at least two neighbors. However, if UAV 1 or UAV 2 crashes, the system is divided into two separate structures that contravene the communication link. When a UAV network only has one peer, the UAV is disconnected if its neighbor fails. This procedure is not the way to make the network two-way. Thus, all nodes are bi-linked in a bilateral system. One may also assume that the two-way-connected links only have a trans link. A minimum of 2 UAVs is unswervingly associated with the BSs of two levels in a static BS service and a bilateral UAV framework (as shown in Fig. 3c. The unistage and bistage system bi-link implement the lenient defect instrument that increases device reliability

Fig. 3 UAV management bi-links (the circles represent UAVs, IoMTs, and the hexagons signify static BSs). **a** Bi-link unit. **b** Two-connected, single-tier system. **c** Two-connected, bilateral networks



and survivability. It has been.planned to deploy minimal UAVs for reduced costs to support as many IoMTs as possible. Furthermore, it must be optimized to balance UAVs for justice, given UAV's power constraints. In other words, it should be reduced the distinction of the quantity of UTs served between UAVs. This work used the two levels of the bipolar system and fewer restrictions of served users as key restrictions in total. They attempt to maximize UAVs and consignment balance by resolving a set of parallel coordinates. Therefore, the topic of UAV positioning can be devised:

$$\min_{\{h_a\}a\in N} N + \frac{1}{N}\sum_{b=1}^{N}\left(\sum_{c=1}^{M} B^{\mathrm{n}}_{\mathrm{b,c}} - \frac{\sum_{b=1}^{\mathrm{N}}\left(\sum_{c=1}^{\mathrm{M}} B^{\mathrm{n}}_{\mathrm{b,c}}\right)}{N}\right) \tag{7}$$

h_{a} denotes the flat coordinates of UAV_{a}. N denotes the total number of UAVs. M represents the total number of devices in the IoMT network. $B^{\mathrm{n}}_{\mathrm{b,c}}$ is the matrix that defines the correlation between fixed and overloaded BSs and UTs.

$$BC = B^{\mathrm{f}}_{\mathrm{a,c}}, B^{\mathrm{n}}_{\mathrm{b,c}}, B^{\mathrm{n}}_{\mathrm{a,b}}, B^{\mathrm{f}}_{\mathrm{a,b}} \in \{0,1\} \forall a \in F, b \in N, c \in M \tag{8}$$

BC is the Boolean criteria for the positioning of UAVs. $B^{\mathrm{n}}_{\mathrm{b,c}}$ is the matrix that defines the correlation between fixed and overloaded BSs and UTs. $B^{\mathrm{f}}_{\mathrm{a,c}}$ is the matrix that defines the correlation among UAV_{a} and UT_{c}. $B^{\mathrm{n}}_{\mathrm{a,b}}andB^{\mathrm{f}}_{\mathrm{a,b}}$ are the matrix that defines the correlation among UAV_{a} and UAV_{b} with fixed BSs and alternate BSs, respectively. F is the number of UAVs served by fixed, overloaded BSs. N is the number of UAVs used to help set BSs from overloading. M denotes the number of IoMT devices on the ground.

All 250 UAVs are assumed to be utilised alone by UAVs as indicated, here, the iteration continues on the superfluous UAVs are destroyed. Based on the 70 iterations, i.e., the under-optimized results that include the needed number of the UAV (i.e., 30 active UAVs) and their corresponding substitutes. The links between working UAVs are highlighted by guided lines and the deleted UAVs are not explicitly displayed.

3.4 Unified Greedy Quest Algorithm for Internet of Medical Things (UGQA-IoMT) Algorithm for Positioning of UAV BSs

Figure 4 depicts Unified Greedy Quest Algorithm for Internet of Medical Things (UGQA-IoMT) algorithm for

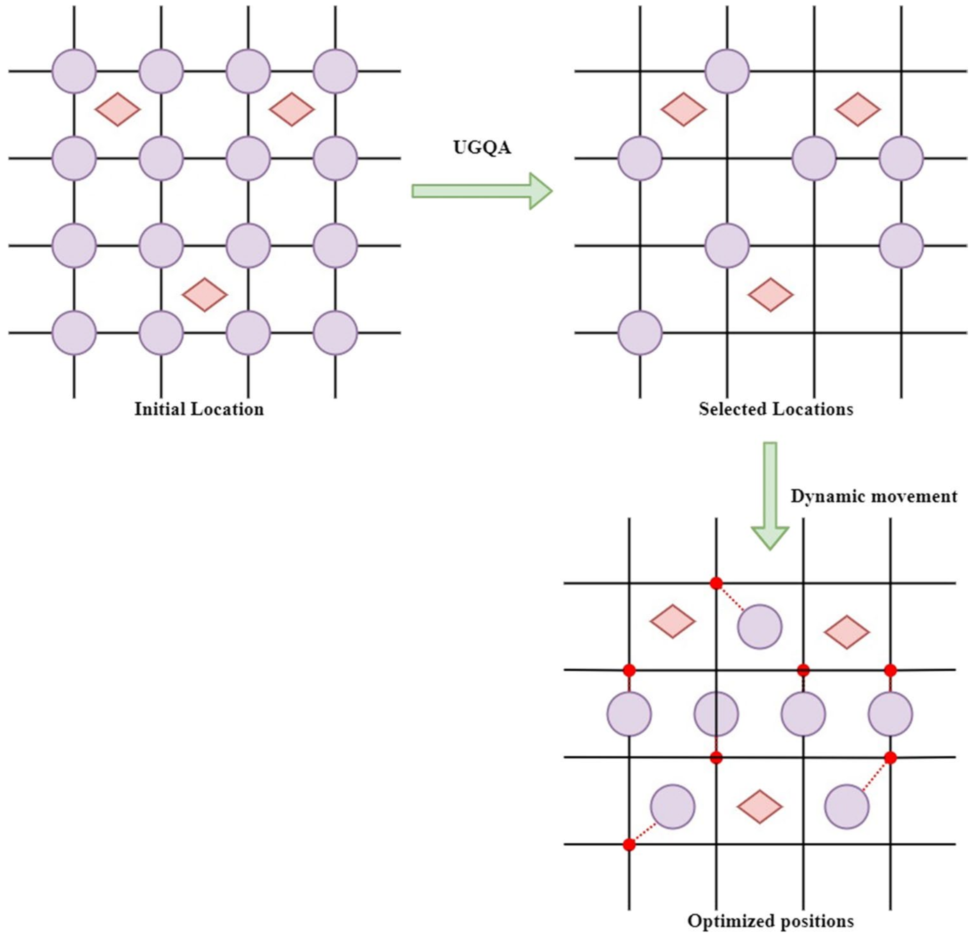


Fig. 4 UGQA-IoMT algorithm for positioning of UAV BSs

positioning of UAV BSs. This paper aims to minimize computational complexity rapidly by determining the preliminary hunt space for the ongoing positioning phase in the under-optimal locations to position the most miniature UAVs at optimum load balances. A hierarchical, low complexity algorithm can extract this sub-optimal condition from a given discontinuous room. In the figure, as mentioned above, the first block defines the smart grid structure with UAV base stations and the IoMT devices in monitoring the target without applying the proposed algorithm. The circled node represents the UAV base stations, whereas the diamond nodes represent the IoMT device. Then, our proposed UGQA analytically acquires from the candidate positions the least number of UAVs and their sub-optimized locations, as shown in the second block of the figure. The dynamic movement is then observed and applies a decentralized movement algorithm to maximize the network load by selecting the optimum location of each UAV in an ongoing space. The final optimized positioning of UAV BSs is depicted in the third block of the above figure.

Figure 5 shows the Unified Greedy Quest Algorithm's flowchart for the Internet of Medical Things (UGQA-IoMT) algorithm. Conversely, UAVs can find the UTs on the ground themselves using goal recognition sensors while flying through their IoMT UTs; unlike the clustered algorithm, the UGQA algorithms do not need a location for each UT in advance. This way, two steps are used in the deployment algorithm, i.e., the core procedure and the proposed UGQA process. The entire method's process flow is illustrated in Fig. 5 for consistency. As seen in Fig. 5, there are five phases in the centered deployment algorithm.

Step 1 Initialization

In this stage, it has been used a sufficient number of target UAVs to mask the AoI. In this case, "sufficient" means that each UT has at least one UAV/static BS and that the two-layer system bi-link can initially be ensured (e.g., install applicant UAV at all the fractious positions in a heavily populated lattice that covers the AoI). They will both be participating in their nations. The distinctions between candidate UAVs are then determined between candidate UAVs and set BS.

Step 2 Develop or Apprise link

This step aims to construct relationship charts by determining the mean SNR between UAVs and UTs, and between BSs and UEs. This step is necessary as it has

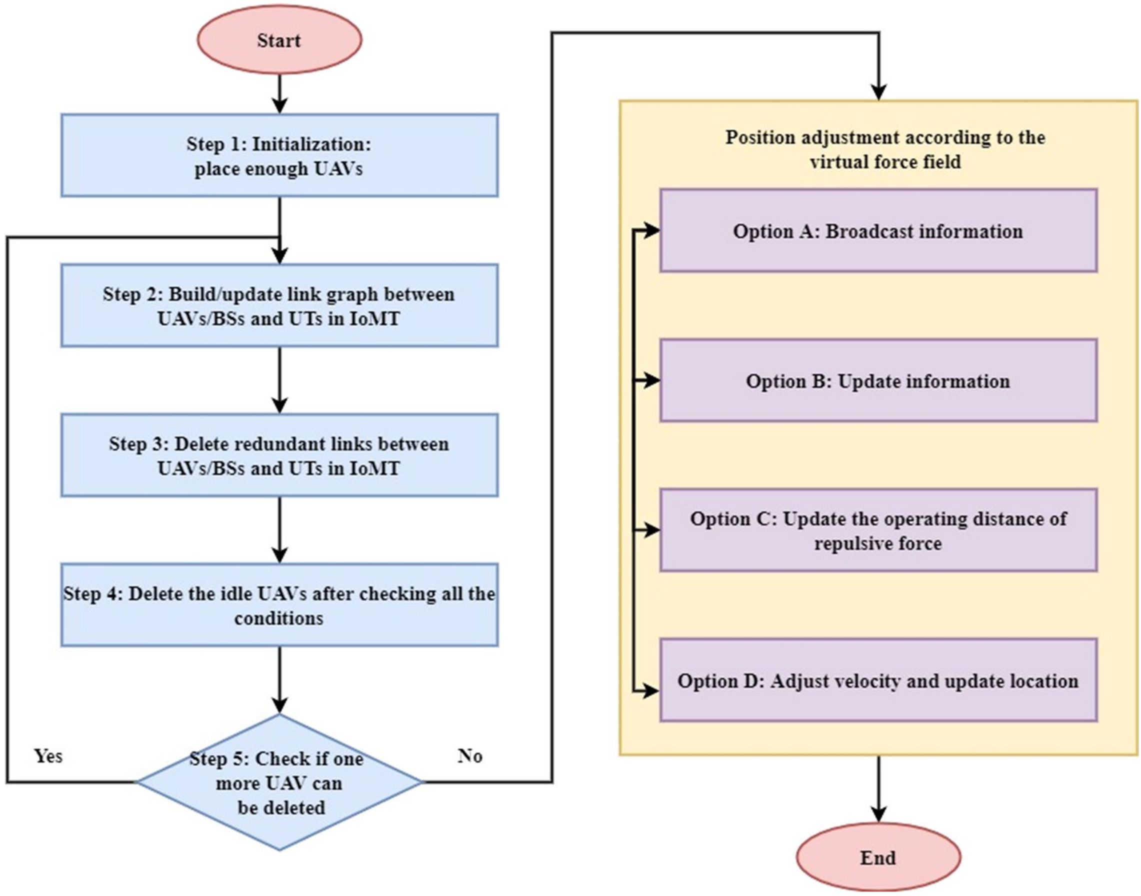


Fig. 5 Flowchart of Unified Greedy Quest Algorithm for Internet of Medical Things (UGQA-IoMT) algorithm

been believed that this device is equally driven in power allocation.

Step 3 Delete superfluous links

The unnecessary link ensures that at least a UT is linked to more than one UAV or BS.

Step 4 Eliminating inactive UAVs

A UAV is set to be inactive if its magnitude after step 3 becomes 0. In this stage, these inactive UAVs are probably deleted. Solutions have been suggested to identify inactive UAVs that cannot be removed explicitly because of the restrictions. The two-connection node can thus be reached, and the relevant data isolation issue can be prevented. Both these cannot, though, ensure a system of biconnections.

Step 5 Finding a chance to delete one more UAV

Suppose after step 3 no idle UAV is available, or because of the restrictions, the idle UAV is not removable at step 4. In that case, a more effective UAV can be uninstalled. The UTs connected with the effective UAV could all be linked with other neighboring UAVs without breaching the defined restrictions given by equation (6). UAVs should be removed to minimize the UAVs deployed in this situation. In this stage, it has been tried to check whether the UAV can be pulled further with the minimum grade of IoMT by setting compulsory transmission power at zero and then repeat step 2 for a new incarnation.

4 Results and Discussion for the Proposed UGQA-IoMT Algorithm

For the implementation of the proposed algorithm, JAVA is used as a simulator. This work takes the exposed UEs in a 1500 to 1500 m AOI into consideration for the simulation. In this respect, an accessibility scheme is followed to ensure the load balances and coverage ratio by the UE with a minor degree. It would provide the least access to UAVs. Various implementation scenarios have been considered to assess the proposed algorithm's scalability, as discussed below.

(1) Fixed BSs: all fixed and non-fixed BSs situations will be considered. UAVs are used to support all UEs, for the former alone, but UAVs are used to support static BSs in the service of exposed UEs in the former.

(2) UT/IoMT device distribution: Here, two common patterns have been followed, that is, the arbitrary pattern (in which UTs are distributed uniformly in the AoI) and the proposed UGQA outline (UTs congregate into numerous groups).
(3) Number of UT's and UAV's candidates: Various EU's and UAV's have been selected. Naturally, additional UTs are demanding more UAVs.

It is considered that all the 250 UAVs will be used by UAVs alone and as shown in Fig. 6. The original allocation of UTs and member UAVs is seen in Fig. 6a. The redundant UAVs are discarded as iteration goes on. The outcome, i.e., a sub-optimized performance that contains the required amount of UAVs deployed (i.e., 30 active UAVs) and their respective sub-optimal places, is shown in Fig. 6b after 70 iterations. The ties between the operating UAVs are marked with directed lines, and the removed UAVs are not shown explicitly. It can be seen from Fig. 6b that 250 UTs and no more than 20 UTs per UAV are supported.

Furthermore, the UAVs have a biconnected backbone network. Then the desired outcome as the final stage of 100 s is entered into the distributed motion algorithm. Following the simulated force field, these UAVs will discover their best positions separately.

Figure 7 shows the mean SNR for varying IoMT devices on the ground using the proposed UGQA (a) with 30 UAVs

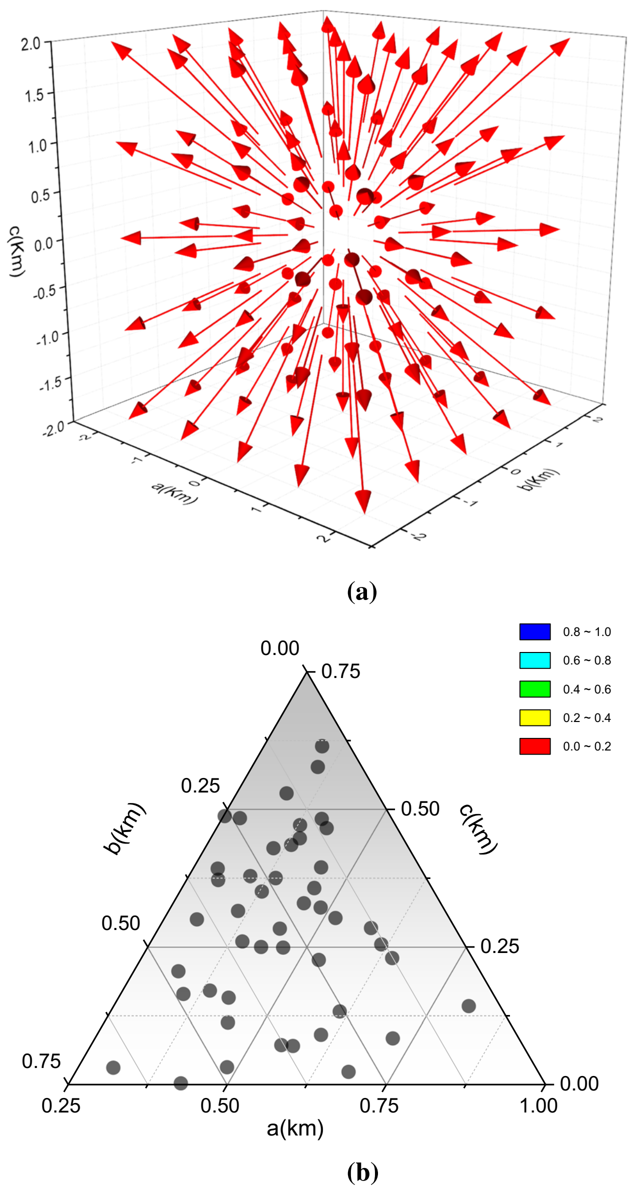


Fig. 6 Positioning of UAVs with M = 250, N = 30. **a** Sub-optimized state of UAVs (0th iteration at initial time). **b** Optimized state of UAVs (at time 100 s)

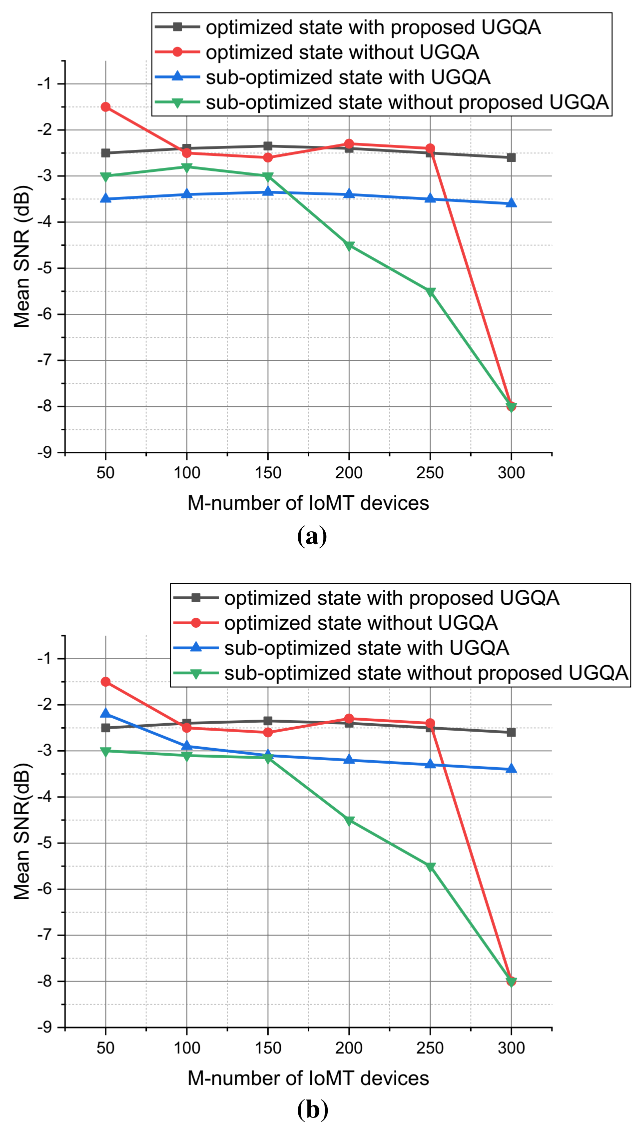


Fig. 7 Mean SNR for varying number of IoMT devices on the ground using proposed UGQA **a** with 30 UAVs **b** with 40UAVs

(b) with 40UAVs. For the mean SNR, in both cases [when the *number of UAVs* = 30 and 40], the optimized state with the proposed UGQA and without the UGQA algorithm gives improved SNR −3 dB. The output is much higher than the threshold value, i.e., −8.5 dB, and with the growing IoMT devices, the results vary very little. On average, a robust increase of 0.9 and 0.65 dB is extracted by the proposed UGQA algorithm in terms of several UAVs = 30 and 40, respectively. But without the need for the suggested algorithm, things are different. The SNR improves as the IoMT devices grow (up to about 4 dB), simply a function of a decreased SNR obtained by the proposed algorithm. The reason is that UAVs get denser in a UT cluster as IoMT devices rise, which adds more intercell interfaces for each UT (IoMT devices). These findings confirm the efficacy of the proposed UGQA algorithm to optimize wireless access to UAVs between IoMTs by changing the UAV locations.

The coverage ratio for the optimized state with and without the UGQA algorithm for several IoMT devices has been given in Table 1. Table 2 shows the sub-optimized state coverage ratio [overloaded BSs] with and without the UGQA algorithm for the number of IoMT devices. In optimized and sub-optimized scenarios, the coverage ratio remains above 0.975 (i.e., the exposure likelihood verge). The tables show that the distributed algorithm increases the coverage ratio. Another fascinating observation is that the coverage ratio usually declines with growing IoMTs. This results in the growing theoretical minimum with UT, which increases the likelihood that such IoMTs will not be serviced, increasingly used by the number of UAVs. For the 40 UAVs, the coverage ratio is small than the coverage ratio with 30 UAVs in both optimized and sub-optimized states.

Load Balancing means that the UAVs that serve IoMTs are equal. Average load balancing will reduce the entire network lifespan. Figure 8 shows the load balancing BSs of 30 and 40 UAVs for the IoMT framework for optimized and sub-optimized states (a) with the suggested UGQA algorithm (b) without UGQA algorithm. Compared to the

Table 1 Coverage ratio for optimized state with and without UGQA algorithm for several IoMT devices

Number of IoMT devices	The coverage ratio for optimized state with UGQA		The coverage ratio for an optimized state without UGQA	
	Number of UAVs = 30	Number of UAVs = 40	Number of UAVs = 40	Number of UAVs = 30
50	1	0.99	0.98	0.98
100	0.99	0.985	0.995	0.999
150	0.985	0.98	0.985	0.989
200	0.98	0.975	0.98	0.985
250	0.976	0.97	0.975	0.98
300	0.97	0.965	0.97	0.975

Table 2 Coverage ratio for the sub-optimized state [overloaded BSs] with and without UGQA algorithm for several IoMT devices

Number of IoMT devices	The coverage ratio for sub-optimized state with UGQA		The coverage ratio for the sub-optimized state without UGQA	
	Number of UAVs = 40	Number of UAVs = 30	Number of UAVs = 40	Number of UAVs = 30
50	0.98	0.99	0.97	0.98
100	0.975	0.985	0.985	0.995
150	0.97	0.98	0.975	0.985
200	0.965	0.975	0.97	0.98
250	0.96	0.97	0.965	0.975
300	0.955	0.965	0.96	0.97

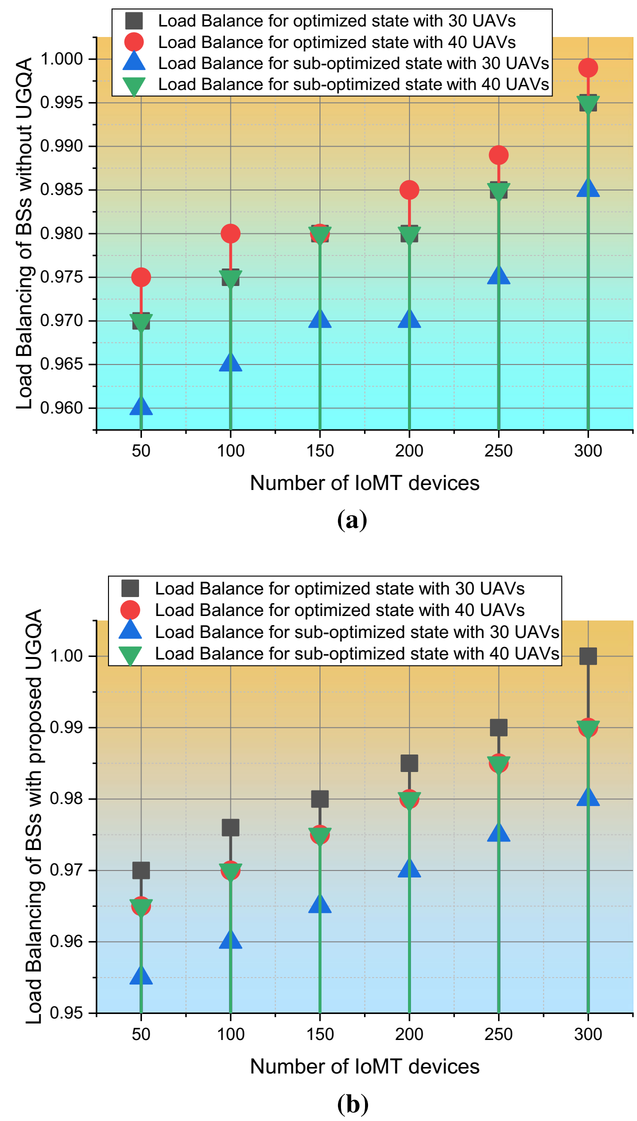


Fig. 8 Load Balancing of BSs for optimized and sub-optimized states with 30 and 40 UAVs for IoMT application. **a** without UGQA algorithm **b** with the proposed UGQA algorithm

minimum number of UAVs deployed with a centralized algorithm, optimizing the load balancing through the distributed algorithm is possible. The load equality of all deployed UAVs is compared by Fig. 8 between the optimum (UGQA algorithm) result and the suboptimal result (with overloaded BSs). From both the figures, it can be seen that the load balance of the ideal outcome in the two scenarios in both traffic patterns is exceptionally close to 1, i.e., the practical limit touches value of 1 with growing IoMT devices. This ensures that the load balancing fairness is strengthened, and the decentralized algorithm will achieve the optimum value. It can also be seen from both statistics that right in load equilibrium improves as IoMT devices rise. That's because the potential minimum of growing M is approached in the number of deployed UAVs.

These findings confirm that the UGQA algorithm proposed can centrally collect the minimum deployed UAVs similar to the hypothetical lowest and a more stable UAV framework and achieve a dispersed overall load balance close to 1 more effectively. Moreover, the proposed UGQA algorithm for IoMT devices optimizes specific system output concerning average SNR, load balance, and coverage ratio.

5 Conclusion of the Research Work

Thus, the Unified Greedy Quest Algorithm for the Internet of Medical Things (UGQA-IoMT) algorithm is used for telemedicine applications and achieves a minimum number of UAVs and optimal places. The algorithm proposed refers to various scenarios in which UAVs are installed by themselves or with the set BSs, irrespective of the UT deployment. The performance gains in mean SNR, network, load stability, and coverage ratio have been checked in coherent simulations. The findings confirm that the UGQA algorithm proposed can centrally collect the minimum deployed UAVs similar to the hypothetical lowest and a more stable UAV framework and achieve a dispersed overall load balance close to 1 more effectively. Moreover, the proposed UGQA algorithm for IoMT devices optimizes specific system output concerning average SNR, load balance, and coverage ratio. As a result, the suggested UGQA algorithm is resilient in handling UAV deployment challenges in mobile networks for the forthcoming 5G and beyond networks in IoMT implementation.

In the future, it is planned to integrate the image-based analysis module in the proposed model with energy-efficient modeling using deep learning techniques.

References

1. Ning, Z.; Dong, P.; Wang, X.; Hu, X.; Guo, L.; Hu, B.; Kwok, R.Y.: Mobile edge computing enabled 5G health monitoring for Internet of medical things: A decentralized game theoretic approach. IEEE J. Sel. Areas Commun. **39**(2), 463–478 (2020)
2. Hiremath, P. N.; Armentrout, J.; Vu, S.; Nguyen, T. N.; Minh, Q. T.; Phung, P. H.: MyWebGuard: toward a user-oriented tool for security and privacy protection on the web. In *International Conference on Future Data and Security Engineering* (pp 506–525). Springer, Cham (2019)
3. Sutrala, A. K.; Obaidat, M. S.; Saha, S.; Das, A. K.; Alazab, M.; & Park, Y.: Authenticated Key Agreement Scheme With User Anonymity and Untraceability for 5G-Enabled Softwarized Industrial Cyber-Physical Systems. *IEEE Transactions on Intelligent Transportation Systems*. (2021)
4. Abdel-Basset, M.; Manogaran, G.; Gamal, A.; Smarandache, F.: A group decision making framework based on neutrosophic TOPSIS approach for smart medical device selection. J. Med. Syst. **43**(2), 38 (2019)
5. Nguyen, C.H.; Pham, T.L.; Nguyen, T.N.; Ho, C.H.; Nguyen, T.A.: The linguistic summarization and the interpretability, scalability of fuzzy representations of multilevel semantic structures of word-domains. Microprocess. Microsyst. **1**, 103641 (2021)
6. Ahilan, A.; Manogaran, G.; Raja, C.; Kadry, S.; Kumar, S.N.; Kumar, C.A.; Murugan, N.S.: Segmentation by fractional order darwinian particle swarm optimization based multilevel thresholding and improved lossless prediction based compression algorithm for medical images. IEEE Access **7**, 89570–89580 (2019)
7. Liu, J.; Wan, J.; Jia, D.; Zeng, B.; Li, D.; Hsu, C.H.; Chen, H.: High-efficiency urban traffic management in context-aware computing and 5G communication. IEEE Commun. Mag. **55**(1), 34–40 (2017)
8. Garg, S.; Aujla, G.S.; Erbad, A.; Rodrigues, J.J.; Chen, M.; Wang, X.: Guest editorial: Blockchain envisioned drones: Realizing 5G-enabled flying automation. IEEE Network **35**(1), 16–19 (2021)
9. Elhoseny, M.; Ramírez-González, G.; Abu-Elnasr, O.M.; Shawkat, S.A.; Arunkumar, N.; Farouk, A.: Secure medical data transmission model for IoT-based healthcare systems. IEEE Access **6**, 20596–20608 (2018)
10. Darwish, A.; Hassanien, A.E.; Elhoseny, M.; Sangaiah, A.K.; Muhammad, K.: The impact of the hybrid platform of internet of things and cloud computing on healthcare systems: opportunities, challenges, and open problems. J. Ambient. Intell. Humaniz. Comput. **10**(10), 4151–4166 (2019)
11. Akram, T.; Awais, M.; Naqvi, R.; Ahmed, A.; Naeem, M.: Multicriteria uav base stations placement for disaster management. IEEE Syst. J. **14**(3), 3475–3482 (2020)
12. Alzenad, M.; El-Keyi, A.; Lagum, F.; Yanikomeroglu, H.: 3-D placement of an unmanned aerial vehicle base station (UAV-BS) for energy-efficient maximal coverage. IEEE Wireless Commun. Lett. **6**(4), 434–437 (2017)
13. Yang, L.; Zhang, H.; He, Y.: Temporal correlation and long-term average performance analysis of multiple UAV-aided networks. IEEE Internet Things J. **8**(11), 8854–8864 (2021)
14. Zhang, J.; Zhang, T.; Yang, Z.; Li, B.; Wu, Y.: Altitude and number optimization for UAV-enabled wireless communications. IET Commun. **14**(8), 1228–1233 (2020)
15. Manzoor, A.; Kim, K.; Pandey, S. R.; Kazmi, S. A.; Tran, N. H.; Saad, W.; & Hong, C. S.: Ruin theory for energy-efficient resource allocation in uav-assisted cellular networks. *IEEE Transactions on Communications*. (2021)
16. Lyu, J.; Zeng, Y.; Zhang, R.: UAV-aided offloading for cellular hotspot. IEEE Trans. Wireless Commun. **17**(6), 3988–4001 (2018)
17. Khayrov, E.M.; Polyakov, N.A.; Medvedeva, E.G.; Pokorny, J.; Gaidamaka, Y.V.; Hosek, J.: Simulating UAV's Movement for Servicing User Groups with a Reference Point in Wireless Networks. In: Internet of Things, Smart Spaces, and Next Generation Networks and Systems, pp. 415–425. Springer, Cham (2020)

18. Liu, B.; Zhu, Q.; Zhu, H.: Trajectory optimization and resource allocation for UAV-assisted relaying communications. Wireless Netw. **26**(1), 739–749 (2020)
19. Liu, Y.; Zhang, S.: Information security and storage of Internet of Things based on block chains. Futur. Gener. Comput. Syst. **106**, 296–303 (2020)
20. Ullah, Z.; Al-Turjman, F.; Mostarda, L.: Cognition in UAV-aided 5G and beyond communications: A survey. IEEE Trans. Cogn. Commun. Netw. **6**(3), 872–891 (2020)
21. Hellaoui, H.; Bagaa, M.; Chelli, A.; Taleb, T.: Joint Sub-Carrier and Power Allocation for Efficient Communication of Cellular UAVs. IEEE Trans. Wireless Commun. **19**(12), 8287–8302 (2020)
22. Qadri, Y.A.; Nauman, A.; Zikria, Y.B.; Vasilakos, A.V.; Kim, S.W.: The future of healthcare internet of things: a survey of emerging technologies. IEEE Commun. Surv. Tutor. **22**(2), 1121–1167 (2020)
23. Girardi, F.; De Gennaro, G.; Colizzi, L.; Convertini, N.: Improving the healthcare effectiveness: The possible role of EHR IoMT and blockchain. Electronics **9**(6), 884 (2020)
24. Ning, Z.; Dong, P.; Wen, M.; Wang, X.; & Guo, L.: 5G-Enabled UAV-to-Community Offloading: Joint Trajectory Design and Task Scheduling (2021)
25. Al-Turjman, F.; Zahmatkesh, H.; Al-Oqily, I.; Daboul, R.: Optimized unmanned aerial vehicles deployment for static and mobile targets' monitoring. Comput. Commun. **149**, 27–35 (2020)