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Proposition of a Novel Multipath-Routing Protocol for Manets Connected Via Positioning of UAVS Using Ant Colony Optimization Meta-Algorithms

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***Abstract*—** In the forthcoming operational theatre, combat radio nodes will be strategically positioned to facilitate a myriad of manoeuvres, constituting a dynamic mobile ad-hoc network (MANET), where communication among participating nodes is achieved collaboratively without fixed base stations. However, due to the nodes' mobility, the cohesive formation may fragment into smaller clusters, while conversely, multiple smaller groups might amalgamate into larger entities. In such a dynamic milieu, the integration of unmanned aerial vehicles (UAVs) emerges as a potent solution to enhance network coverage and connectivity among disparate groups. Sending of information all over the MANETs is dependent mostly on methodologies of routing, where the on-request unitary paths procedures to route like AODV and AOMDV (which stands for routing via multiple roads) play crucial roles. Leveraging authentic topographic data becomes imperative to ascertain precise connectivity metrics among nodes, while devising an efficient resource allocation strategy for reliable communication via UAVs warrants attention. Given the predominance of line-of-sight links between UAVs and ground nodes, substantial traffic is anticipated despite less amount of information sectional resources. Furthermore, diverse quality-of-service requirements of network traffic necessitate prioritization based on tactical imperatives. In these studies, formulations have been done for Unmanned Flying Vehicle localizing problems geared towards maximal connectivity inside groups along with information section allocating problems aimed at increasing utilities of GC to maximum levels, demonstrating superiority over conventional methodologies through numerical analysis validating the efficacy of our proposed scheme. Wireless connections implemented rapid growths in recent times essentially network of MANET, showcasing significant developments of science and technology.

Key words: AOMDV, MANET, AODV, Routing Protocols, Unmanned Aerial Vehicles.

I. INTRODUCTION

In the prospective landscape of tactical warfare networks, combat radio nodes will undergo deployment, facilitating the establishment of MANET or network of ad-hoc mobile absent the oversight of a centralized base station [1]. Nevertheless, the exigencies of diverse battlefield engagements demand a malleable network configuration. A unified assemblage, where node-to-node communication occurs through ground ad-hoc networking, may bifurcate into multiple smaller clusters with diminished node counts. Conversely, numerous diminutive clusters may amalgamate into a singular entity. Furthermore, the exigencies posed by operational settings like mountainous landscapes and the imperative of real-time data transmission present formidable challenges in case of tactics-based MANETs like depicted in Fig.1.

In these contextual domain, UAVs or Unmanned Flying Vehicles emerge as a viable solution to extend coverage and bolster connectivity among disparate clusters. Nonetheless, several considerations must be deliberated in cases of optimized installations of Unmanned Flying Vehicles. Foremost among these has been the imperative for ascertaining optimal positioning in case of Unmanned Flying Vehicles to enhance connectivity in one group with another. While business-based networks prioritize throughput maximization and serving a larger user base, over tactics based MANETs, the preservation of within the group links takes precedence for network resilience and survivability.

It is noteworthy that in the scenario where solely one node within a cluster is linked to a UAV, the rest of the nodes within said cluster maintain the capability to engage in communication with other clusters through the intermediary of the UAV, provided that the connections within the cluster itself are fortified.

Furthermore, a proficient scheme for the allocation of resources to ensure dependable communication through the UAV is imperative. Despite the finite number of data slots available within a tactical MANET, a multitude of nodes can establish connections with Unmanned Flying Vehicle via link on the basis of lines-of-sights. Consequently, a unmanned flying vehicle boasting superior connection characteristics may encounter congestion due to the substantial traffic flow to and from ground nodes. Furthermore, different sorts of traffics like emergency messaging, voice transmissions in real-times transmissions, or basic situational updates, necessitate diversified Qualities-of-Services provisions. Additionally, distinct importances are assigned based on the hierarchical positions of nodes and the significance of the clusters involved in the tactical maneuvers assigned to them.

In studies [2-11], the focus was primarily on determining the suitable positioning of a UAV for commercial communication purposes. Study [2] utilized a UAV to extend network coverage and address unforeseen emergencies, such as urgent communication needs. Authors in studies [3] and [4] demonstrated the effectiveness of UAVs in mitigating earth-stations malfunctions through serving far-away utilizers enhancing Qualities of Services. A framework of attenuation over routes towards UAV-to-ground connection proposed in study [5] was utilized to ascertain the optimal UAV altitude for maximizing network coverage. Study [6] explored the 3D deployment of UAVs to cater to as many nodes as feasible. In study [7], a method was proposed to link mobile-communications cell areas with UAVs to augment network capacity. Furthermore, installing many different UAV has been examined for creation of coverages that don't not overlap along with boosting of capacities of links towards nodes on the ground in hotspots. Effective placements of UAV has been achieved by the usage of theories of packing circles. Study [8] determined optimized UAV height to ensure reliability towards a single node at the cell edge. Authors in study [9] have made the proposition of strategies for placing UAVs in two dimensions for minimization of mean latencies in HETNETs. Study [10] investigated the three-dimensional placements of UAVs over hotspots with the aim of maximizing node coverage, while introducing various QoS constraints through the proposed scheme.

The primary distinction between their work and the aforementioned studies lies in the absence of consideration for situations in which networks inside unitary groups undergoes division while it is moving. In case of small divided groups might be linked by a UAV, prioritizing the connection between these separated groups becomes significantly more crucial than merely expanding numerical values of node straight away linked through UAVs. Consequently, supporting more than two groups requires determining the UAV's position based on inter-group connectivity. Rather than solely focusing on the quantity of nodes to be linked, emphasis is placed by the connectivities between the group, which reflects network's topologies. Furthermore, geographic factors were not been considered in separate studies. In tactical environments, obstacles like mountainous terrains serve as significant impediments to communication, necessitating the inclusion of terrain information. The algorithm diverges from others in its utilization of topographic data to establish connectivity, resulting in the acquisition of more precise connectivity information.

Numerous studies have been conducted on media access control (MAC) protocols aimed at giving QoS or giving Qualities of Services for a Mobile Ad hoc Network (MANET). Most of these studies fall into categories such as demand-based CSMA or Carrier Sense Multiple Access, demand-zero TDMA or Time Division Multiple Access, or a combination of the 2, like it has been outlined over previous literatures. TDMA is recognized as effective for sending real-times information and ensuring Quality of Services over tactics based MANETs. Consequently, adoption of this access scheme is observed in tactical radios, and investigations into allocations of sections that are dynamized for allocating on the basis of requests of users have been undertaken. One study, the concept of multiple jump desynchronizations (MH-Desync) was introduced, in which every connecting point gives and takes data on sections through their 1-jump in which every node gives and takes section data through their single-jump surrounding nodes for allocations of under- utilized sections. These exchange of data enables every node to acquire slot allocation information for its 2- hop nodes. Another proposed method, Kuramoto-Desynchronization (K-Desync), aims for rapid convergence of desynchronization. Weight desynchronization (W-Desync) was introduced in another study, where QoS considerations were made through the assignments of weights. Furthermore, Qualities of Services-reaching procedure has been proposed, taking into account energy efficiency. A Time Division Multiple Access-based multiple jump resources reservations (TMRR) procedure was introduced for flow-basis section scheduling to minimize start-to-completion delays. Additionally, a demand-based section allocating scheme was introduced in another study, which adapts to topology changes and traffic demand. One study focused on exchanging single-jump node data to all node along with scheduling sections based on demanded values of sections. Another proposed procedures of time division multiple access that are distributed, considering on-demand frame size. On top of that media access control procedures ensuring minimized section allocations for each node have been presented in separate studies. One such study made the proposition of a allocating procedure of sections that is distributed supporting multiple-jump links. Finally, penta-phase procedure for reserving was proposed, in which demand-based allocating of sections were employed.

Table-I: Character of Channels with Application Frameworks

Character of Channels	Application Frameworks
Fading by downpours	ITU-P.618.12
Loss on Surroundings	4-TIREM
Fading from Multiple Routes	Distribution Rician
Shadow effect	4-TIREM
Loss in Path traversed	4-TIREM

II. FRAMEWORKS OF SYSTEMS AND PROBLEMS FORMED

Various phenomena impact the communication between air and ground, encompassing path attenuation, obstruction effects, signal distortion from multiple paths, atmospheric

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interference, and signal degradation due to rain. A series of studies, spanning from [27] to [31], employs the free-space propagation model to estimate path attenuation, while integrating supplementary factors to address other influences on communication links. Instead of relying on vacuum-based route attenuation framework, the military Terrain Integrated Rough Earth Model 4 (4-TIREM) [32] is opted for to account for geographical factors in tactical scenarios. If Lines of Sights or Not Lines-of-Sights signals reflection, and diffraction effects are applicable is dictated by the terrain data. In Figure 2, the lower section depicts terrain data, while the upper section illustrates signal attenuation between two points within this terrain. Signal diffraction occurs in the upper section when LoS is obstructed by terrain elevation along the path. The surface information source for the 4-TIREM model is provided by [33] Digital Terrain Elevation Data 2 (DTED-2) system. Attenuation influences sue to atmosphere and Shadows have been incorporated by 4-TIREM, resulting in greater precision-based attenuation of routes of channels frameworks when operating within designated areas. The K factor for the Rician distribution [34], employed as a multipath fading model, is adjusted based on the available frequency band [35]. The rainfall reduction model outlined inside the [36] ITU-R P.618-13 standards have been implemented, given the possibility of operating in adverse weather conditions. This model applies to frequency bands ranging from 1 GHz to 1000 GHz, with minimal rainfall attenuation observed around one Giga hertz band slowly increasing throughout the higher frequencies. As a result there has been an assumption of attenuating of rains do not happen under one gigahertz. A summary of frameworks that have been applied is presented over Table-I.

Power that have been received in i^{th} $node$ from senders having power $Power^{transmit}$ namely EIRP or Power Radiated with Effective Isotropic features may be show as

$$Power_{received} = Power_{transmit} - L_{TIREM}(r_j, h) - L_{RICIAN} - L_{Downpour}$$

In which r_j *and* h represent lateral-wise displacement from earth level and height-wise displacement from earth level respectively. The power which have been got should stay in threshold called P_{th}

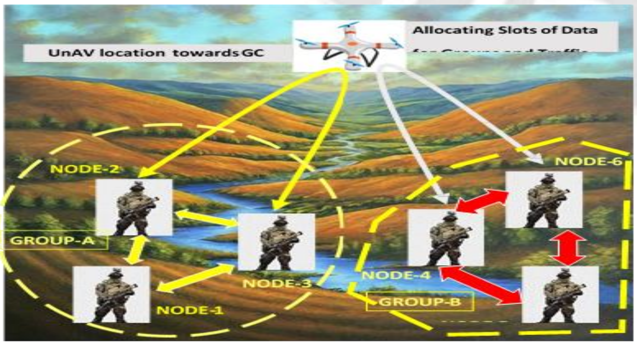

Figure 1 GC_TMAC model of systems

III. FRAMEWORK AND QUALITY OF SERVICES SATISFYING MODEL

Fig. 3 is illustrated by the Group Connectivity Tactical Medium Access Control (GC-TMAC) system, where the capability of a UAV to facilitate either a unified group or multiple segmented groups is presented. Within a group, ad-hoc connections are established by ground nodes, with the UAV serving as a communication hub for interconnecting these ground nodes. Typically, live audio data or asynchronous status updates are transmitted by ground nodes.

A diagram illustrating the operational flow is provided in Fig. 4. Initially, information is shared by each node with both the UAV and its neighboring nodes. Subsequently, a search for the most optimal position is undertaken by the UAV, followed by relocation to that position. In the event of communication disruption between groups, a data slot request is initiated by one node from each group to the UAV. Subsequently, a slot allocation algorithm is implemented by the UAV, with the allocated information being relayed to the ground nodes. Continuous monitoring of network neighbor information is carried out by the UAV. Periodic updates of the UAV's location are performed, with the frequency determined based on factors such as ground node velocity, link status, and node connectivity. It is assumed that each ground node is carried by an individual, resulting in updates of the UAV node's location once every specified time period, denoted as Tp, which represents the UAV's position update frequency. In numerical simulations, Tp is set to 5 minutes, reflecting the assumption that ground nodes are carried by infantry soldiers.

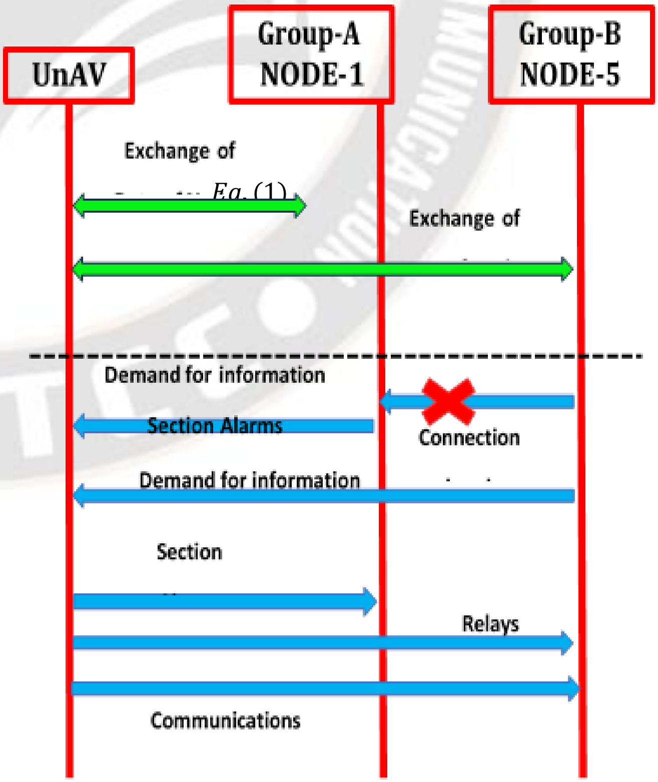

Figure 2 Steps to postion UnAVs

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A superframe of the system is composed of two distinct subframes: the Control subframe and the Data subframe, as depicted in Fig. 5. By utilizing the Control Slot within the Control subframe, each node transmits its NCF (Network Configuration) message to establish connections with other nodes, including the UAV. Furthermore, slot requests, neighbor node information, and node status reports are dispatched to the UAV by each node using the Control Slot. Additionally, slot scheduling information is disseminated to the ground nodes by the UAV via the Control Slot. The status of 1-hop neighbors for each node is also exchanged using the Control Slot. When the total number of slot requests is less than the total number of unused slots in the UAV, slots are allocated upon request. Conversely, in a saturated network where the total number of slot requests exceeds the total number of unused slots, necessitating a slot assignment policy. During connection setup and packet routing, all nodes function in an ad-hoc mode supporting communication up to a maximum of 4 hops. The number of hops is contingent upon the operational area of the nodes, superframe size, and traffic delay requirements. The maximum hops are determined by the operational area of the nodes, with the superframe size designed to accommodate these maximum hops to mitigate end-to-end delay escalation with increased hops. In the event of a node failing to secure a data slot allocation, it retries; however, consecutive failures prompt a reset of the routing path in the upper layer.

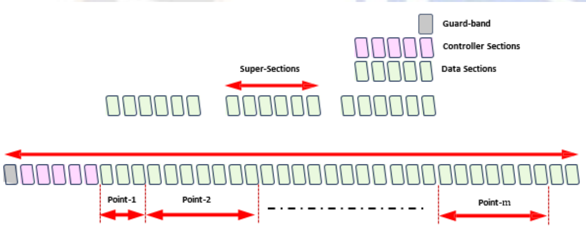

Figure 3 Structures for Super-Section for Time Division multiple Access.

In Equation (2), the QoS satisfaction function Qi(si) is defined, representing a commonly used approach for capturing network characteristics. Such functions are commonly employed in network modeling due to their versatility. Specifically, for real-time data, which exhibit inelasticity and sensitivity to delay, an S-shaped form is often adopted by a QoS satisfaction model, utilizing standardized utility features. Conversely, for non- real-time data, which demonstrate elasticity and tolerance to delay, an incremental function may be taken on by a QoS satisfaction model.

$Eq.$ (2) has the symbol ti that stands for the numerical values of sections under allocation to ith node and the variables which would be needing adjustments are $bj,\ cj,\ lj\ and\ smaximum$ represents variables for

$$P(t) = \begin{cases} d_i\left(\frac{1}{1+e^{\ldots}} - e_i\right), & in\ case\ of\ real\ times \\ \frac{log(l_i t_i + 1)}{log(l_i t_{max} + 1)}, & in\ case\ of\ Unreal\ times \end{cases} \quad Eq.(2)$$

adjustments, along with ci =

1+$ebjcj$

$ebjcj$

, di =

1 , $Q(\infty) equals\ to\ one$ and Q (0) equals zero.
1+$ebjcj\ j$

In Fig. 6, the Qualities of Services fulfilment in cases of traffics of voice that are not real-time and real-time like situational updates, is represented via beige and blueish columns on graph, respectively. Traffics that are realtime like information from voices, typically exhibits small chunk sizes, resulting in an immediate increase in satisfaction level upon the allocation of a single slot. Satisfaction is dependent on slot assignment. However, this level of satisfaction won't rise even with additional sections given towards traffics of voices. Consequently, levels of Qualities of Services is rendered binary, indicating in cases required qualities of calls for voice communication is met or not, thereby allowing for the establishment of voice calls. This characteristic shapes bluish curves of fulfilment over Fig.6. Conversely, a logarithmic function is depicted by the red line on the graph, depicting levels of Qualities of Services for tolerating delays along with traffics that are not realtime. It is assumed that data traffic has lenient delay requirements

IV. UnAV LOCALISATION OBJECTIVE

In the sections presented here localizing the Unmanned Flying Vehicles dilemma have been addressed, with a focus on group connectivity. The optimal positioning of the UAV depends over selected working metrics and indices. Over these studies, 2 distinct metric, namely connectivity among node and between one group with another group have been scrutinized. Connectivity of nodes represents the count of nodes capable of establishing a link with the UAV, implying attenuations in paths from unmanned flying vehicles to the nodes are below a specified threshold termed Lossmax. Connectivities between groups denotes numnerical values of group that connect straight away with Unmanned flying vehicles. A group is considered directly linked to the UAV if at least one node within the group establishes a direct connection with unmanned flying Vehicle.

In case of the causes of ensuring networking resilience, connections of one node with another node that are inside the same group is deemed significantly essential. Consequently, group connectivity is formulated by concurrently considering 2 parameters. Connectivity of Group contingent upon locations of Unmanned Flying Vehicles (yv, zv, kv) is established accordingly.

$$D_{gr}(y_v, z_v, k_v) = \sum_{j\in M} \beta_j J_j(y_v, z_v, k_v) + \sum_{k\in P} \gamma_k H_k(y_v, z_v, k_v) \qquad Eq.(3)$$

In which β_j and γ_k represent j^{th} node of the relevant priorities and values of the k^{th} group. $M = \{1,2,3, \dots, m\}$ and $P = \{1, 2, 3, \dots, p\}$ were used to index the node-sets and groups. In this section

$0 \le \beta_j \le 1$ *and* $0 \le \gamma_k \le 1$ where $J_j(y_v, z_v, k_v)$ and $H_k(y_v, z_v, k_v)$ represents function of indicators expressed as shown in the bottom :

$$J_j(y_v, z_v, k_v) = \begin{cases} 1, & \text{in case } P_{r_i} \text{ greater than or equal to } P_{th} \\ 0 & \text{in other cases} \end{cases}$$

$$H_k(y_v, z_v, k_v) = \begin{cases} 1, & \text{in case } P_{r_i} \text{ greater than or equal to } P_{th} \\ 0 & \text{in other cases} \end{cases}$$

In which P_{th} and P_{r_i} represent energy that have been got to the stations (j) in the ground from the UnAV mentioned in Equation-01 and the thresholds of energy that is necessary for ensuring links of communications.

P1: Groups optimizing of Connectivities

$$\underset{z}{maximize}\, \Gamma_{gr}(y_v, z_v, k_v)$$

such that,

$C-I: y_{minimum} \le y_v \le y_{maximum}$

$C-II: z_{minimum} \le z_v \le z_{maximum}$

$C-III: h_{minimum} \le h_v \le h_{maximum}$

$C-IV: J_j \in \{0,1\}, j \in M$

$C-V: Gr_j \in \{0,1\}, j \in P \qquad Eq.(4)$

V. PROBLEM OF INFORMATION SECTION ALLOCATING

In this section, a formulation for the allocating of information sections concerning the demands of sections received via node on the ground is presented by paper. The optimization of the satisfaction level of all nodes is aimed by the UAV scheduler, operating below principles related to welfares of society, incorporating concepts like reducing of utilities that are marginal as proposed in the law [41]. From this perspective, the satisfaction of each node, denoted as $V_j(t_j)$, is determined by the number of slots assigned to it.

$$V_j(t_j) = log\,(1 + R_j(t_j))^{x_j} \qquad Eq.5$$

$$x_j = \delta \cdot C'_{gr} \qquad Eq.6$$

P2: Allocating of Sections for Data

$$\underset{T}{maximize} \sum_{j\in M} V_j(t_j)$$

$$such\ that\ C-I: \sum_{j\in M} t_j \le T_t$$
$$C-II: t_{minimum_j} \le t_j \le s_j, \quad \forall j \in M, \qquad Eq.7$$

In which $t = [t_1, t_2, \dots, t_M]^T, T_t, t_{minimize_j}$ and s_j represent net section numbers , minimized numerical size of sections along with numerical values of sections that have been demanded.

VI. MECHNISMS OF LOCALIZING UnAVs

A solution is presented for determining optimized locations of Unmanned Flying Vehicles. The situational and single hops data which includes their current locations, are shared by each node to establish the network. The problem of selecting the UAV's candidate positions, with constraints represented as either 0 (inactive link) or 1 (active link), can be transformed into BILP or binary integer programming linearly. This may then be addressed utilizing the processes of bound-and-branch [42] along with the methodologies of interior points like in LP or Programming Linearly approach [43]. Subsequently, the lowest altitude, h, is selected from possible three dimensional locations available in case of Unmanned Flying Vehicles. This is aimed at improving energy efficiency by avoiding unnecessarily high altitudes for the UAV's positioning. Algorithms under proposition have been detailed over Algo-1.

In various studies examining commercial networks, the positioning of a UAV is typically chosen to maximize altitude, with the aim of expanding coverage over users dispersed around a base station. However, in a tactical MANET scenario, where combatants are served by the network following a planned strategy, the preference shifts towards lowering the altitude of the UAV, provided the network area is effectively covered. This strategy results in the enhancement of the survivability of the MANET. Additionally, potential exists for minimizing the energy consumption of the UAV with this approach, particularly when nodes are engaged in tactical maneuvers.

Algo-I: Mechanisms for localizing UnAVs Inputs: Location of every nodes, Qu Returns: Locations of the UnAV ($y*$, $z*$, $k*$)
While $Tclk = Int$.
Tg

Do
{

I. Perform the solution of $Lmaximum$ from locations representing nodes from UnAV utilizing frameworks of Rician, Losses due to Rains and TIREMs.
III. Evaluate Qs through solutions of $Eq.$ (1).
IV. Evaluate Cgr through solutions of $Eq.$ (3).
V. Get possible three dimensional locations through solutions of $Eq.$ 4 utilizing BILP by the utilizations of methodologies of bounds and branches.
VI. Discover optimized solutions for frameworks of Linear Programmings
VII. Following the reformulations of $Eq.$ 4 after location updatation $C-I$ and $C-I$ of points along with relaxations of $C-IV$ and $C-V$.

$C-I$: $yminimum \le yv \le ymaximum$
$C-II$: $zminimum \le zv \le zmaximum$
$C-III$: $hminimum \le hv \le hmaximum$
$C-IV$: $Jj \in \{0,1\}$, $j \in M$
$C-V$: $Grj \in \{0,1\}$, $j \in P$

VIII. Following this application of $Eq.$ 4 that has undergone reformulation via linear programming methodologies of Interior Points is performed.
IX. In branch point-I, UL (Upper Limit)= relaxation solutions, LL (Lower Limit)= rounded-down solutions
X. Consider S as variables in which biggest fractional parts towards branchings.
XI. Form 2 novel branching points for variables (in branching point-II) S = $zero$;
(in branching point-III) S = One;
XII. (In branching point-II) Find solution of $Eq.$ (4) that have undergone reformulation in which S = 0
utilizing Linear Programming frameworks
XIII. Application of $Eq.$ (4) that have undergone reformulation in which S = 0 as Linear Programming methodologies of Interior Points
XIV. (in branching point-II) (Upper Limit) or UL = relaxation solutions, (Lower Limit) or LL = rounded- down solutions
XV. Relaxation Solutions over Upper Limits in which S = 0 utilizing frameworks of Linear Programmings

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XVI. Application of $Eq.$ (4) in which $S = 1$ inside the methodologies of Linear Programming for Interior Points methodologies.
XVII. (In branch point-III) (Upper Limit) or UL = relaxation solutions, (Lower Limit) or LL = rounded- down solutions
XVIII. If
This procedure forms possible integers with biggest higher limits values
Then
Memorize (y', z', k) *as* possible positions
If every variables have undergone branching Then Send back every possible locations Else go back to Step-VIII
Else go back to Step-VIII
XIX. Take into account locations in which lowest h out of all possible 3 dimensional locations
}
Algo-II: Information Section Allocating Procedures
I. Submit section demand number, si towards the UnAVs
II. Reception of demanded section by every nodal points
III. Identify additions of the sections that have been demanded where the net sections $Tsections$.
IV. If $\Sigma j \in J\ tj \leq Tsection$ then
V. Take section allocation processing=demanded sections and Send Back s
VI. Else
VII. Evaluate optimized information section allocating procedure utilizing the procedures illustrated below:
VII.A Begin by ϵ *gretaer than Zero*, k *equals to zero* and put in maximum iterations
$Kmaximum$
VII.B Evaluate

$$L(\pi, t) = \sum_{j \in I} v_j log(1 + V_j(t_j)) - (\sum_{j \in I} t_j - T_t)\sigma_1 - \sum_{j \in I} (t_j - t_{minimum_j})\sigma_{j,2} - \sum_{j \in I}(t_j - r_j)\sigma_{j,3}, \forall j \in I$$

While $\max_t \frac{\partial L(\pi,t)}{d\pi} \geq \partial$
Do
If $k < K_{maximum}$ then
Calculate (9) , get s^k
Refresh pi^{1+k}; Fix $1 + k \rightarrow k$
OrElse
Send back s^k
And Send Back s
Clear memory for section assigning s_j in $node - j$ in case of every node.

VII. OUTPUTS AND DISCUSSION

The efficiency in proposed procedures is verified through number based results obtained using Riverbed Modeler 18.6 [49]. Furthermore, for visualization purposes, 3-Dimenstional tools like Unity along with Tools for Analyzing Monitor of Simulations [50] are employed for generations three-dimensional representation, which is linked to the Riverbed Modeler. To simulate tactical environments, 4-TIREM along with frameworks of Rician fading distributions are utilized in both mountainous and plain areas spanning 14 km by 14 km. System parameters adaptable based on the operational setting, are delineated in Table 3. In the radio system design, connections between nodes are established at which time the energy from the signals exceeds minimized obtained energy levels, set at -78 dBm as specified in Table 3. Additionally, it is assumed that up to 24 nodes can be allocated a slot within the same superframe. Furthermore, ad-hoc communication can be established between nodes within a 4-hop range, while points in 4 Kilometers while belonging to similar groups may connect via one another.

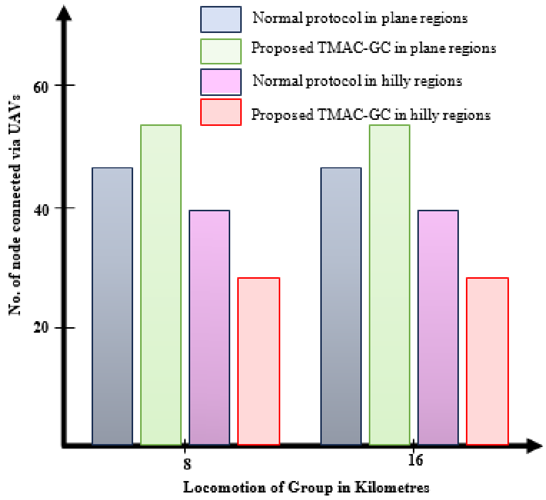

Fig.10(a) # node connected with UAVs

Fig.10.a presents comparing from a nornally practiced procedure with a procedure under proposition regarding the numerical values of node connected with Unmanned Flying Vehiclein form of group traverse both plain (light blue and blue bars) and mountainous areas (red and purple bars). As the group distance increases, the UAV position is adjusted by the conventional algorithm to maximize the number of connected nodes. Conversely, the proposed algorithm, while also enhancing group connectivity, yields a lower average number of nodes linked to the UAV (15.25 nodes on average) compared to the conventional algorithm (27 nodes on average).

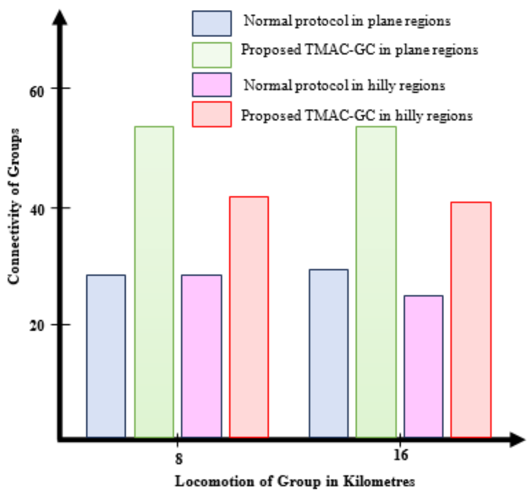

Fig.10(b) Connectivity of Groups

In Figure 10 (b), a comparison is presented between connectivity of groups achieved by the conventional algorithm and that achieved by the proposed algorithm as the groups traverse both plain and mountainous areas. Unlike the conventional algorithm, which prioritizes maximizing the total number of connections, the proposed algorithm positions the UAV to maximize inter-group connectivity. Consequently, under the proposed algorithm, group connectivity is higher compared to the conventional algorithm, contrary to the findings in Figure 10 (a). The average group connectivity achieved with the proposed algorithm is 26.525, whereas with the conventional algorithm, it stands at 17.7.

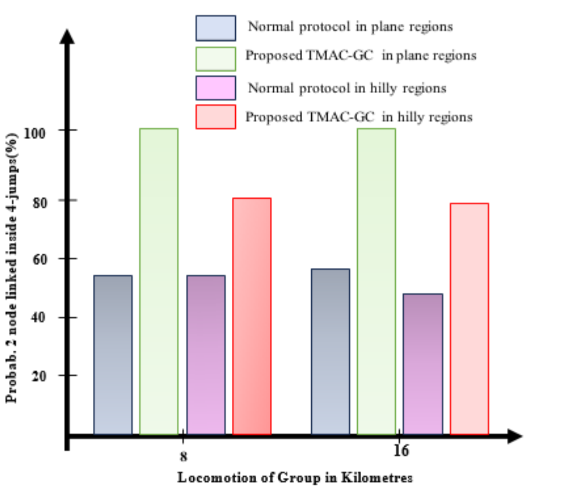

Fig.10(c) Probabilities of 2 nodes connected inside 4-jumps

Fig. 10 (c) illustrates comparing in likelihood in establishing a connection between 2 randomized taking of points under selection in 4-jumps. It is assumed if any 2 node inside this hop range may connect via networks that are ad-hoc. Under proposed algorithm, the probabilities stands at 88.78%, surpassing the conventional algorithm's probability of 58.33%. Fig.10 also displays connectivity of groups achieved by both the conventional and proposed algorithms like these groups traverse planes along with mountainous areas, based on movement time. Initially, all four graphs exhibit identical values, covering all nodes and groups within approximately 50 minutes. However, disparities emerge beyond 55 minutes, as the conventional method steers the UAV to increase the node count, leading to a decline in group connectivity. In comparison, TMAC-GC under proposition sustains comparatively large group connectivity. To demonstrate robustness, the UAV's location is updated every 5 minutes, ensuring it remains within the node range without sudden deviations. In 2nd case, depicted in Fig.10, involves 2 separated sets both adjusted with Unmanned Flying Vehicles. Node-1 in Set-1 sends 1 traffic of voice signals with 1 going out traffic that is not realtime towards Nodes-4 in Set-2 through Unmanned Flying Vehicles. Meanwhile, 2-Node and 3-Node in 1-Group exchange incoming traffics of voices and incoming traffics that are not realtime and of voices inside similar sets through Unmanned Flying Vehicles. Subsequently, net node count is incrementally increased from four to 20 points in case of every increasing adding 3 points towards 1-Group with 1-point in 2-Group.

VIII. CONCLUSIONS

In this paper, an investigation was conducted into problems of localizing of Unmanned flying Vehicles aimed at increasing Connectivity of Groups (GC), alongside problems of section-allocating of information aimed at increasing the utilities of GC. Following this, mechanisms for optimized localizing and allocating of sections were proposed, prioritizing traffics and group within MANET based on tactics. The procedures position the unmanned flying vehicles in raising the GC to maximum values in place of numerical values of nodes, while also assigning slots preferentially to traffic designated for other groups or carrying real-time voice data. Efficiency in the schemes under proposition for localizing of Unmanned Flying Vehicles with information section allocating procedures was verified through numerical analysis. As part of future work, GC-TMAC will be further validated across diverse topologies, and research will be conducted on optimal UAV placement in scenarios involving multiple UAVs, with a focus on maximizing survivability and connectivity. Additionally, efforts will be made to enhance communication performance through collaborative relays between UAVs.

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