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Resources Efficient Dynamic Clustering Algorithm for Flying Ad-Hoc Network

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Abstract
Unmanned Aerial Vehicles, often known as UAVs, are connected in the form of a Flying Ad-hoc Network, or FANET, and placed to use in a variety of applications to carry out efficient remote monitoring. Their great mobility has an adverse effect on their energy consumption, which in turn has a detrimental effect on the network's stability and the effectiveness of communication. To manage the very dynamic flying behavior of UAVs and to keep the network stable, novel clustering algorithms have been implemented. In this context, a novel clustering technique is developed to meet the rapid mobility of UAVs and to offer safe inter-UAV distance, reliable communication, and an extended network lifespan. It also provides a detailed analysis of the similarities and distinctions between AODV, AOMDV, DSDV, and DumbAgent.The performance of these protocols is analyzed using the NS-2 simulator. The simulation results are shown in our study with AODV, AOMDV, DSDV, and DumbAgent. The results of the simulation make it abundantly evident that the AODV routing protocol outperforms the other routing protocols DSDV, AOMDV, and DumbAgent in terms of the number of packets lost, the amount of throughput achieved, the amount of routing overhead generated, and the amount of delay.

Keywords: Unmanned aerial vehicle (UAV), clustering algorithm, energy consumption, stability, mobility, Flying Ad-hoc network (FANET), AODV, AOMDV.

1. Introduction

In the last ten years, there has been a growing trend in Wireless Sensors Networks (WSN). This can be attributed to the major necessity and usefulness of Flying Ad-hoc networks (FANETs) in a variety of sectors, including political and industrial applications, such as defense and politics. The core components of a WSN are a collection of micro-sensor nodes that are planted at random in a certain area and a minimum of one sink or Base Station (BS). Depending on the needs of the system and how it is deployed, there are micro-sensor nodes that evaluate various qualities in addition to those already mentioned, such as temperature and smog, the physical surroundings, heat output, and a great lot more. Once the nodes have acquired the data, they will transmit it to the BS, where the user will get it through a user a great [1]. Sensor nodes are common components of a wireless sensor network (WSN), and their batteries are often not removable and non-rechargeable. The gathering, processing, and sending of packets each take up a significant portion of the total amount of energy that is needed. The most significant drawback of a WSN is its restricted capacity for energy consumption. Additionally, one of the restrictions that affect and decreases the amount of energy that sensor nodes use is data replication. This limitation is responsible for this reduction [2]. A process known as the routing protocol allows for the transmission of data from its source to its final destination. Its goals are to achieve scalability in the network, a high data transmission rate, and efficient use of energy resources. Several routing techniques have emerged in recent years to reduce the energy consumption of WSNs and hence increase the network's lifetime. FANETs are a kind of Ad-hoc network setup that can be implemented using UAVs.

As part of a “UAV-to-ground (U2G) communications system”, UAVs take photographs, compile additional data depending on the information gleaned from their sensors, and send this information to a base station (BS) [3]. In contrast to the conventional cable infrastructure that is used in general topology, FANETS need the resolution of much more difficult problems:

1. The method that most effectively monitors areas while keeping costs low and maximizing the use of available resources in the network.

2. Reduce the detrimental impacts that are brought on as a result of the high mobility of UAVs.

3. Traditional routing techniques are unable to operate flying networks effectively due to high node mobility and constant topology changes.

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After the energy consumption of UAVs, the range and mobility of UAVs are recognized to be the second most important problem, and they are also anticipated to be the key influences on UAV network architectures [4].Furthermore, FANETS are capable of free-ranging movement in three dimensions. Due to the drones' capacity to operate in 3D, the topology might be extended from 2D to 3D with a free movement scheme, as illustrated in figure 1 [5].

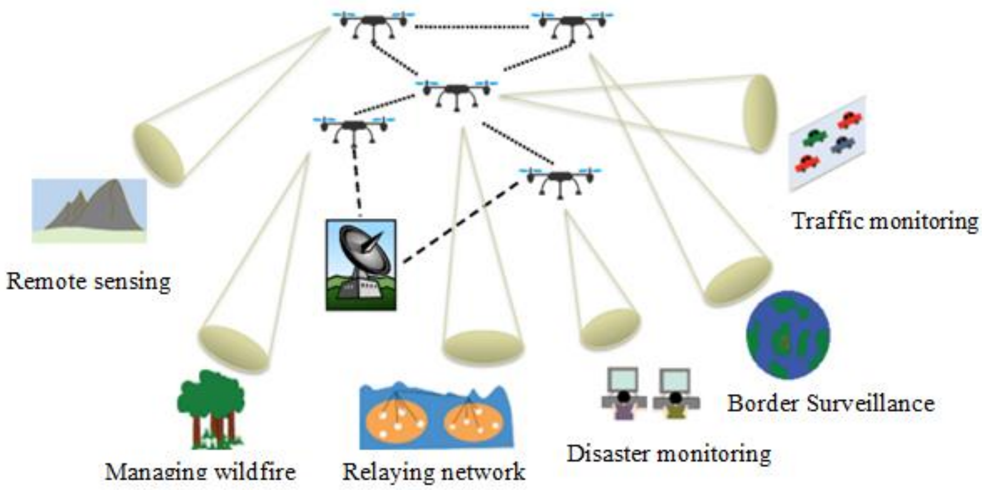

Figure 1.The architecture of FANETs.

In these types of situations, a cluster-based approach could be able to permit the creation of large-scale FANETs while simultaneously reducing power consumption and the amount of overhead required for communication; however, this can only be possible if the approach can adapt to the mobility patterns of UAVs and distribute traffic fairly among suitable Cluster Heads (CH) [6]. Several cluster-based solutions, including the selection of CHs as the primary method for ensuring effective cluster management, have been presented [7].

1.1 Various routing protocols for FANETs

Due to the exceptionally dynamic nature of UAVs in FANETs, the topology of the network is subject to frequent changes. The routing protocols play a crucial part in ensuring the integrity of data transfer from beginning to end, and the potential for reduced routing overhead makes routing an intriguing area of study for researchers interested in FANETs when talking about UAV-to-UAV communication [8].However, the major difficulty is still being investigated: how to create routing protocols that work in every situation.

UAVs have unique characteristics that make network routing a critical issue; for example, the connection quality may vary quickly and the UAVs can move quickly in three-dimensional space.

1.1.1 Static Routing protocols

Each UAV equipped with a static routing protocol maintains a static routing table for the duration of the flight. The use of static routing protocols is appropriate in circumstances in which the topology of the network does not undergo any changes and in which the available alternatives for route selection are constrained. In this scenario, each UAV can interact with the ground station and only keeps the information that they receive. The number of communication connections has decreased. However, if the attempt to update the routing table fails, it is necessary to wait until the mission is finished before continuing.

1.1.2 Proactive Routing Protocols (PRB)

This routing system has the benefit of having routes that are readily available whenever they are required because of the proactive nature of the protocol. Proactive routing techniques are not particularly helpful for UAV networks because of their high level of mobility and high level of dynamic activity. Second, these routing protocols have a sluggish response time to failure, which may be an issue in situations when the network topology changes or a connection fails. This category encompasses a wide variety of routing protocols, each of which has its specific function [9].

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1.1.3 Reactive Routing Protocols (RRP)

The RRP is a kind of on-demand routing protocol that may be used to locate or maintain a route. The Route Request message is sent from the source UAV to all of the UAVs in the nearby area using the flooding mechanism because the method is the same for each UAV up until it reaches the UAV that will serve as its ultimate destination. The Route Reply message is sent in a unicast fashion from the destination UAV back to the sending UAV. A full network table refresh is not required to implement this routing strategy [9].

1.1.4 Hybrid Routing Protocols (HRB)

The HRB combines the finest parts of proactive and reactive routing protocols to create a system that is more efficient and robust. Human growth hormones may help with these problems. Hybrid protocols are designed with big networks in mind; they use zone principles to do intra-zone routing with proactive methods and inner-zone routing with reactive methods [10].

1.1.5 Hierarchical Routing Protocols

The capacity to switch between proactive and reactive routing in hierarchical routing protocols is conditional on the UAV's position in the network's hierarchy. Proactively designed routes provide the backbone of this system, with lower-level support provided by reactive protocols in response to requests from nodes that have been activated. The primary disadvantages of this protocol are its difficulty and the addressing system that responds to traffic requests but ultimately drapes the linking components [11].

1.1.6 Ad Hoc On-Demand Multipath Distance Vector (AOMDV)

A multipath routing protocol called AOMDV [8] is used for mobile ad hoc networks. AOMDV is a routing protocol that extends AODV and gives recipients LOOP flexibility and disjointness of other paths.

AOMDV is built on the idea of a distance vector and shares many traits with AODV. The primary distinction between AOMDV and AODV is that numerous reverse paths are established at both the intermediate node and the destination node during the propagation of route requests (RREQ) from the source to the destination. Route maintenance and route discovery stages make up the AOMDV routing protocol. Similar to AODV, when a source needs to reach a destination node, it floods the network with RREQ to start the route discovery process.

2. Review of literature

Zhao et al., (2022) [12] stated that WSNs have a network lifespan that is a significant consideration for the related applications due to their limited energy supply. Though, the Hot Spot Problem and the inevitable loss in network lifespan are always the results of the overall network's unequal energy consumption. This research examines energy-efficient cluster head rotation and energy-balanced uneven clustering as potential solutions. A new Energy-Balanced unequal Clustering Approach (EBCA) method is presented and explained in detail for circular WSN. In comparison to both traditional and state-of-the-art clustering algorithms, EBCA's experimental findings show that it can more effectively balance the energy consumption of cluster heads across gradients, minimize energy consumption, and increase network lifespan.

Tadkal et al., (2022)[13] studied an unexplored aspect of network design is the use of a vertical routing system based on a Deep Q-network (DQN) to choose paths with greater residual energy levels and lower mobility rates. The primary goal of this study is to enhance network performance in the face of difficulties such as frequent link disconnection and network partitioning. The suggested technique is a hybrid solution that facilitates communication between Centralised controllers (CC) and Decentralised controllers (DCs) while simultaneously allowing both to deal with global and local data. The proposed technique facilitates data transfer between UAVs, making it ideal for highly dynamic ad hoc FANETs with a wide range of conceivable applications such as border and target surveillance and monitoring (e.g., object tracking). A vertically routed network is constructed into clusters spanning many network layers to accomplish inter-plane and inter-cluster communications. Data traffic must be distributed over many network layers, which extends the lifespan of the underlying infrastructure. Network lifespan must be increased by up to 60% using the suggested DQN-based vertical routing system, while energy consumption can be reduced by up to 20% and the rate of link failures can be reduced by up to 50% when compared to the conventional reinforcement learning strategy.

Bharany et al., (2021) [14] studied that FANETs is made up of several sensor nodes, each of which is powered by a very small battery and as a result has extremely sluggish processing speeds and only a limited amount of storage space. The sensor node's principal function is to gather data, which it then sends to the Base station (BS). Since sensor nodes are inherently resource-constrained, the network lifespan is the most crucial factor in determining a FANETs network's efficacy. The Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol is based on an energy-efficient

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clustering method for data gathering and transmission. The new optimal threshold function provides the foundation for choosing CH. LEACH is a hierarchical routing system that chooses cluster head nodes at random in a loop, which increases the cluster's total number of nodes but also significantly accelerates its power consumption. It has needed to enhance the LEACH Protocol to get around these restrictions. As a result, the suggested technique reduces the routing protocol's energy consumption for data transmission while simultaneously increasing the network's lifespan by making optimal use of nodes' remaining energy.

The experimental results obtained in Matrix Laboratory (MATLAB) demonstrate that the new protocol outperforms the existing LEACH in terms of energy efficiency per unit node and the PDR with lower energy usage.

Da costa et al., (2021)[15] studied that FANETs is an implementation of ad-hoc networking that is used in the context of flying nodes. This implementation enables flying nodes and ground control stations to communicate in realtime with one another. The structure of a FANET is dynamic and is subject to significant and frequent change because of the nature of this kind of node. It is necessary to have a network that is flexible, dependable, and mission-critical, with strong and efficient routing protocols since it has applications in military situations as well as other mission-critical systems. There is still a significant obstacle to overcome to keep an acceptable network latency created by the selection of routes; this is because the nodes have a high degree of mobility. To combat this issue, this research proposes a new routing technique called Q-FANET, which is based on an improved version of the Q-Learning algorithm and seeks to reduce network latency when users are highly mobile.The performance of this approach is analyzed and compared to other techniques that are considered to be state-of-the-art utilizing the Wireless network simulator (WSNET). The results demonstrate that the Q-FANET exhibits decreased latency compared to existing reinforcement learning-based routing protocols, as well as a slight rise in the PDR and a much lower jitter.

Sang et al., (2020)[16] intended that FANETs are a novel sort of self-organizing network in the air, and due to their time-varying network topology and dynamic connection, it might be challenging to keep in constant contact while carrying out duties. As a result, developing a routing system for FANETs that can ensure high-quality data transfer and improve the efficacy of communication is a significant challenge.It developed a metric to quantify the node's trajectory properties to prevent using too many edge nodes. The limited power reserves and storage capacity of UAVs need a data forwarding approach that minimizes energy consumption, which is considered while selecting relay nodes. Simulation results suggest that it may reduce delays by up to 80% and increase delivery rates by up to 40%, compared to the best available procedures.

Cheriguene et al., (2020)[17]analyzed that there has been a rise in interest from both academics and practitioners in the field of cooperative UAV applications for the deployment of distributed task execution. Using a fleet of UAVs, rather than just one, may improve service quality and reliability, as well as increase the area that can be covered by a mission. However, it presents additional hurdles to conventional inter-UAV communication protocols owing to the extremely dynamic nature of the swarm topology to coordinate such a huge number of UAVs. Therefore, new networking protocols must be developed to efficiently serve the fast and real-time requirements of coordinated swarm movement in a variety of contexts. UAVs that can form swarms may now take use of a Swarm energy-efficient multicast routing protocol (SMERP) technology. To minimize inter-UAV packet loss, re-transmission, and end-to-end delay, SEMRP was developed to improve control and information transfer between UAVs. To meet these goals, this research describes how SEMRP strikes a good balance between severalQoS parameters, such as network throughput, UAV mobility, and energy efficiency, to guarantee that all members of a UAV swarm get information in a timely and correct manner. The NS-2 simulations verify the gains of the concept and the two versions are given, which "decrease the total emission energy, improve the End-to-End Delay, and increase the PDR (by at least 22%)" in contrast to the SP-GMRF protocol.

Mowla et al., (2019) [18] examined that the UAV clients in FANET are susceptible to assaults, such as the jamming attack. In a jamming assault, the aerial opponents cause communication disruption on the victim network by creating interference for the receivers. Due to its fundamental distinctions from traditional ad hoc networks, detecting jamming attacks in FANET presents novel problems. The emergence of federated learning as a viable option for FANET is largely attributable to the fact that it provides efficient communication and accounts for imbalances in data. Using the suggested prioritizing approach, the aggregator node may determine which client groups would provide the most accurate global update. The suggested method is more accurate than the traditional distributed solution (82.01% for the CRAWDAD dataset and 89.73% for the ns-3 simulated FANET dataset respectively). In addition, the Dempster-Shafer-based client group prioritizing approach is used to ascertain the client groups

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that should be prioritized for the most efficient use of federated averaging.

Yang et al., (2019)[19] intended that FANETs have been getting an increasing amount of interest from the business world because of the widespread deployment of MANETs. The technology that handles routing is an essential component of ad hoc networks. The FANET routing technique is presented with an even bigger problem of the high-speed mobility of the nodes. To accommodate the fast-paced motion of the FANET"node, the continuous Hopfield neural network is used to enhance the route based on the "Dynamic Source Routing (DSR) protocol. The results of a simulation carried out utilizing NS3 reveal that the enhanced DSR protocol has resulted in significant improvements across a variety of important metrics, including the end-to-end average latency, the throughput, and the PDR.

Zheng et al., (2018)[20] intended that the FANET is a novel approach to wireless communication that not only facilitates communication between UAVs but also controls their autonomous flight. A FANET can provide many UAV systems with an efficient means of real-time communication that may be used simultaneously by treating each flying UAV as a router. Traditional mobile ad hoc protocols fall short of what is required in FANETs because of the high mobility and frequent topology change inherent to these networks. The conventional in-flight built-in regulatory rules are insufficient to fulfill the demands of autonomy due to the growing complexity of the flight environment and the scope of flying duties. The results of the performance analysis demonstrate that the employment of directional antennas in the proposed PPMAC effectively addresses the problem of directional sensitivity and that the RLSRP provides a dynamically adaptive and more effective routing system. The created hybrid adaptive communication protocols could serve as an independent and intelligent method of communication for FANETs.

Laroiya et al., (2017)[21] observed that the use of wireless devices is one of the defining characteristics of the technological revolution, which has also permeated the realm of transportation thanks to the development of the VANET. VANET is a beneficial solution that enables the achievement of higher performance and ensures the safety of the transportation system in the future. VANETs use moving automobiles as mobile nodes to connect and communicate with one another as well as with base stations located along roadways to form a network. An increase in the usage of VANET encourages the development of several applications, some of which include electronic toll collection, road topology, and emergency information, amongst many more. The growth and development of VANET would give rise to a plethora of applications such as real-time traffic, electronic toll collection, and the general conditions of the surrounding roads. To guarantee real-time communication between nodes, the authors of this study have developed a mechanism called R-optimal routes.

Any node that wishes to construct a route to its destination must choose that way via the root node. The probability of a connection failing in the network is reduced as a result of this. It has been determined that the suggested method is superior in terms of latency, throughput, PDR, and power consumption. The algorithm has been built in NS-2, and it has been established that the offered method stands out.

2.1 Comparison of reviewed techniques

The following study expands on the previous Resources efficient dynamic clustering algorithm for flying ad-hoc networks; several researchers explain their findings as seen in table 1 below.

Table1. Summary of reviewed techniques.

Authors[Ref.]	Techniques	Outcome
Zhao et al., (2022)[12]	EBCA	In comparison to both traditional and state-of-the-art clustering algorithms, EBCA's experimental findings show that it can more effectively balance the energy consumption of cluster heads across gradients, minimize energy consumption, and increase network lifespan.
Tadkal et al., (2022) [13]	DQN	The DQN-based vertical routing system can decrease link failures by 50%, energy consumption by 20%, and network lifetime by 60% compared to the reinforcement learning technique.
Bharany et al., (2021) [14]	LEACH	The experimental results obtained in Matrix Laboratory (MATLAB) demonstrate that the new protocol outperforms the existing LEACH in terms of energy efficacy per unit node and the PDR with lower energy usage.
Da costa et al.,	Q-FANETs	The results demonstrate that the Q-FANET exhibits decreased latency compared to existing reinforcement learning-based routing protocols, as well as a slight rise in the

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(2021) [15]		packet delivery ratio and a much lower jitter.
Sang et al., (2020) [16]	FANETs	In simulations, it improves delivery rates by 40% and delays by 80% compared to the best methods.
Cheriguene et al., (2020) [17]	SMERP	The simulations performed in NS-2 support the usefulness of the proposal and its two presented variants by decreasing the total emission energy, enhancing the Delay and raising the PDR (by at least 22%) in comparison to the SP-GMRF protocol.
Mowla et al., (2019) [18]	FANETs routing protocol	The suggested method is more accurate than the traditional distributed solution.
Yang et al., (2019) [19]	FANETs routing protocol	The results of a simulation carried out using NS3 reveal that the enhanced DSR protocol has resulted in significant improvements across a variety of important metrics, including the end-to-end average latency, the PDR, and throughput.
Zheng et al., (2018) [20]	FANETs routing protocol	The results of the performance analysis demonstrate that the employment of directional antennas in the proposed PPMAC effectively addresses the problem of directional sensitivity and that the RLSRP provides a dynamically adaptive and more effective routing system.
Laroiya et al., (2017) [21]	Routing protocol	It has been determined that the suggested method is superior in terms of throughput, latency, power consumption, and PDR.

3. Problem formulation

The FANET can quicken or slow down its speed between sensors. The implementation of traditional closest-point-of-approach (CPA)-based trackers are made more complex as a result of both of these factors. Existing clustering algorithms are inefficient because they select and group data items based on precise matching criteria. This results in a high number of false positives. To do dynamic clustering effectively, a novel strategy that makes use of metaheuristic algorithms is necessary. It is required to construct and put into operation a dynamic algorithmic method that can cluster and display data items. This would ensure that data items from a variety of areas are grouped without any type of bias. In addition, it's possible that numerous sensors could make observations while simultaneously time, which could overwhelm the network with information.

4. Research Methodology

Most existing clustering techniques for FANETs use a straightforward equation of neighborhood-based only on the value of the transmission range to determine whether or not two nodes are neighbors. In general, this assumption is true for MANET, Ad-Hoc, and VANET networks but most of the time; this assumption doesn't work for UAVs because the neighborhood only exists when there is enough space between UAVs to keep them safe. This distance does not take into consideration the safety degree that is required between nodes to reduce the likelihood of collisions and make the network more stable. In this methodology, To achieve optimal and energy-efficient routing in FANETs, the proposed method Ad-hoc on-demand vector (AODV) is used and compared with the other methods.

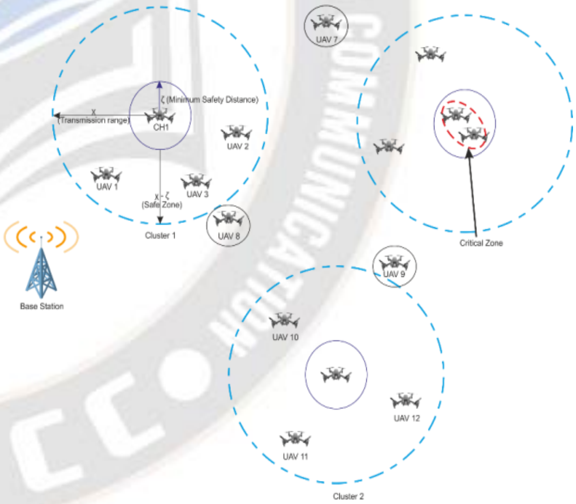

Figure 3 Suggested safe and stable FANET clustering.

4.1 Technique

- **Clustering method**

The cluster method, also known as clustering is the multivariate descriptive approach of data analysis and data mining that is used the most frequently[22]. It has several applications, including the social sciences, natural sciences, business, and marketing. The primary goal of the clustering method is to optimize the degree to which each cluster is similar to its neighbors and to which they are dissimilar

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from one another in terms of a set of predefined criteria[23]. Clusters can be formed using a variety of dissimilarity metrics, including density in a Euclidean or non-Euclidean data space,edit distance, a distance estimated using Minkowski measures, proximity measures, and probability distributions.

The UAV network can be considered as an undirected graph G. So G = (V, E) with E as a set of links of graph G and V as a set of UAV nodes. ζ is the transmission range between two nodes. Edges E between two nodes is defined as a neighbor when their distance is less than χ . Therefore any pair of nodes (u,v) $\in$ V,

$$\text{When dist}(u, v) \leq \chi \text{ then } \{u,v\} \in E \quad (1)$$

In the described UAV system, each node transmits HEY packets to its neighbors to notify them about its velocity, ID, location, and direction, to ease and make clearer inter-UAV communication. Table 2 depicts the HEY packet's structure as seen below.

Table 2 HEY packet's structure.

State	ID	Cluster-ID	Velocity	Position	α_i	ω_i	Direction
1	2	3	4	5	6	7	8

The HEY message contains information on the current state of the UAV, ID , its CID_i (cluster ID), its velocity υ_i , its location (x_i, y_i coordinates), its CH selection index α_i , its behavior ω_i , and its direction of flight. In the cluster, the status of the UAV indicates whether it is a CH or CM. CID_i stands for Cluster ID. When it comes to mobility, the UAV's velocity and location are key indicators to look at. Each UAV participating in the CH election keeps track of the selection index α_i . The parameter ω_i indicates and out the behavior of UAVs in a network. Setting this value to 1 shows that the UAV intends on leaving this system, which is why 0 is set if the UAV doesn't want to leave.

According to the existing research, two nodes are deliberated to be two χ -neighbors if the distance between them is either less than or equal to the transmission range χ of the network. The total number of χ neighbors of a node i is described as its nodal degree (nd_i) or the cardinality of the set N_i (number of neighboring UAVs). Equation (2) depicts the nodal degree nd_i .

$$nd_i = |N_i| \quad (2)$$

As for safety, it's usually a primary concern to avoid collision in the network. The equation (3) for the inter-distance between every pair of nodes has to be satisfied.

$$dis_{i,j} > \zeta \quad (3)$$

Where ζ = minimum safety distance between two UAVs.

The UAVs must be present in the transmission range, but they must also be within a safe zone for the neighborhood of nodes to function properly. To get to equation (4), equations (1) and (3) must be combined.

$$\zeta < dis_{i,j} \leq \chi \quad (4)$$

The contribution of this work is to select CH positioned at a safe distance from its neighbors. The proposed safe distance between UAV_i and UAV_j is presented in equation (5).

$$safed_{i,j} = \begin{cases} dis_{i,j}, & \text{if } dis_{i,j} \leq \chi \text{ and } dis_{i,j} > \zeta \\ \chi + \zeta & \text{otherwise} \end{cases} \quad (5)$$

Equation (5) penalizes the un-respectful UAV_j by setting its distance from the UAV_i to $\chi + \zeta$ such that it is effectively isolated from the rest of the UAV_i .

The equation (6) that represents the suggested "average absolute distance η_i between UAVs" that is directly linked to UAVi must be found in the preceding paragraph.

$$\eta_i = \frac{1}{nd_i - 1} \sum_{j=1}^{nd_i - 1} safed_{i,j} \quad (6)$$

The smaller the value η_i , the closer the node is to the center of its neighbors. The authors suggested a fitness function for optimum CH selection, which reduces network energy consumption and extends cluster lifespan, therefore improving the clustering process [24].

It has also stipulated that the number of CMs must be uniform across all clusters. Because of the dynamic nature of UAVs, which causes them to continually and arbitrarily change their locations and thus update their collection of neighbors, it is impossible to satisfy this restriction. Every UAV identifies the list of its transmission-neighboring nodes through the clustering procedure. Therefore, it

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computes its fitness value and communicates it to its neighbors. The proposed fitness function used in this study appears in equation (7).

$$\alpha_i = \frac{1}{\mu_1 \gamma_i} * \frac{\mu_2 \varphi_{R,i}}{\mu_3 \sigma_i} \quad (7)$$

Here, $\mu_1, \mu_2 \; and \; \mu_3$ are the weighting factors for the utilized factors, such as $\mu_1 + \mu_2 + \mu_3 = 1$. The CH is going to be the one with the lowest fitness function. The values γ_i, ϕ_R and σ_i for each $UAVs$ and UAV_i within its broadcast range are calculated. The computation of value γ_i, ϕ_R and σ_i is given in [25][26] respectively. The proposed cluster head selection algorithm with improved parameters discussed above is described in Algorithm 1. Each UAV node starts in the initial Free Node state (the system has not yet built a cluster), and then it programs a HEY message to all of its neighbors specifying its location, direction, and velocity.

Algorithm for the proposed cluster,

Input: let N – 1 be the number of UAVs in the network
Output: Cluster Head of Network
Algorithm 1: CH Selection
Start:

For 0 $\rightarrow$(N-1) // For every UAV_k in the network.

For 0 $\rightarrow$(N-2) // find the neighbors of UAV_k where (i $\neq$ k)

If $dis_{k,i} \leq \chi \; and \; dis_{k,i} > \zeta$:

neighbor[UAV_k] $\leftarrow UAV_i$

For 1 $\rightarrow (nd_i - 1)$ //fitness function computation for each $UAV_i \in neighbor[UAV_k]$

$\alpha_i = \frac{1}{\mu_1 \gamma_i} * \frac{\mu_2 \varphi_{R,i}}{\mu_3 \sigma_i}$ // computation of value σ_i, γ_i and ϕ_R in [11], [30], and [31] respectively

$\Psi_k \leftarrow \alpha_i, UAV_i$ // list of all selection indexes α .

Sort ψ in increasing order

The UAV whose one-hop neighbors have the least α_i becomes the CH.

The CH extends an invitation to its immediate neighbors, who thereafter become its CMs.

All of the cluster head's neighbors will no longer be permitted to vote and will be eliminated from the set of possible UAVs.

End.

- **Ad-hoc on Demand Vector (AODV)**

For the FANET network, the AODV routing protocol was designed. It employs a reactive strategy for route discovery and a proactive strategy to determine the way to its target. The primary benefits of utilizing this protocol include the fact that it provides high mobility rates in addition to a variety of data traffic levels, has a low consumption of battery power, improves scalability reduces the overhead on data traffic and performance and presents a low battery consumption.

The following is an overview of the control messages that AODV uses for maintaining routes:

A. **Route Request (RREQ):** A node sending an RREQ message requires the other node's assistance in choosing the best route. This request packet includes a broadcast identifier, the source IP address, the destination sequence number, the destination IP address, the source sequence number, and the maximum number of hops.

B. **Route Reply (RREP):**It is the RREP message's function to respond to an RREQ message. Since the migration message sent by the original sender is cached, RREP messages are only broadcast to the original sender. When responding, the same method is used.

C. **Route Error (RERR):** RERR signals are sent to other nodes to inform them of the termination of a link, which results in a crack in any active route.

Algorithm of the proposed method

Input: Forwarding Node F, Destination D, *Neighbour-List* (F)

Auxiliary Variables:*Progress (F, 1)* where I ∈*Neighbour-List* (F)
Maximum-Progress

Output: *Next-Hop-Node*//if Greedy forwarding is successful perimeter forwarding is needed

Initialization:*Next-Hop-Node* = NULL
Maximum-Progress←0.0

Begin GPSR *Greedy forwarding Algorithm*

$Distance_{F-D} = \sqrt{(X_F - X_D)^2 + (Y_F - Y_D)^2}$

for every neighbor node I ∈*Neighbour-List* (F) **do**

$Distance_{I-D} = \sqrt{(X_I - X_D)^2 + (Y_I - Y_D)^2}$

if($Distance_{I.D} < Distance_{F.D}$) **then**

$$Progress\ (F, I) = \frac{Distance_{F-D} - Distance_{I-D}}{Distance_{F-D}}$$

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if(*Maximum-Progress< Progress (F, 1))**then***
Maximum-Progress = Progress (F, I)
Next-Hop-Node←I
end if
end if
end for
if** (Maximum-Progress>0.0)**then
***return** Next-Hop-Node// Greedy forwarding is successful*
else
***return** NULL // Greedy forwarding is not successful and //perimeter forwarding is needed*
end if
***End** GPSR Greedy forwarding Algorithm*

The structure of the methodology is shown in the figure 4below. The following described proposed methodology which as described given below.

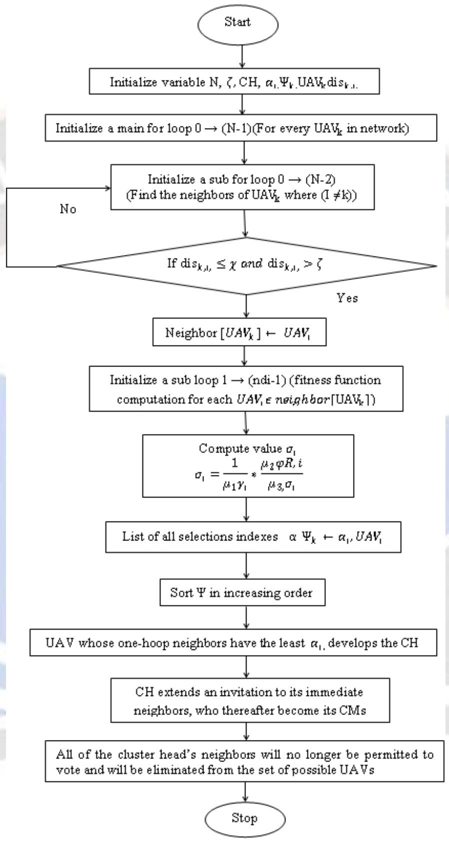

Figure4. A proposed framework

- **Simulation platform**

The NS-2 simulator is used in the process of assessing and analyzing the performance of AODV. The application-layer simulator is known as NS-2. The NS-2 front-end is an OTcl interpreter, whereas the backend is composed of C++ libraries. NS-2 is capable of simulating both wired and wireless networks, as well as a wide variety of communication protocols, including UDP, TCP, and multicast routing, amongst others.Table 3 depictsthe simulation parameter which has been described given below.

Table3. Simulation parameter

SimulationParameters	Values
Simulator&Version	Ns-2(Version)
ChannelType	Wireless
Protocol	AODV,DSDV,Dumb Agent,AOMDV
SimulationTime	200 (s)
No. of flows in time (sec)	50, 100, 150, 200, 250, 300
Constant bit rate	100kb

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5. Results and discussion

The findings are obtained by first varying the number of nodes while holding the node speed constant (50 ms) and then varying the node speed while keeping the number of nodes constant (40nodes).The deviation involved changing the routing protocol from AODV toDSDV, Dumb Agentand AOMDV, respectively. To determine the outcome, the number of nodes for each comparison was likewise changed from 50 to 100 to 150 to 200 to 250 to 300. Performance metrics such as Packet Delivery Ratio, Routing Overhead, End to End Delay, and Throughput were used to compare all situations. In our research on and comparison of FANET routing protocols, four evaluation factors were used.

- **Routing overhead**

The number of routing packets that are sent both for route discovery and for route maintenance. The sending of additional control packets to ensure the successful delivery of data packets is a primary cause of routing overhead.

- **Packet Loss**

The term "packet loss" refers to data packets that are sent through a network but do not make it to their target destination after being sent. This happens when routers at the network layer drop packets because their storage capacity is insufficient or the packets' transit time exceeds the buffer's maximum time limit.

- **Throughput (Thp)**

The computation for the average throughput includes taking the total number of bits that have arrived at the destination node over the time of one second and averaging these bits' overall numbers. This is used as a measurement of the dependability of the protocol under diverse situations; as a result, the network's average throughput has to be as high as it possibly may be. It is possible to characterize it using mathematical expressions as,

$$Average\ thp = \frac{N_p * packetsize * 8}{Seconds}$$

Where N_p is the number of bits received successfully by all destinations.

- **Delay**

The average amount of time it takes to travel from the source to each of the destinations. This time takes into account any possible delays, such as those caused by buffering in route discovery latency, re-transmission delays MAC, due to the interface queue, and propagation.

Figure 5 depicts that altering the network's data rate over time affects its performance in terms of the routing overhead that is generated. The amount of time between each created packet is determined as the number of packets being produced is progressively raised. When compared to other existing techniques, AODV's routing overhead is generally constant, and it is connected to the delay. Other methods do not have this feature. When there is a continuous increase in the amount of data being produced, there is a significant rise in the performance of the network.

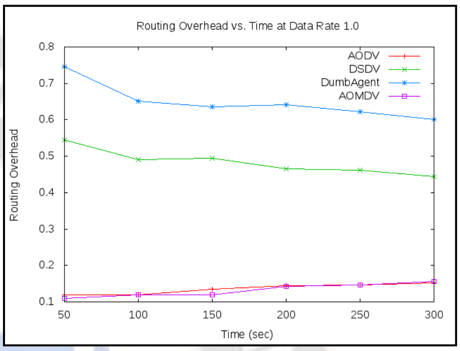

Figure5: Normalized routing overhead vs speed andseveral flows.

Figure 6 depicts the packet drop rate for the entire simulation time. The packet loss varies with time at the data rate as shown in figure 6. This figure clearly shows how the packet loss varies. Figure 6 displays the results of a comparison of the ratio of packet loss provided by various protocols. These findings demonstrate that AODV is capable of providing lower packet loss than other protocols. According to the figure, DumbAgent methods have a high rate of packet loss, but DSDV gets a low rate of packet loss in comparison to DumbAgent. When compared to DSDV and the DumbAgent technique, AOMDV protocols have much less packet loss.

The suggested technique (AODV) has the lowest rate of packet loss in comparison to all of the other techniques, as can be seen in the figure below, which depicts the proportion of packet loss vs. time at the data rate.

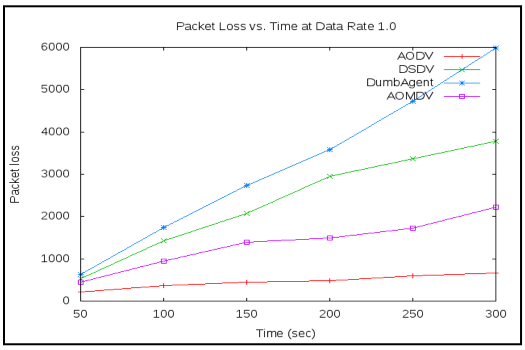

Figure 6: Packet Loss vsTime and several flows.

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Figure 7 illustrates the end-to-end delay which varies with time at the data rate. It does so by analyzing the effects that the various algorithms have on delay when the time variable is changed. The simulation figure shows clearly that the approach that has been proposed has the potential to significantly reduce the delay. The DumbAgent method has not significantly decreased the delay, the DSDV method has more or less decreased the delay in comparison to the DumbAgent method, and the AOMDV method has reduced the delay in comparison to both the DumbAgent method and the DSDV method. However, the proposed method has decreased the delay in comparison to other existing methods, as will be demonstrated in the given figure 7.

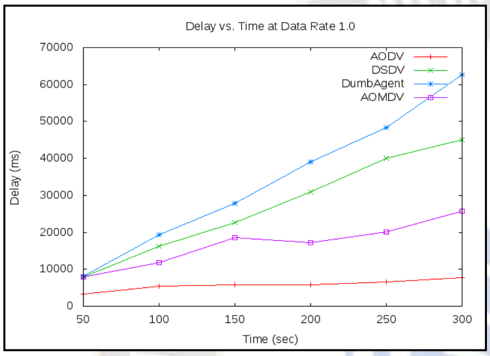

Figure7: End to End delay vsTime and several flows.

In figure 8, the findings are described in terms of the throughput and the way it varies with time at the data rate. It has been found that as the data rate is increased, throughput also increases because more data packets are delivered to the network. Throughput begins to decline because the load on the network strains wireless connections when the data rate gets up to 100 kbps. It is evident that DumbAgent has raised the throughput, but DSDV has increased the throughput even more when compared to the DumbAgent technique. On the other hand, the AOMDV approach has a high throughput when compared to both the DSDV method and the DumbAgent method. In conclusion, the throughput of the proposed technique is much higher than that of existing methods, as can be seen in Figure 8, which depicts throughput about the amount of time at the data rate.

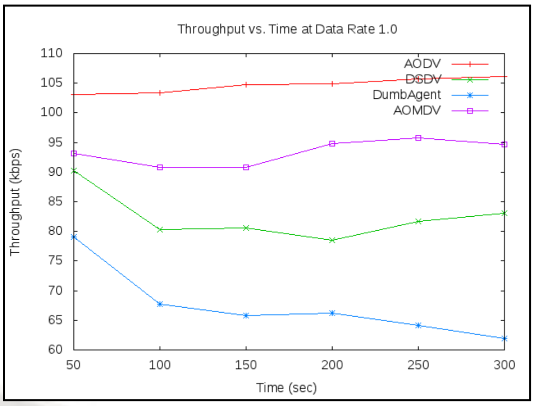

Figure8: Throughput vsTime and number of flows

6. Conclusion

The research emphasis on Flying Adhoc Networks has always been aimed at the clustering method. This study provides a brief overview of the several routing protocols available, including AODV, AOMDV, DSDV, and DumbAgent, and then classifies them following the method they use (i.e. table-driven, on-demand routing protocol). It also provides a detailed analysis of the differences and similarities between AODV, AOMDV, DSDV, and DumbAgent. The NS-2 simulator is used to evaluate the functioning of various protocols. The research demonstrates the simulation results using AODV, AOMDV, DSDV, and DumbAgent. Throughput, latency, routing overhead, and packet loss are only some of the metrics used to assess the performance of the AODV, DSDV, AOMDV, and DumbAgent routing protocols. Throughput begins to decline because the load on the network strains wireless connections when the data rate gets up to 100 kbps. It has been evidenced that DumbAgent has raised the throughput, but DSDV has increased the throughput even more when compared to the DumbAgent technique. On the other hand, the AOMDV approach has a high throughput when compared to both the DSDV method and the DumbAgent method. In conclusion, the throughput of the proposed technique attained much higher than that of existing methods.

The findings demonstrated that AODV is capable of providing lower packet loss than other protocols. The results of the simulation make it abundantly evident that the AODV routing protocol outperforms the other routing protocols DSDV, AOMDV, and DumbAgent in terms of the number of packets lost, the amount of throughput achieved, the amount of routing overhead generated, and the amount of delay. As a result, the performance of FANETs may be improved by using AODV as their primary routing protocol.

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Future work

In the future, we plan to consider the high mobility of nodes to execute efficient routing. We will consider modulation and techniques to increase the network's performance and reliability in the future.

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