Webology (ISSN: 1735-188X)
Volume 18, Number 6, 2021

Novel Clustering Based Energy Efficient With Adaptive Pso Approach For Congestion Control In Fanet

Megala D[1] , Dr. V Kathiresan[2]

[1]Research Scholar, Department of Computer Science, SNS Rajalakshmi College of Arts and Science, Coimbatore, Tamilnadu, India.

[2]Professor and Director, Department of Computer Applications, SNS Rajalakshmi College of Arts and Science, Coimbatore, Tamilnadu, India.

Abstract: - Flying ad-hoc networks (FANETs) are a very vibrant research area nowadays. They have many military and civil applications. Limited battery energy and the high mobility of micro unmanned aerial vehicles (UAVs) represent their two main problems, i.e., short flight time and inefficient routing. A large number of recent advancements in the technology of Unmanned Aerial Vehicles (UAVs) have enabled them to be very useful and effective in many applications in today's society. Unmanned aerial vehicles (UAVs) are proving to be an extremely flexible platform for a variety of applications. With advances in computation, sensor, communication, and networking technologies, the utilization of UAVs for military and civilian areas has become extremely popular in the last two decades. UAVs have to exchange information with each other and with the control station in order to meet the needs of their applications. The Mobile Ad hoc Network (MANET) is a solution to deliver this information to its destination over long ranges via one or multiple relays. In fact, MANET is a multi-hop wireless network where each node in the network acts as a mobile wireless terminal as well as a router to forward information to its neighbours. Thus, all nodes in the network are connected without requiring a pre-existing infrastructure, which makes MANET a cost-effective technology. Now, the researchers focusing on the Energy efficient techniques for improve the lifetime of the network. We propose a new EE-FANET based hybrid novel clustering based routing approach called Energy Efficient Clustering and Route Optimization Scheme in Flying Ad Hoc Networks (EECROS-EE-FANET). The proposed scheme combined with two aspects, initially, the UAV (node) energy information's are collected and based on the energy level it is clustered. Secondly, the route formation between the nodes and data transmission is made through the swarm optimization based approach. Our proposed approach will provide the efficient usage of energy, packet delivery ratio and throughput.

Keywords: - FANET, Sensor nodes, Applications, Energy Efficient, Unmanned Aerial Vehicles, Clustering, Swarm Optimization.

I. INTRODUCTION

A FANET is a derived form of vehicular ad-hoc network (VANET) and mobile ad-hoc network (MANET). In FANETs, UAVs are network nodes. FANETs follow the same peer to peer communication. Apart from many common characteristics, there are also some differences between FANETs, MANETs and VANETs. FANETs have fast mobility, rapid topological changes, 3D environmental conditions, different mobility patterns and terrain structure [7]. The highly dynamic topology and the harsh FANET environment produce many challenges for networking and communication [8]. As the nodes fly in the air, they have clear line-of-sight and a relatively large distance from each other. Equipped with wireless communication modules and appropriate sensors, Unmanned Aerial Vehicles (UAVs) can be used as a single connected group and deployed in many civilian and military applications.

Using small group of flying vehicles this network could be deployed rapidly and the nodes are coordinated from the ground which gives high degree of freedom compared to any other networks. Unmanned aerial vehicle network is discussed earlier to bring this effective flying ad hoc network. This flying networks helpful in complex situations where the conventional network could not be established due to natural calamities. The wide range of applications of FANETs will be disaster management, rescue operations, security and other location aware services [9]. Earlier single aerial vehicle network based systems are evolved, but these systems have lagged performance due to its network scalability and limited capability operations. This makes the system inflexible and non-adoptable for wide range of applications.

Energy efficiency is one of the maximum crucial factors in designing a FANET. As FANET is deployed in many adversarial and extreme environments, it isn't always viable to deliver energy supply or recharging facility. A complete network has to carry out its challenge on the embedded batteries. If a few nodes died because of low battery power, it can result in the breakdown of complete network termed as network partitioning [10], so one of the most important functions is to extend the FANET lifetime [12]. Built-in energy technology together with batteries is continuously improving [13], and there are numerous energy saving strategies for FANETs [11]. However, most of FANETs are deployed in harsh environments wherein there is a want of environmental energy efficiency. Energy efficiency is a mechanism in which sensor nodes have the capacity to extract energy from surroundings, shop it, and then use it each time wished. In FANET more energy is used in statistics transmission from supply to multi hop away destination. This is the reason; energy-green routing is constantly suited in such sort of networks [15]. Energy efficiency can be performed via making use of clustering mechanism in FANET. Clustering is a way wherein many sensor nodes are grouped together to perform a undertaking. Cluster head is chargeable for monitoring all of the nodes in its own cluster. In cluster-primarily based FANET, routing mechanism is extra simple and easy in comparison to non cluster FANET. Cluster head allows the routing protocol to reliably send facts from source to destination.

Energy Efficient routing is fairly applicable for multi hop wireless networks including FANET. Multi hop wireless networks are sharing the information between the nodes compared to single hop wireless networks. The reason is that maximum of multi hop wireless networks are disbursed having no centralized frame. Designing the proper growth the lifetime of the network primarily based routing for FANET is a difficult challenge. In FANET, an appropriate routing algorithm ought to be efficient in phrases of energy consumption.

In this paper, we present energy efficient routing algorithm that's based on clustering based totally statistics change and power efficiency approach. Our thought is capable to constantly monitor the power consumption and select comfy and energy-efficient path from supply to destination. In the remaining of the paper is organized as follows. Chapter 2 discusses about the associated work of the proposed system. Proposed work structure and its phases are addressed in Chapter 3. Chapter 4 describes the performance evaluation parameters and simulation effects. Chapter 5 concludes the paper.

II. LITERATURE SURVEY

Most IoT nodes are commonly battery powered and that makes energy efficiency critical for proper functioning and management of those nodes. Energy efficiency and sufficiency in IoT sensor nodes had been active research regions. IoT nodes have restrained energy and communique among the special nodes is energy consuming. Many low-powered communique technologies are evolved and considered these days as allowing technology for IoT. These encompass, technologies enabling "matters" obtaining contextual information, technologies allowing "things" processing contextual facts, and technology improving safety and privateness [16].

Banik, S., Mowla, M. M., & Sarkar, P. (2019) proposed an efficient routing strategy is presented with two mobility models, e.g., Random Way Point (RWP) and Gauss Markov (GM) [1]. Due to increasing number of UAVs and fast changing topology, FANETs require an adaptable, delay-bounded, and reliable communications among UAVs while maintaining the desired network quality of services. Multi-cluster FANETs handle resource scarcity problems and optimizes network performances over single cluster by efficient management of UAVs. The performance analysis of different network parameters (i.e., jitter, throughput, packet delivery ratio, end to end delay, and normalized routing load), are illustrated for four routing protocols (AODV, DSR, DSDV, and OLSR).

Khan, I. U., et al., (2020), proposed Flying Ad Hoc Network (FANET) is one of the emerging areas that evolved from Mobile Ad Hoc Networks. Selecting the best optimal path in any network is a real challenge for a routing protocol [2]. Because the network performance like throughput, Quality of Service (QoS), user experience, response time and other key parameters depend upon the efficiency of the algorithm running inside the routing protocol. The complexity and diversity of the problem is augmented due to dynamic spatial and temporal mobility of FANET nodes. Due to these challenges the performance and efficiency of the routing protocol becomes very critical. The proposed work presents a novel routing protocol for FANET using modified AntHocNet. Ant colony optimization technique or metaheuristics in general has shown better dependability and performance as compared to other legacy best path selection techniques. Energy stabilizing parameter introduced in this study improves energy efficiency and overall network performance.

Albu-Salih, A. T., & Khudhair, H. A. (2021) proposed, novel adaptive software defined networking (SDN)-based routing framework for FANET called ASR-FANET is proposed to solve the above challenges [3]. The ASR-FANET framework is mainly composed of three important parts, which are the topology discovery mechanism, statistics gathering mechanism and route computation mechanism. In topology discovery mechanism, the periodic information about network topology is collected, including nodes and links. In statistics gathering mechanism, the status of the wireless network connection and flight statistics are collected. In route computation mechanism, the optimal path is calculated based on link costs.

Usman, Q., et al., (2020) proposed, FANET provides new ways of information sharing in several applications of the military- and civilian-based communication systems [4]. Nevertheless, due to the dynamic topological structure in FANET, it has many distinctive challenges; a key one is the effective and reliable sharing of messages with the destination. Consequently, choosing the most effective node and link according to the desired objectives within the defined vicinity play a vital role. Particularly, in this regard, a Lifetime improvement through suitable next-hop nodes (LISN) using forwarding angle by establishing the forwarding zone in FANET has been proposed. The forwarding zone is created to spot the front relative nodes. Among the front relatives, the most effective appropriate node is chosen with a comparatively higher energy state.

Wen, S., & Huang, C. (2019) aims to propose an optimization framework with end-to-end (E2E) delay constraint, and formulate the problems as a utility maximization problem with respect to link capacity, E2E delay and flow conservation by coupling data flows and decomposing the E2E delay constraint [5]. The authors propose a delay-constrained path selection algorithm and an asynchronous distributed optimization method which requires only the local channel information and outdated messages to optimize different parameters. The authors further, to optimize such a non-linear maximization problem; it employs primal–dual decomposition and the delay scale factors to cast the maximization problem into several sub-problems with lower complexity. Finally, to highlight the advantages of the proposed method, we further give the related analysis from the viewpoint of the different solutions of the maximization problem. Simulation results demonstrate that the proposed framework obtains significant network performance in terms of energy efficiency and packet timeout rate, compared with traditional methods.

Khan, A., Aftab, F., & Zhang, Z. (2019) addressed As UAVs in a Flying ad-hoc Network (FANET) are mobile in nature, thus results in frequently changing topology and creates the communication issues [6]. For better networking to have efficient communication in FANETs, This work propose self-organization based clustering scheme inspired by the behavioral study of glowworm swarm optimization (GSO) for cluster formation and management. The cluster head election and cluster formation take place based on connectivity with the ground control station along with luciferin value and residual energy of the UAVs. The cluster management mechanism uses behavioral study of GSO by updating the luciferin value based on the UAVs' position. Furthermore propose a mechanism for route selection based on the neighbor range, residual energy and position of UAV for efficient communication.

In order to efficiently transfer packets, a swarm of UAVs communicate and collaborate with each other to self-organize into a network, called a UAV flying ad hoc network (UFANET). Mobile Ad Hoc Network (MANET) is a collection of mobile nodes that communicate without relying on any pre-existing infrastructure. In a Mobile Ad hoc Network (MANET), mobile nodes move around arbitrarily, nodes may join and leave at any time, and the resulting topology is constantly changing. Routing in a MANET is challenging because of the dynamic topology and the lack of an existing fixed infrastructure. There are two scenarios in UAV implementation, namely the single-UAV and multi-UAV scenarios. In the single-UAV scenario, a single UAV establishes a connection to a radio access infrastructure. The multi-UAV scenario can be extended to multi-

UAV swarm, whereby a large swarm of autonomous, small-sized, and lightweight UAVs are deployed [17]. The multi-UAV swarm can coordinate and prevent collisions among themselves while completing tasks that require a large swarm of UAVs, such as surveillance and search and rescue missions during catastrophe and gathering a swarm of UAVs at a target location. The multi-UAV swarm can be used to upload a huge amount of data collected in a distributed manner (e.g., data collected from cellular users) to the base station.

III. ENERGY EFFICIENT CLUSTERING AND ROUTE OPTIMIZATION SCHEME (EE-CROS)

Flying ad hoc network (FANET) is a self-organizing wireless network that enables inexpensive, flexible, and easy-to-deploy flying nodes, such as unmanned aerial vehicles (UAVs), to communicate among them in the absence of fixed network infrastructure [18]. FANET is one of the emerging networks that have an extensive range of next-generation applications. Hence, FANET plays a significant role in achieving application-based goals. Routing enables the flying nodes to collaborate and coordinate among themselves and to establish routes to radio access infrastructure, particularly FANET base station (BS).

Routing must cater to two main characteristics of FANETs that reduce the route lifetime. Firstly, the collaboration nature requires the flying nodes to exchange messages and to coordinate among themselves, causing high energy consumption. Secondly, the mobility pattern of the flying nodes is highly dynamic and they may be spaced far apart, causing link disconnection. In this work, propose an optimization framework with end-to-end (E2E) delay constraint, and formulate the problems as a utility maximization problem with respect to link capacity, E2E delay and flow conservation by coupling data flows and decomposing the E2E delay constraint [5]. Aiming at the problem of falling easily into local optimal solution of conventional particle swarm optimization algorithm, an adaptive particle swarm optimization algorithm is proposed, which adaptively adjusts the values of inertial weight and two learning factors in the iterated search process. The environment model of path planning is built for unmanned aerial vehicle (UAV) to perform reconnaissance task in mountain environment. The self-constraint conditions of UAV are analyzed. The fitness degree function of adaptive particle swarm optimization algorithm and flow chart of path planning algorithm are designed. Subsequently, propose two level data aggregation and compression method which consist of two types of data aggregated by the CH. One is external data, and the other is internal data. External Data is the standard sensor node data, and internal data is the nodes data. After the data aggregation process is completed, the uniform data aspect assignment is encountered. In this module, data compression is applied. It is to reduce the number of data transmitted from cluster head to sink [24].

A large number of recent advancements in the technology of Unmanned Aerial Vehicles (UAVs) have enabled them to be very useful and effective in many applications in today’s society. Trust management is needed when participating nodes (UAVs) without any previous interactions desire to establish a network with an acceptable level of trust relationships among themselves.

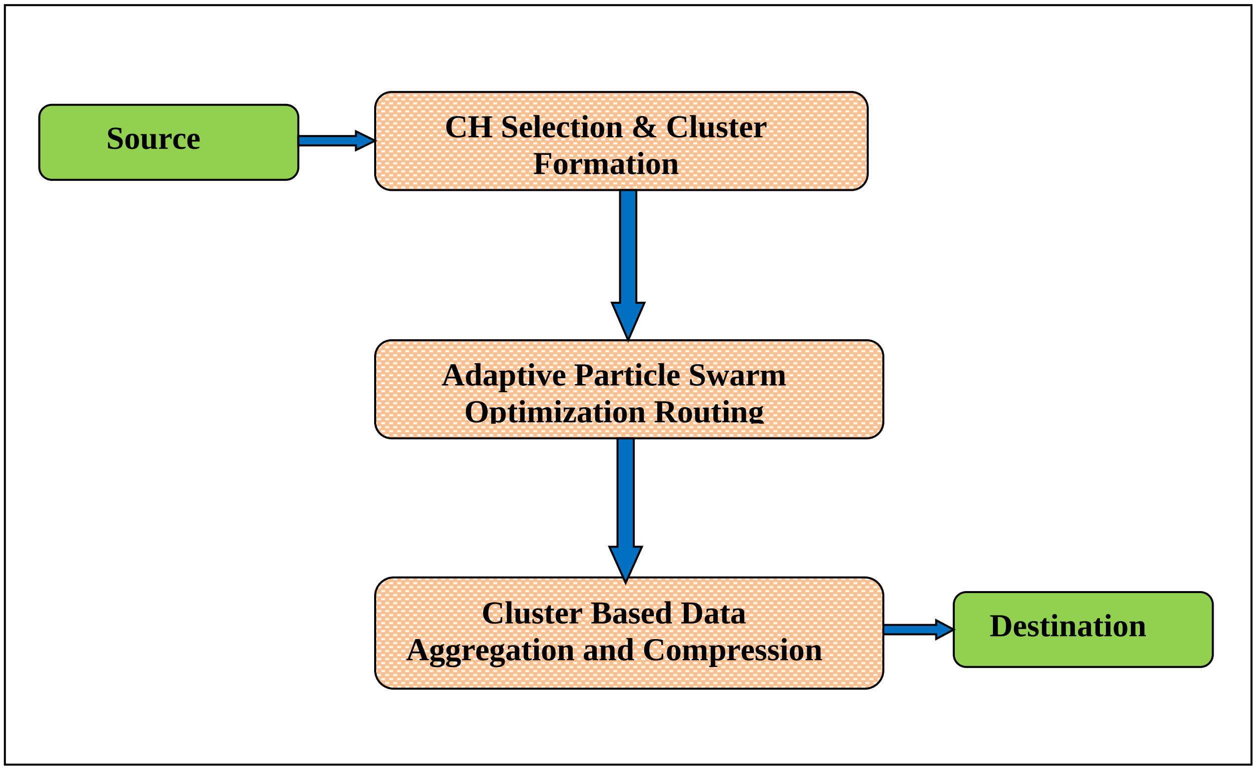

Figure 3.1: - Workflow of the Proposed Work

A semi - infrastructure UAV network is considered in this research work. The network model takes into account of the following preliminary considerations.

a) There are a set of UAVs in the network
b) Every UAV node is having built-in GPS device for helping to identify its current position
c) Each UAV node has a dedicated short-range communication (DSRC) device and has the indistinguishable communication radius.
d) The overall UAV network is split into clusters
e) Maximum hops between one cluster head and its normal node are set to maximum of 5 and minimum of 1.

3.1. Fuzzy based CH Selection & Cluster Formation

In this research work, fuzzy logic is employed for clustering operation in FANETs. At first, the UAV nodes are setup in the terrain region. In order to perform energy efficient clustering operation, the UAV nodes that are active remains in 'ON' state and the inactive UAV nodes are put into 'OFF' state [23]. This results in considerable decrease in overall energy consumption. At the point of time when the UAV nodes starts flying as well as owing to the energy exhaustion, the topology of the UAV network keeps on changing over a period of time. For that reason, a fuzzy condition is fixed based on cost for identifying the cluster head UAV nodes. Certain parameters are considered for choosing the cluster head UAV nodes.

1) UAV Node Residual Energy.

2) Betweeness Centrality of UAV Node.
3) UAV Node Location
4) UAV Node Speed.

The only output fuzzy variable is called a priority opportunity. The fuzzy CH selection model is shown in Figure 3.2.

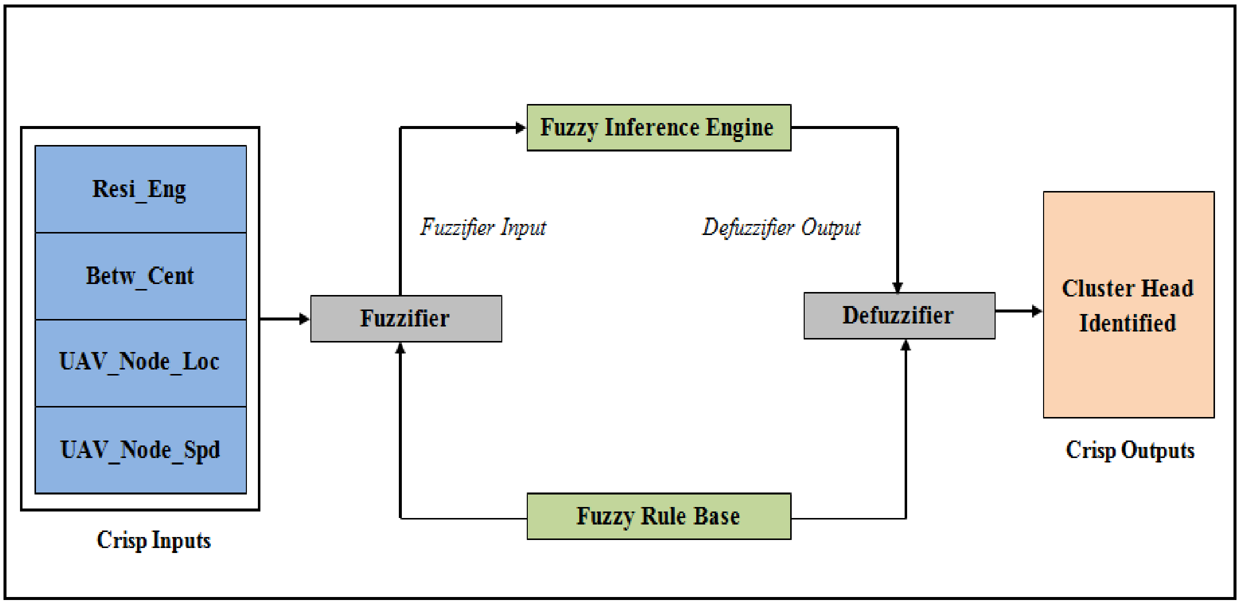

Figure 3.2: - Proposed Fuzzy based System

The BS generates the gateway value 'G' is calculated and forwarded to the rest of the UAV nodes. Every UAV nodes calculated the energy value and is compared with the received gateway value. If the energy value is greater than the gateway value, then the nodes is selected as a cluster head, and all other nodes are treated as a normal node.

By using this adaptive method, the betweenness centrality is of nodes to CH is calculated using a distributed mechanism. Once the CH receives the updates from its neighbours, then it calculates the betweenness centrality of each node.

The fuzzy process maps each smooth input value to a set of respective fuzzy member functions for each temporary CH over three parameters. The output variable indicates the possibility of a temporary cluster head becoming a cluster head. Now, each sensor nodes are prepared to become a member of a cluster, and it is joined with the nearest CH. After the cluster formation, the required data is generated and sensed by the members those who are joined. The CH is the In-charge to collect and integrate the data from their members. After the aggregation is over, the CH made the compression process to reduce the overload and energy consumption of the cluster head. Finally, the CH communicates to the base station or ground station and transmits the data.

3.2. Adaptive Particle Swarm Optimization (APSO) Routing

In this proposed work, a Adaptive Particle Swarm Optimization (APSO) algorithm is proposed where three different adaptive strategies are used. Particle Swarm Optimization algorithm has been proved to be a very efficient algorithm for the solution of routing type problems. At first, the performance of classical PSO algorithm is enhanced using the proposed adaptive PSO (APSO) algorithm. Different from the traditional PSO algorithm, the optimal solution is searched through cooperating four best vector types into three velocity updating strategies.

The advantages of particle swarm optimization algorithm are strong robustness, low sensitivity to population size, with few design parameters and fast convergence in the early stage; the disadvantages lie in the slow convergence in the late stage, which results in easily falling into the local optimal solution prematurely [19]. In order to overcome the shortcomings of PSO algorithm, some researchers have explored in recent years and proposed several improved methods. An adaptive particle swarm optimization algorithm is proposed. It only needs to adjust the inertia weight and learning factor adaptively, and does not need to add other algorithms. It can overcome the problems of local optimization and slow convergence in the later stage, and meet the requirements of simplicity and efficiency. It provides a reliable guarantee for fixed wing UAV to perform tasks in complex environment space.

The fixed wing UAV does not have the vertical take-off and landing, hovering in the air, flight flexibility and other performance of the rotor UAV, so the self-constraint conditions in flight are stricter than that of the rotor UAV. Compared with rotary wing UAV, fixed wing UAV has the advantages of fast flight speed, long range and low energy consumption, so it is more suitable for long-distance and large-scale space environment.

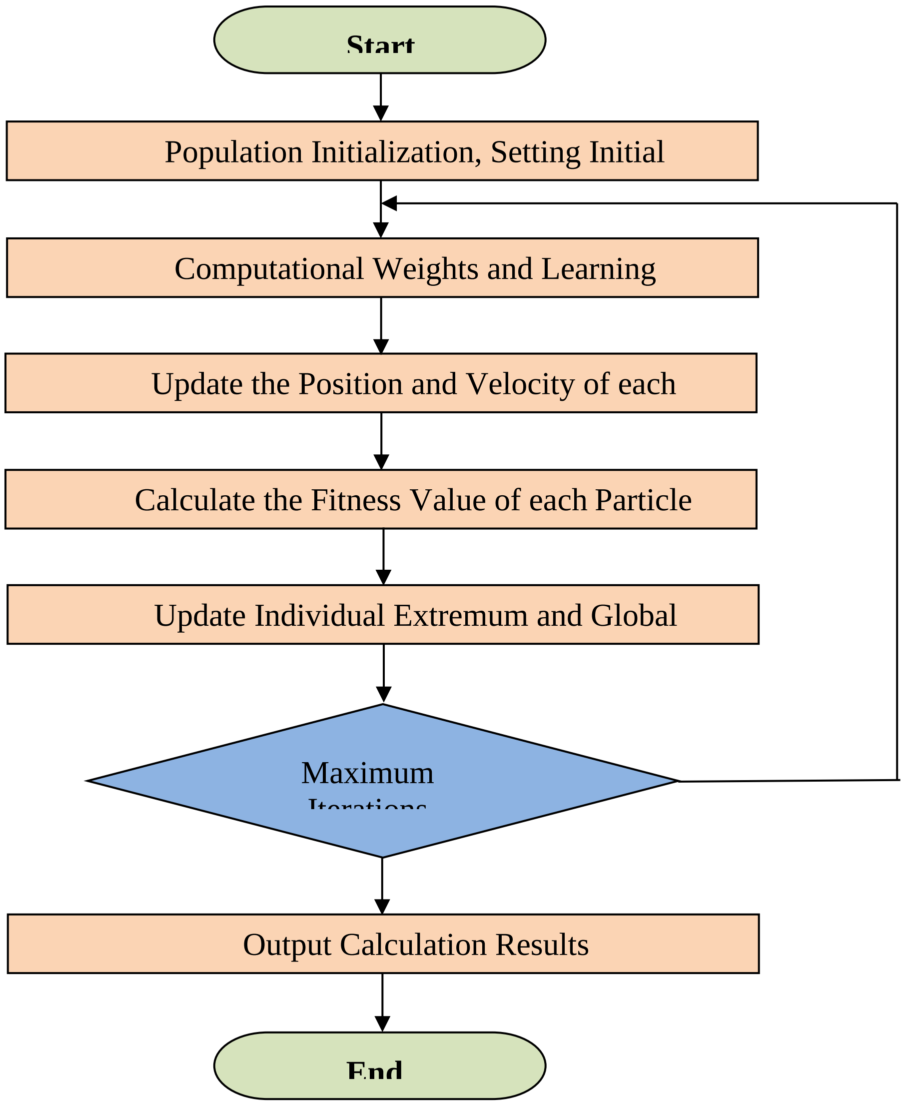

Figure 3.3: - Flowchart of APSO route planning algorithm

It mainly considers the following constraints:

- **Maximum Track Distance.**
- **Minimum Inertial Distance.**
- **Maximum Horizontal Turning Angle.**
- **Maximum Elevation Angle.**
- **Maximum/Minimum Flight Altitude.**

Particle Swarm Optimization (PSO) is a common method for UAV path planning. Its main defects are: slow convergence in the later stage, easy to fall into the local optimal solution. In order to overcome this defect, an adaptive particle swarm optimization (APSO) algorithm is proposed by adding an adaptive adjustment algorithm to the particle swarm optimization algorithm, adjusting the inertia weight and two learning factors at the same time.

3.3. Data Aggregation and Compression

In FANETs, data aggregation is required because of two primary reasons. The first reason is the large amount of data produced by each node and a large number of nodes in each network, which gives a stack of data to process and analyse. This data must be converted into information relevant and valuable to the data consumer. The second reason is the energy optimisation in FANETs, as this has been workable in recent years. Data aggregation reduces the amount of transmission and processing and, thus, energy uses [20]. Therefore, reduced network traffic, reduced energy consumption, and enhanced lifetime are the results of data aggregation on a sensor network. Several performance parameters for energy-efficient data aggregation are the accuracy of data, reliability, and correlation coefficient, detection of a false alarm, data redundancy, latency, power consumption, and a lifetime of the network. Aggregation, such as any other mathematical concept, depends upon a few elements or factors, which influence the outcome of it, each having equal importance in the construction of the technique. These elements for aggregation are network architecture, aggregation function, data representation, and aggregation resources.

The neighbouring UAV nodes have redundant or correlated data. It is not necessary to transfer the redundant data to the base station. Data generated by different sensor nodes can be jointly processed when forwarding towards the sink. Sensor nodes have limited resources. Data aggregation is a three-step process.

- Cluster Head (CH) node collects data from several UAV nodes.
- Aggregates the set of data from several UAV nodes into an aggregated data.
- Transfers the aggregated data to the sink or Base Station (BS).

Cluster-based data aggregation is the most common approach to perform data aggregation. The objective of this work is focused on energy cost reduction in the clustering process. In most of the existing clustering approaches, clusters are formed for every round.

In FANETs, clustering management refers to selecting a series of UAV nodes as cluster-heads according to a specific communication protocol. CH aggregates the data generated by the UAV nodes in its cluster and then send such data to the BS [21]. There are two kinds of provenance in FANETs. One is a simple provenance, where data is generated at a leaf UAV node and forwarded by UAV nodes CH; Second is an aggregated provenance, where data are aggregated at CH and forwarded to the BS. Once CH receives the data from their cluster members, it compresses according to the data correlation model. It then sends the aggregated data to the selected next-hop CH. If a CH receives data from other CH, it will forward the data directly to the selected next-hop without performing aggregation. Since the CH which collects data from its members has high residual energy and applies compressed aggregation, the intra-cluster energy consumption is balanced. Similarly, while selecting the next hop CH, the CH with high residual energy and the least load is selected, thereby balancing the inter-cluster energy consumption also.

4. EXPERIMENTAL RESULTS

Simulation-based experiments have been conducted in this research to evaluate the performance of the proposed algorithm. Nowadays, computer-based discrete-event simulation has widely accepted to be a valuable tool in several areas where analytical methods are not applicable, and experimentation is not feasible [22]. The mainstream approach in the FANET research community follows the development, simulation, and publishes process. FANET publications typically include performance simulations that compare different protocols. NS-3 is used to simulate the proposed architecture. The user writes an OTCL script that defines the network (number of nodes, links), the traffic in the network (sources, destinations, type of traffic) and which protocol that is used. NS3 uses this script during the simulation. The results of the simulation is an output trace file that can be used to do data processing (calculate throughput, and delay) and visualize the simulation with a program called Network Animator (NAM). NAM is a visualisation tool that visualizes the packet as it propagates through the network.

4.1. Simulation Parameter

In this simulation, UAV nodes are randomly deployed over a 1000-meter x 1000-meter region with a transmission range of 250 meters (Table 4.1). The sink or BS is located in the top right corner of the topology. The data from the sensors are considered as periodical and with constant size, and hence the Constant Bit Rate (CBR) traffic is applied for data generation.

Table 4.1: Simulation Settings

Parameter	Value
Number of Nodes	150 Nodes
Number of Flows	25, 50, 75, 100, 125, and 150.
Simulation Range	1000 m X 1000 m
Channel type	Wireless Channel
Transmission Range	250 m
Simulation Time	900s
Traffic Source	CBR
MAC Layer	802.11 DCF
Network Layer	AODV
Transfer Model	WaveLan
Mobility Model	Random Waypoint Mobility
Data Transmission rate	1 Mbps
Max No. of CBR Connections	100

4.2. Performance Metrics

The performance of CDA is studied for network lifetime, latency, and filtering efficiency. Simulation results show that the proposed CDA algorithm achieves maximum efficiency when compared with the existing algorithm.

- **Network Lifetime**

  Network lifetime is defined in the earlier research in many ways. In this work, the network lifetime is considered as the time until when all the UAV nodes in the network die out of their energy. Network lifetime depends on the average energy spent.

- **Latency**

Latency is defined as the delay involved in data transmission, routing, and data aggregation. It can be measured as the time delay between the data packets received at the sink and the data generated at the source UAV nodes.

- **Filtering Efficiency**

  It is defined as the percentage of false data to be filtered out within a specified number of hops. Filtering efficiency can be based on the authentication information owned by the forwarding UAV node to detect and drop forged MAC.

- **Average Aggregated Ratio (AAR)**

  The Average Aggregated Ratio (AAR) in the intermediate UAV nodes (i.e. aggregator UAV nodes), defined as the ratio of the number of packets sent by the intermediate UAV nodes to the number of packets that they have received, as described in Equ.6.1:.

$$\mathrm{AAR} = 1 - \frac{\#\mathrm{PktsSend}}{\#\mathrm{PktsRecv}} \qquad \text{... (equ 4.1)}$$

- **Energy Saving**

  The Energy Saving (ES) is defined as the ratio of the total energy saved (i.e. remaining) when the aggregation is enabled to the total energy saved when the aggregation is disabled. It is calculated using the following formula.

$$\mathrm{ES} = \frac{\mathrm{Energy_{remaining}(Agg\_On)}}{\mathrm{Energy_{remaining}(Agg\_Off)}} = \frac{\mathrm{Energy_I} - \mathrm{Energy_{consumed}(Agg\_On)}}{\mathrm{Energy_I} - \mathrm{Energy_{consumed}(Agg\_Off)}} \qquad \text{... (equ 4.2)}$$

Where Energy $_I$: Initial energy of a UAV node.
Energy consumed: The energy consumed for packets transmission/forwarding.

4.3. Results and Discussions

I. Network Lifetime

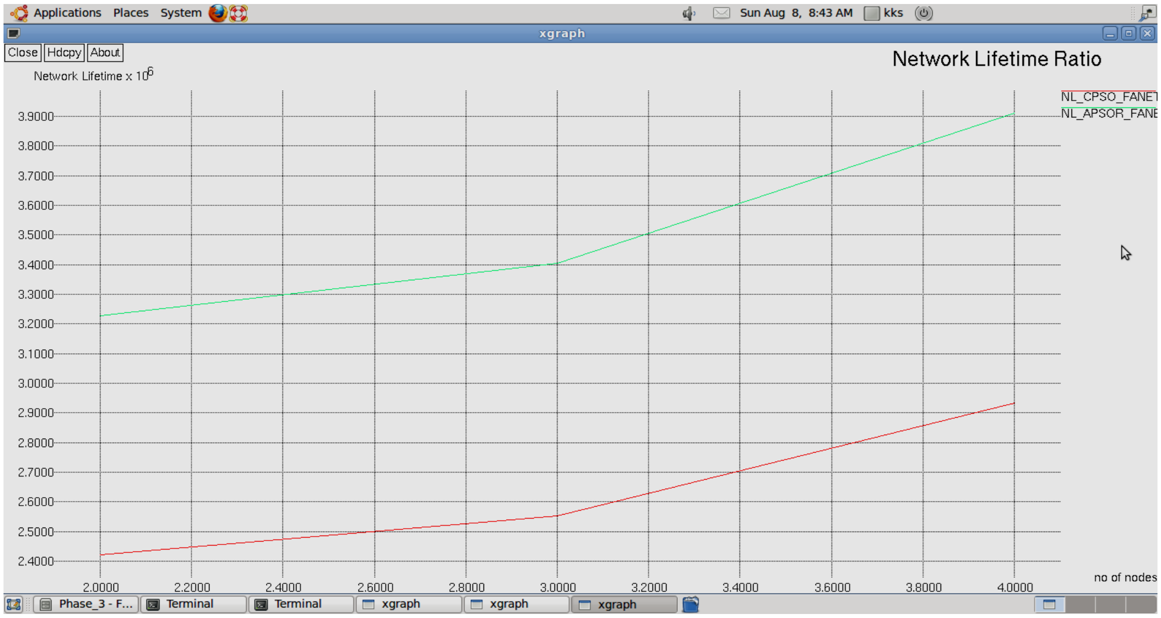

Figure 4.1: Network Lifetime

Figure 4.1 shows the comparison of network lifetime for the existing without compression and proposed CDA & TCC algorithm. The variation of network lifetime for networks and the varied number of UAV nodes and simulation time(s).It is understood that the proposed algorithm (CDA & TCC) shows higher value compared to the existing algorithm.

II. Latency

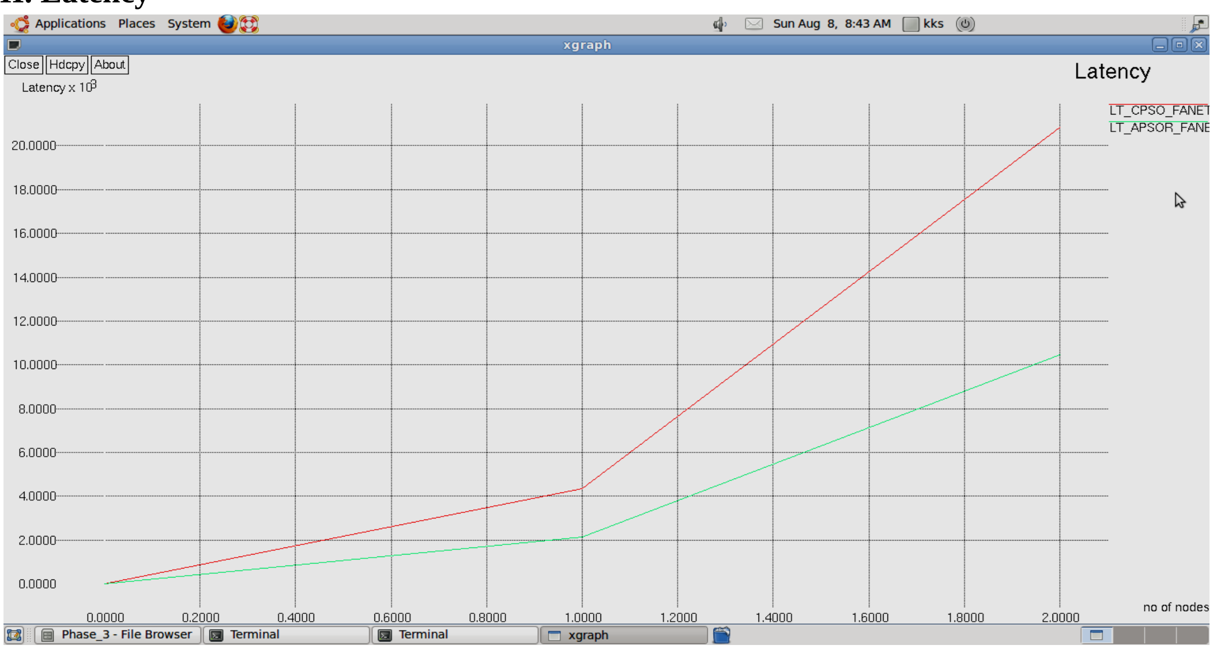

Figure 4.2: Latency

Figure 4.2 shows the comparison of the latency or end-to-end delay of the proposed and existing algorithm. The proposed CDA & TCC algorithm has a lower delay compared to the existing algorithm. The proposed algorithm selects the cluster heads that can send the aggregated data to the base station directly. The maximum delay is 40% lower than that of the existing algorithm.

III. Filtering Efficiency

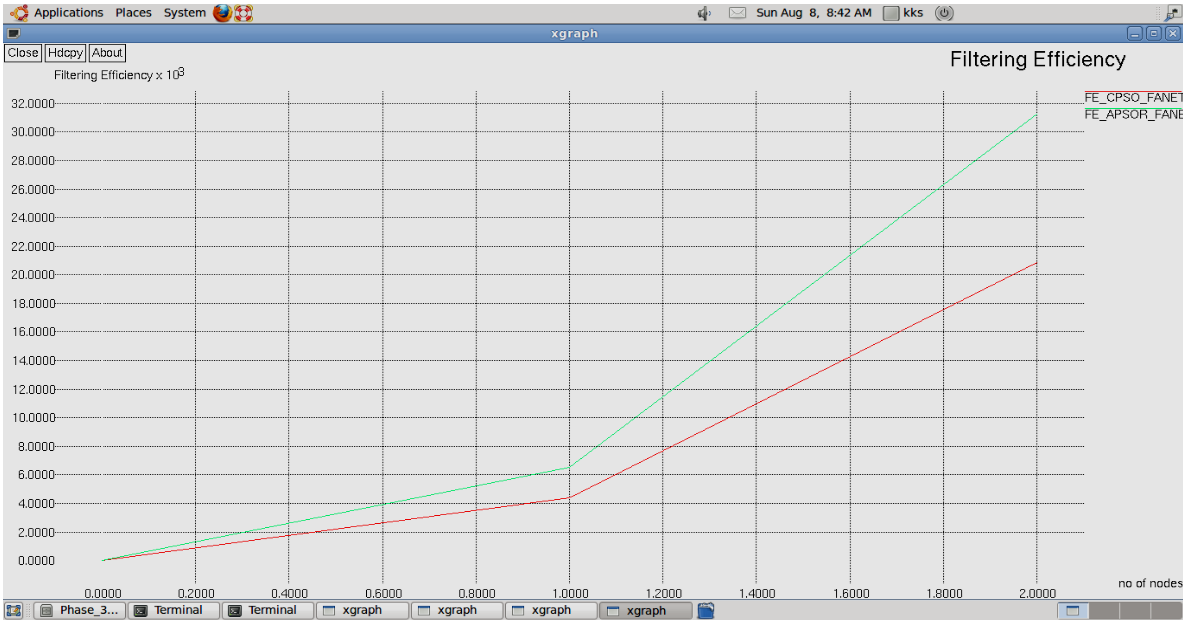

Figure 4.3: Filtering Efficiency

Figure 4.3 illustrates the filtering efficiency of CDA & TCC and the existing algorithm, which can filter false data injected by compromised cluster members. CDA & TCC is tested by allowing compromised enroute cluster UAV node within the cluster to inject false event report. This is tested in the presence of 25, 50, 75, 100, and 125 compromised UAV nodes. In the proposed algorithm, filtering is based on the authenticated information supported by the cluster heads.

IV. Average Aggregation Ratio

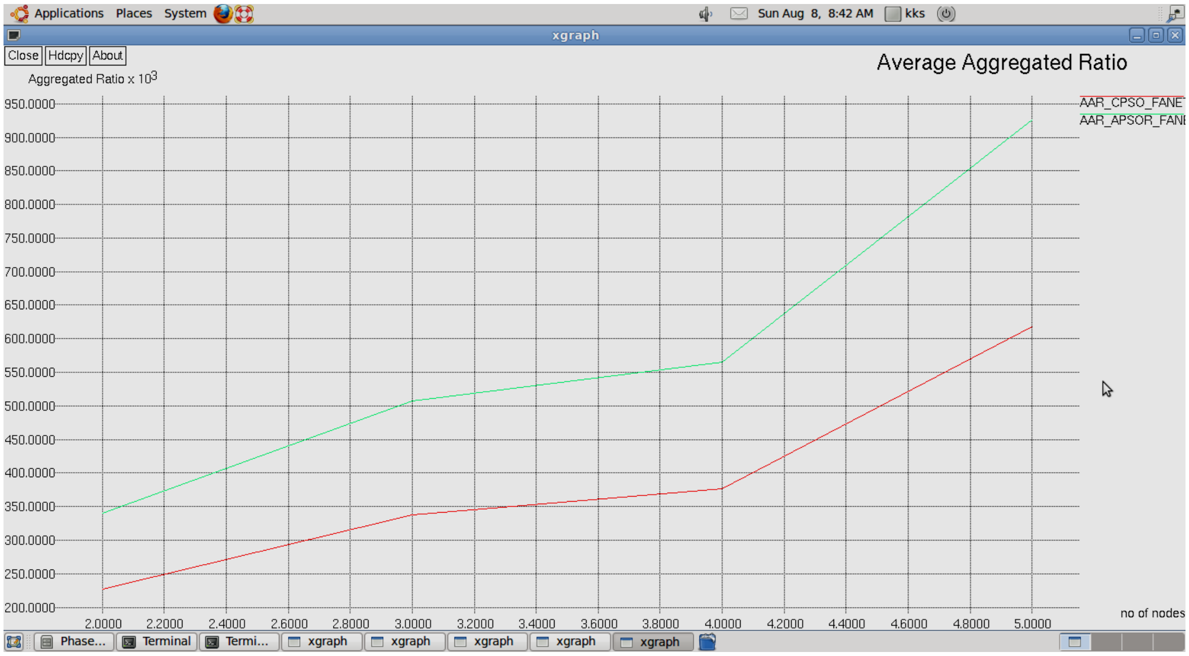

Figure 4.4: Average Aggregation Ratio

Figure 4.4 illustrates the Average Aggregation Ratio (AAR) of CDA & TCC and existing algorithm; however, it is observed that higher network densities have little influence on AAR, in the existing algorithm. This consists of 25, 50, 75, 100, and 125 UAV nodes.

V. Energy Saving

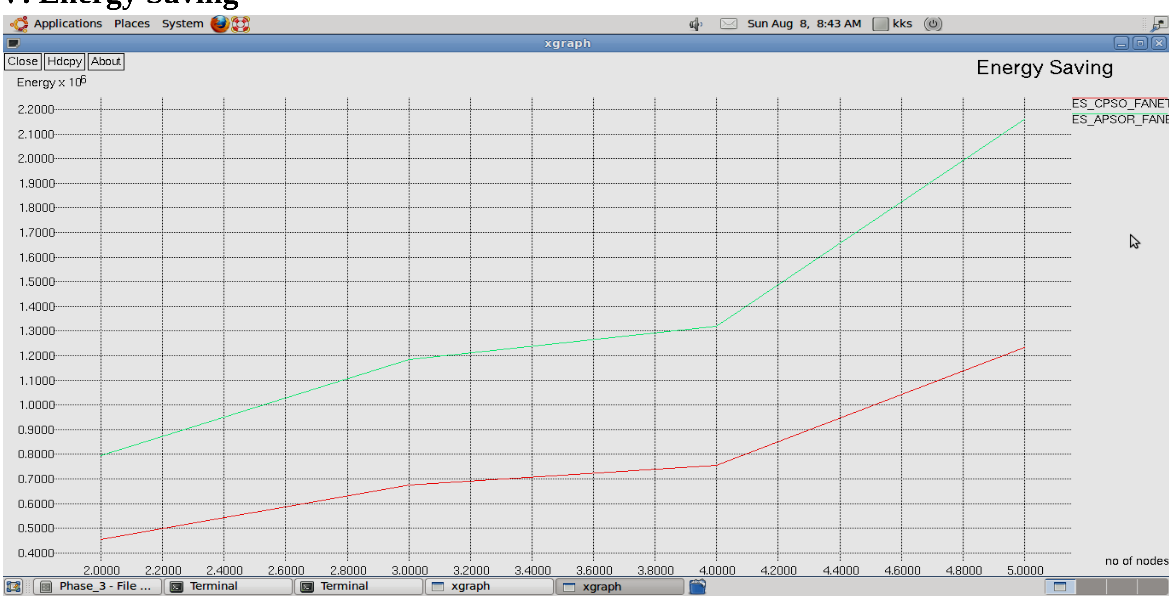

Figure 4.5: Energy Saving

Figure 4.5 illustrates the energy saving of proposed CDA & TCC and existing algorithm, the ES decreases with the longer duration of the monitoring period interval, as it is more likely for the CH to receive more packets and aggregate them together. Moreover, the frequency of sending aggregated packets when the period is long is lower than that of shorter monitoring periods.

5. CONCLUSION

Initially, the UAV nodes are deployed randomly in the working environment. The first method will form an energy-efficient clustering using a fuzzy-based rule set to reduce the energy consumption by UAV nodes and avoid a number of retransmissions by a hybrid scheduling mechanism. The simulation results of the proposed work first phase show that the proposed Fuzzy based Cluster Head selection aims at providing a competent cluster head selection process concerning all the essential features. The second phase finds the results taken across Adaptive Particle Swarm Optimization (APSO) routing algorithm strategies prove the longevity of the FANET UAV network and hence certify the distribution of the energy consumption throughout the functioning of the network. Also, the energy consumption of the APSO algorithm is less to the compared algorithms across several scenarios irrespective of the density and location of the sink in the networks. This ensures the adaptability and scalability of APSO to several types of FANET applications. The proposed algorithm is designed to effectively elect cluster heads and aggregate the data from the sensor nodes. The third phase performs the cluster-based data aggregation and compression made in the CH.

REFERENCES

[1] Banik, S., Mowla, M. M., & Sarkar, P. (2019, September). A new routing scheme for multi-cluster flying ad hoc networks. In 2019 5th International Conference on Advances in Electrical Engineering (ICAEE) (pp. 323-328). IEEE.

[2] Khan, I. U., Qureshi, I. M., Aziz, M. A., Cheema, T. A., & Shah, S. B. H. (2020). Smart IoT control-based nature inspired energy efficient routing protocol for flying ad hoc network (FANET). IEEE Access, 8, 56371-56378.

[3] Albu-Salih, A. T., & Khudhair, H. A. (2021). ASR-FANET: An adaptive SDN-based routing framework for FANET. International Journal of Electrical & Computer Engineering (2088-8708), 11(5).

[4] Usman, Q., Chughtai, O., Nawaz, N., Kaleem, Z., Khaliq, K. A., & Nguyen, L. D. (2020, August). Lifetime improvement through suitable next hop nodes using forwarding angle in FANET. In 2020 4th International Conference on Recent Advances in Signal Processing, Telecommunications & Computing (SigTelCom) (pp. 50-55). IEEE.

[5] Lyu, J., Zeng, Y., Zhang, R., & Lim, T. J. (2016). Placement optimization of UAV-mounted mobile base stations. IEEE Communications Letters, 21(3), 604-607.

[6] Khan, A., Aftab, F., & Zhang, Z. (2019). Self-organization based clustering scheme for FANETs using Glowworm Swarm Optimization. Physical Communication, 36, 100769.

[7] Aadil, F., Raza, A., Khan, M. F., Maqsood, M., Mehmood, I., & Rho, S. (2018). Energy aware cluster-based routing in flying ad-hoc networks. Sensors, 18(5), 1413.

[8] Lee, S. W., Ali, S., Yousefpoor, M. S., Yousefpoor, E., Lalbakhsh, P., Javaheri, D., and Hosseinzadeh, M. (2021). An energy-aware and predictive fuzzy logic-based routing scheme in flying ad hoc networks (fanets). IEEE Access, 9, 129977-130005.

[9] Adya, A., & Sharma, K. P. (2020). Energy Aware Clustering Based Mobility Model for FANETs. In Proceedings of ICETIT 2019 (pp. 36-47). Springer, Cham.
[10] Mariyappan, K., Christo, M. S., & Khilar, R. (2021). Implementation of FANET energy efficient AODV routing protocols for flying ad hoc networks [FEEAODV]. Materials Today: Proceedings.
[11] Kumar, S., Raw, R. S., & Bansal, A. (2021). Energy and Direction Aware Routing Protocol for Flying Ad Hoc Networks. In Proceedings of International Conference on Communication, Circuits, and Systems: IC3S 2020 (pp. 371-378). Springer Singapore.
[12] Mukherjee, A., Misra, S., Chandra, V. S. P., & Raghuwanshi, N. S. (2020). ECoR: Energy-Aware Collaborative Routing for Task Offload in Sustainable UAV Swarms. IEEE Transactions on Sustainable Computing, 5(4), 514-525.
[13] Usman, Q., Chughtai, O., Nawaz, N., Kaleem, Z., Khaliq, K. A., & Nguyen, L. D. (2020). Lifetime Improvement Through Suitable Next Hop Nodes Using Forwarding Angle in FANET. In 2020 4th International Conference on Recent Advances in Signal Processing, Telecommunications & Computing (SigTelCom) (pp. 50-55). IEEE.
[14] Namdev, M., Goyal, S., & Agarwal, R. (2021). An Optimized Communication Scheme for Energy Efficient and Secure Flying Ad-hoc Network (FANET). Wireless Personal Communications, 1-22.
[15] Bharany, S., Sharma, S., Badotra, S., Khalaf, O. I., Alotaibi, Y., Alghamdi, S., & Alassery, F. (2021). Energy-efficient clustering scheme for flying ad-hoc networks using an optimized LEACH protocol. Energies, 14(19), 6016.
[16] Chowdhuri, S., Banerjee, S., & Chaudhuri, S. S. (2018). Implementation of a novel Minimum Energy Consume Secure Routing Protocol for reliable and energy efficient rescue operation of FANET. In 2018 IEEE Applied Signal Processing Conference (ASPCON) (pp. 129-133). IEEE.
[17] Bhardwaj, V., & Kaur, N. (2021). SEEDRP: a Secure Energy Efficient Dynamic Routing Protocol in Fanets. Wireless Personal Communications, 1-27.
[18] Nithyanandh S, Jaiganesh V (2020) Quality of service enabled intelligent water drop algorithm based routing protocol for dynamic link failure detection in wireless sensor network. Indian Journal of Science and Technology 13(16): 1641-1647.
[19] Sang, Q., Wu, H., Xing, L., Ma, H., & Xie, P. (2020). An Energy-Efficient Opportunistic Routing Protocol Based on Trajectory Prediction for FANETs. IEEE Access, 8, 192009-192020.
[20] Hassan, M. A., Ullah, S. I., Salam, A., Ullah, A. W., Imad, M., & Ullah, F. (2021). Energy efficient hierarchical based fish eye state routing protocol for flying Ad-hoc networks. Indonesian Journal of Electrical Engineering and Computer Science, 21(1), 465-471.
[21] Mahmud, I., & Cho, Y. Z. (2021). LECAR: Location Estimation-Based Congestion-Aware Routing Protocol for Sparsely Deployed Energy-Efficient UAVs. Sensors, 21(21), 7192.
[22] Wen, S., Deng, L., Shi, S., Fan, X., & Li, H. (2020). Distributed Congestion Control via Outage Probability Model for Delay-Constrained Flying Ad Hoc Networks. Wireless Communications and Mobile Computing, 2020.
[23] Khan, A., Aftab, F., & Zhang, Z. (2019). Self-organization based clustering scheme for FANETs using Glowworm Swarm Optimization. Physical Communication, 36, 100769.

[24] Sharma, V., You, I., Kumar, R., & Chauhan, V. (2018). OFFRP: optimised fruit fly based routing protocol with congestion control for UAVs guided ad hoc networks. International Journal of Ad Hoc and Ubiquitous Computing, 27(4), 233-255.

[25] Zafar, W., & Khan, B. M. (2017). A reliable, delay bounded and less complex communication protocol for multi cluster FANETs. Digital Communications and Networks, 3(1), 30-38.