An Adaptive Routing in Flying Ad-Hoc Networks using FMCC Protocol

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Abstract – The increasing need for portable and flexible communication has paves a way for network evolution amongst unmanned aerial vehicles (UAVs) which is known as FANETs. Moreover, owing to its exclusive features of UAVs like frequency topology, high mobility and 3D movement makes routing most confronting task in FANETs. With these features, designing novel clustering model is quite complex. In general, topology based routing is determined as significant factor for resolving routing crisis. Henceforth, this investigation specifically spotlights on topology based routing protocol termed as Fuzzy based Markov chain Cluster (FMCC) with an objective of enhancing efficiency of networks in terms of resource utilization, time delay, transmission ratio and resource availability. Initially, consider a network model and the problems related in constructing a network without loss of packet transmission, neighbourhood construction and so on. In this work, simulation is done in NS-2 simulator and outcomes are analyzed based on end-to-end delay, throughput, cluster formation, cluster lifetime and so on. This method depicts better trade off in contrast to prevailing techniques. The information associated with the information exchange is considered for renovating the work effectually.

Keywords- FANET, clustering, network lifetime, Fuzzy based Markov chain clustering, throughput.

I. INTRODUCTION

In the recent times, exponential growth in constructing of UAVs has assisted in constructing infra-structure of models of network which is termed as Flying Ad-hoc Networks (FANETs). Owing to its adaptability, simpler way of deployment, FANETs is a hopeful solution for diverse civilian and military applications like disaster assessment, border surveillance, search and rescue operations, relaying network, forest fire detection, wind estimation, agricultural purposes, civil security and traffic monitoring [1]. FANETs are necessary for ad-hoc construction by numerous UAVs to facilitate flexible and solutions devoid of infrastructure [2]. UAVs are thereby equipped by board monitor, sensors and GPS that work autonomously.

So as to eliminate limitations constructed using traditional infra-structure based communication frameworks in disastrous situation, they are deployed rapidly, self-configured and offers cost-effectual communication.

It has its ability to share and collect information among UAVs; they are delivered from ground station [3]. UAVs are interrupted during the transmission process owing to weather conditions, it posses to connected to network. With ad-hoc networking, it can eliminate obstacles like restricted guidance, short range communication and network failure that rises single UAV [4].

Subsequently, certain unique characteristics lead FANETs as an appropriate solution for various applications scenarios; however, it as well generates certain challenges in networking and communication amongst multiple UAVs. The primary crisis are cooperative communication amongst UAVs. Henceforth, routing turns to be a significant and compulsory task for superior assistance of packet transmission of packets amongst UAVs.

In general, FANET applications are extremely assisted by multi-hop communications, where UAV speed span from about 30-400 km/h in 3D environments. In context, network topology alters outcomes in link variation crisis. In addition, a frequent topology change also improves packet loss, latency and signalling overhead [5]. Moreover, it is deployed in sensitive applications that definite transmission in robust and cost-effective. Choosing and designing of suitable cluster based routing are necessary to maintain services to be active and stable. To design routing solution, MANET and VANETs routing protocols are validated. They are characterized to topology, position and swarm protocols. Topology-based routing approaches exploit IP addresses to utilize prevailing link information to forward data packets on optimal path [6]. Protocols need topological information from communicating to establish optimal path. Swarm routing is inspired by social insect communities like being self-organized, co-operative and self adaptive, to find optimal path. Moreover, significant failing of swarm based routing is extremely latency owing to high mobility of UAVs. In position based routing protocols, packet forwarding is performed on basis of geographic location of UAVs. Significant disadvantage is state information transmission regarding route during frequently changing locations. Henceforth, explicitly concentrates on topology based routing protocols in this investigation. These protocols are measured as significant method for resolving routing issues.

In this investigation, Fuzzy based Markov Chain Clustering (FMCC) is a topology based routing which attempts to offer an optimal path amongst UAVs by diminishing control overhead. Therefore, this investigation attempts to offer a solution for routing issues, based on the simulation analysis amongst diverse topology based routing protocols. This investigation will assists in selecting effectual routing protocols for FANET deployment. In this work, based on the fuzzy design cluster formation, cluster lifetime, throughput is measured. This work is not based on routing protocol design, however the solution to routing crisis.

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Remainder of the paper is as follows. In Section 2, is background of topology-based routing protocols, followed by analysis of anticipated FMCC in Section 3. Simulation outcomes are provided in Section 4. Finally, concluding comments in Section 5 with direction of future work.

II. LITERATURE REVIEW

Cristina Mayr, [7] depicted a novel mathematical way to deal with known issues of refection, by methods for a plan that improves scalability termed ORRTD. With ORRTD there is no compelling reason to alter BGP standards. Experimental outcomes substantiate not just hypothetical ORRTD consistency, however performance over other heuristic methodologies. Ozgur Koray Sahingoz [8] anticipated to build the versatility of framework, there is networking standards. Networking of multi-UAVs isn't just attractive yet in addition a significant element to build the efficiency of the framework by guaranteeing availability of frameworks in non-LOS, urban, threatening, and additionally noisy environmental management. Due to extremely portable nodes, the networking structure ought to be developed, which needs reliable, real-time and peer-to-peer among UAVs.

Vishal Sharma, [9] proposed G-FANET permits availability between aerial and ground networks to frame a search and tracking based guidance framework. Adding to this structure, quaternion neural feedback replica has been built up that works over fuzzy based decision support system. This decision framework enables genetic modeller to direct traffic flow among nodes working in various transmission conditions utilizing inference rules. The anticipated outline is approved utilizing statistical and mathematical investigation. Investigation demonstrated that G-FANET is equipped for giving fault tolerance and continuous among aerial and ground ad hoc with upgraded traffic the executives and flow control.

Do-Yup Kim [10], examined the topology development issue for FANET. Since we consider the reliance among topology, our concern is NP-hard, therefore, author build up a topology development algorithm dependent on PSO algorithm. Through the simulation outcome it is demonstrated that this algorithm gives a decent topology based on E2E, quality and security from collision.

Gaurav Singal, [11] examines previling mesh based multicast routing protocols. It is extremely induced that choosing QoS metric in MRP. An appropriate QoS is valuable in "goodness" of routing solutions to imperative execution. Different enhancements based on modifications and QoS. They are sorted based on modifications to attain throughput with E2E delay, PDR, CO and PLR. Prevailing multicast routing protocols is introduced and examined with benefits and limitations.

Wajiya Zafar, [12] anticipated the idea of multi-cluster FANETs utilizing IEEE 802.15.4 MAC layer protocol for UAV-to-UAV communication. The anticipated scheme permits collision free, dependable and data transmission with GTS and virtual TDMA and beaconless methods of 802.15.4. It is explored in: OLSR, DSDV and AODV. Outcomes meets QoS increases equivalent to prevailing

examinations performed for cluster network as utilize progressively complex protocols. 802.15.4 have turned out to be a potential candidate appearing 98% PDR and delays to IEEE 802.11 includes complexity and high transmission capacity. Henceforth, it is reasonable decision for applications to transfer speed thorough and lesser information rate. Zeinab Shariat, [13] designed a routing protocol and principle guidelines of NDN is an alternative approach in every path request, along these lines, multicast trees to watch this standard is utilized. One method for multicast trees is provided by Steiner tree development in graph. As indicated by anticipated algorithm, content requester and owners are Steiner tree root and terminal nodes. Dijkstra's algorithm in routing is utilized for automata convergence. Anticipated algorithm using NS2 demonstrates numerical standards. Experimental results demonstrate excellence of the proposed strategy over usual routing protocols as far as throughput, CO, PDR and E2E delay. Zhigao Zheng, [14] described about adaptive hybrid communication protocols including PPMAC and RLSRP. Simulation outcomes demonstrate that anticipated communication protocols outperform existing protocol strategies and can ensure fast link establishment and successful data delivery with low latency. The main contribution of this article is that anticipated protocols can defeat the directional deafness issue. The second is that proposed intelligent and adaptive protocol solution can create communication tasks as indicated by states and natural development of flying UAVs. The third is that the anticipated protocols are strong and solid. At last, proposed hybrid adaptive communication protocols can possibly give an insightful and highly autonomous communication solution for FANETs, and bring up the primary research introduction of FANET protocols. Xianfeng Li, [15] anticipates LEPR protocol dependent on AODV. LEPR builds various reliable link-disjoint paths with link stability metric constructed, and provides preemptive routing maintenance for repairing links that are probably going to break soon. Experimental outcomes demonstrate that LEPR is improved contrasted with AODV and DSR, as in PDR, delay and CO in high or low portability. Ganbayar Gankhuyag,, [16] anticipated novel strong and dependable predictive routing scheme with directional and dynamic angle adjustment transmission for FANETs. A few novel features of anticipated strategy were clarified in detail, for example, forecast of expected connection time, utility function for path selection, directional transmission with fresh update mechanism, dynamic angle adjustment with utilization of an adaptive antenna, alternative path setup, and local path repair. An exhibition assessment of anticipated strategy was done contrasting it with traditional strategy. The outcome demonstrated that proposed routing schemes expanded the route setup success rate and active-path lifetime. With assistance of dynamic angle adjustment PDR, lifetime and disruption time additionally demonstrated improvement, in contrasted with static antenna transmission with non-adaptive antenna.

III.   PROPOSED METHOD

3.1 FANET network model

In FANET, network formation initiates only when UAVs starts flying in the air. With the task based sensors, UAVs are equipped with height sensors and GPS. Sensors equipments offer 3D positional information. Consider four diverse power levels, which associates with transmission ranges of 200, 400, 600, 800 and 1000m correspondingly. Initially, nodes choose highest power level.

Subsequently, nodes adjusted the power level that is most appropriately placed in accordance to position and neighbourhood nodes. This method is utilized to preserve energy.
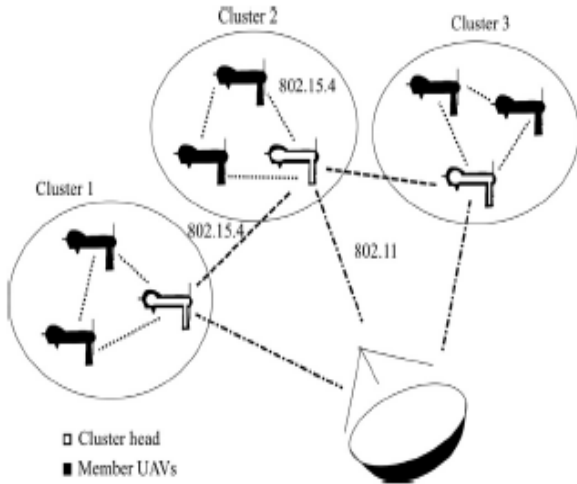

Figure 1: FANET architecture

3.2 Topology construction

The aim of this investigation is to construct a cluster based algorithm that develops a finest topology by locating UAVs at appropriate locations. Based on this application, UAVs has to be located to ensure that every UAV is capable to communicate effectually with GCS. Therefore, the following constraints have to be considered as in Eq. 1:

$$\max_{k=1\dots n} d\left(p_v(k), p_v(k+1)\right) \le d_0, \quad for\ all\ v \in V_m \quad (1)$$

Where $p_v(k)$ is k^{th} routing element from v^{th} to GCS, d_0 is threshold distance for effectual communication.

Constraints of UAV's crashing are also to be considered owing to be of higher speed. They are not flying in high speed, as strong wind hinder UAVs from various locations. Subsequently, the following also to be considered as in Eq.2:

$$\min_{u,V \in V} d\left(u, v\right) \ge d_{safe} \quad (2)$$

where d_{safe} is threshold for minimum safe distance amongst UAVs.

With the system design, and by considering the constraints of optimization problem is designed as in Eq. 3, Eq. 4 and Eq. 5;

$$\min_{X \in S} f(X_{V_G}, X_{V_M}, X_{V_r}, \vartheta) \quad (3)$$

$$\max_{k=1,\dots,|P_v|-1} d\left(p_v(k), p_v(k+1)\right) \le d_0 \quad (4)$$

$$\min_{u,v \in V} d\left(u, v\right) \ge d_{safe} \quad (5)$$

where 'S' is 3 dimensional deployment space, 'R' is the routing path identified using the above equations and objective function 'f' is distinct as ways of system.

The topology construction procedure is anticipated in the section given below using Fuzzy based Markov Chain Clustering approach works in unconstrained optimization. In inequality constraints, optimization crisis is replaced by unconstrained with penalty technique. Therefore, problem can be reformulated as in Eq.6:

$$\min_{X_{VR} \in S|V_R|} F(X_{VR}, \vartheta) = f(X_{VG}, X_{VM}, X_{VR}, \vartheta) +$$
$$\sum_{v \in V_m} ([\max_k d(p_v(k), p_v(k+1)) - d_0])^2 +$$
$$\mu\ ([dsafe - \min_{u,v \in V} d(u,v)])^2 \quad (6)$$

Where, μ is penalty co-efficient constraints. Penalty co-efficient provides solve to above problem.

3.3 Selecting Transmission Range

Transmission range should be maximal acceptable distance between transmitter and receiver such as signal from transmitting to receiving node with signal strength. Power shows signal strength at emission time from transmitter. Range 'R' of node is coupled with power. Frist equation is relationship between P_T and R as in Eq. 7:

$$P_T = P_R + 20 \log\left(\frac{4\pi R}{\lambda}\right) - G_T - G_R \quad (7)$$

G_T and G_R is transmitter and receiver antenna gain, correspondingly. 'λ' is frequency, P_R is receiver sensitivity. It is provided in Eq. (7) for transmission power is higher than range. Moreover, nodes with higher range possess superior connectivity.

Subsequently, higher power consumes diminishes node lifetime. Higher power consumption leads to higher transmission range, however raising power does not double range. Increasing power 100 times increases range. Reduction in range will causes more savings, whilst more transmission power than applicants' requirement reduces amount of energy.

By maintaining transmission power lower does not ensure optimization problem. Lower power transmission offers least communication range those outcomes in lower degree of neighbourhood. Even if the nearer location nodes possess poor connectivity and experiences low link quality. With reduced transmission ranges, neighbourhood nodes alter more rapidly. These modified changes interrupt the data route ad often needs reestablishment of novel routes. Constructing a new route is also determined as a network communication overhead. It takes huge channel bandwidth and drains energy. Poor link quality, change in neighbourhood and route reestablishment outcomes in higher Packet Loss Ratio (PLR) and needs data packets re-transmission. Huge amount of re-transmission takes more energy as more packets to be transmitted to deliver same information; therefore, it is desirable to maintain balance amongst energy optimization and transmission range. A set of values or optimal values are evaluated for FANET application. With optimal outcome, energy consumption has to be optimal. Lower or higher transmission ranges will reduce the node lifetime.

3.4 Fuzzy based Markov model

The real time transmission receives continuous data from the successive data packets rather than losing data packets that have been spotted in advance. In this segment, a hybrid Fuzzy based Markov Chain cluster (FMCC) for continuous dynamic data recognition as in flow chart given below:

The anticipated FMCC model includes five layers: With this,

First and second of Markov based state transmission of Fuzzy based Pre-processing component, 3rd and 4th layers are Fuzzy interference component and fifth layer is de-fuzzification component.

The primary layer is input interface which is responsible for transforming exact variates in input space to space variance. Data transmission is decomposed in changes of packet loss and end to end delay and changes of motion trajectories, and then related with two neurons in first layer as independent observation sequences. After data conversion, two observation sequences are fed to two groups of Fuzzy based Markov Chain Cluster model in Markov model separately.

Input: Initial weight vector W, no. of clusters c.
Output: Cluster centres, membership matrix
1. Let N is total n nodes
2. P is attribute set
3. Weights W = {wi | i = 1, 2, 3…m}. Total weight for parameters is equal to 1
4. Computes a characteristic vector
5. Normalize recognition matrix
6. Use membership functions to compute membership matrix
7. while (iterations)
8. Compute cluster centres with membership matrix
9. for i = 1
10. for j = 1
11. end
12. end
13. Calculating the value of the objective function and compare threshold value.
14. for i = 1
15. for j = 1
16. end
17. end
18. if (iteration~=1))
19. break;
20. end
21. Optimizing U with W and CC
22. for i = 1
23. for j = 1
24. for k = 1
25. end
26. end
27. end
28. Now, optimizing W with U and CC
29. for i=1
30. for k=1
31. for j=1
32. for h=1
33. end
34. end
35. end
36. end
37. end while
38. Assign classes to nodes using membership matrix
39. Calculate accuracy of clustering using confusion matrix

Here, HMM and second layer are fuzzification layer. There is one-to-one mapping between one state transition layers to another state transition layer in second layer. Neuron in second layer specifies fuzzy subclass. If observation sequence is extraneous, it is rejected by anticipated threshold model. Else, it is output by transition model of Markov chain with result that specifies fuzzy subclass to observation sequence. For input observation O, probability is cast off as fuzzy membership degree of fuzzy subclass variable. Neurons defines conditional probability of fuzzy rules.

Third layer is fuzzy inference layer. Every neuron specifies fuzzy rule. As Bayes' rule is unruly for large networks, Sum-Product is utilized for fuzzy inference. For instance, if data transmission is uni-directional (condition C1), and transmission is multi-directional (condition C2), then construct cluster for transmission (rule conclusion). Number of neurons is equal to number of fuzzy rules. Connection neuron weight amongst 2nd and 3rd layers determine conditional parts of fuzzy rules. Output of third layer is calculated as in Eq. 8:

$$O_j^{(3)} = \sum_{i=0}^{n} \varphi_{ij} \, p \, (O \, |\lambda_i), \sum_i \varphi_{i,j} = 1 \qquad (8)$$

where $O_j^{(3)}$ is j^{th} neuron in 3rd layer, $\varphi_{i,j}$ is connection weight amongst i^{th} neuron in 2nd layer and j^{th} neuron in 3rd layer, and n is number of conditional parts of jth neuron.

4th layer is normalization with objective of enhancing convergence speed in training process. Normalization is provided as follows in Eq. 9:

$$O_j^{(4)} = \frac{O_j^{(3)}}{\sum_{j=0}^{N} O_j^{(3)}} \qquad (9)$$

Algorithm 1. Constructing CH

for (i=1 to Y)
if (α < threshold value for connectivity)
if (UAV_i is CH)
Sense other network
Forward request
else
ACK CH of network connectivity
end else if
end if
end for

Algorithm 2. Cluster head selection

for i=1 to Y do
if ($UAVi$ with SNR)
Arrange SNR against UAV IDs
end if
if (UAVi has highest SNR)
Transmit "selection message"
else
Provide message to UAV with SNR
end if
end for

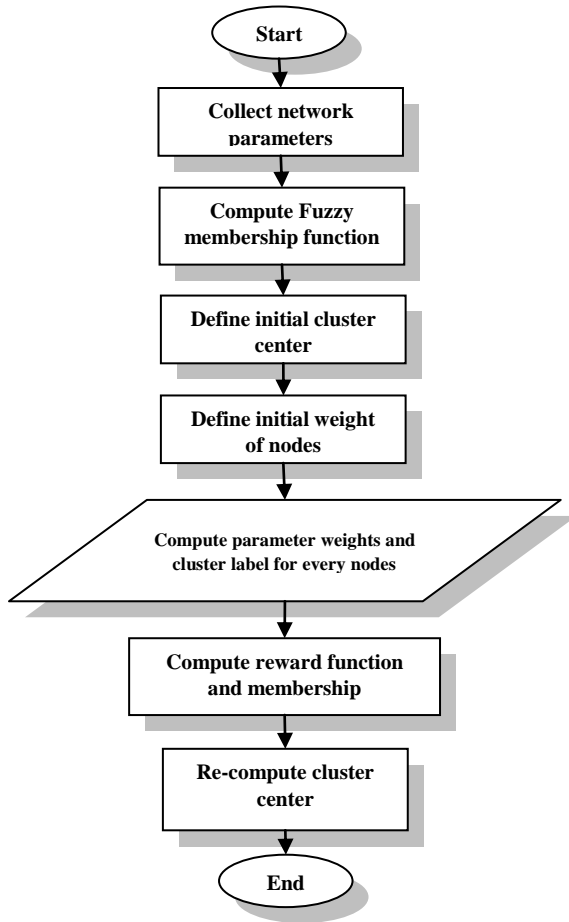| Frequency	2.45 GHz
Constant rate	100 kbps
Sensitivity	-90 dBm

4.1 Cluster formation

There are three factors that influence efficiency of routing protocol. Initially cluster formation, optimizing energy with cluster needs optimal amount of clusters. If number of clusters is lesser than optimal value, some nodes will be placed away from cluster head which leads energy consumption rapidly. If clusters are higher than optimal clusters, huge cluster heads needs to transmit data to longer distances to establish communication with BS. Figure [3] to [10] shows the mobility delay between the clusters and total amount of nodes. The anticipated method considers transmission range to determine number of clusters and cluster size. Henceforth, they have same amount of cluster with diverse node degrees and size. Table shows the control factor based on both mobility and pause time.
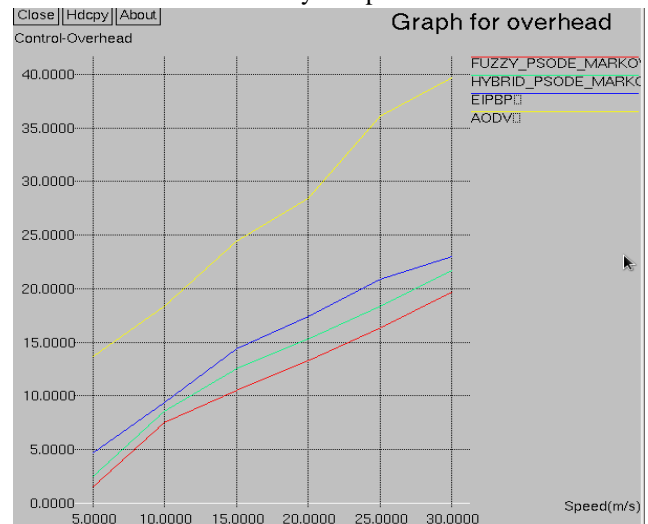

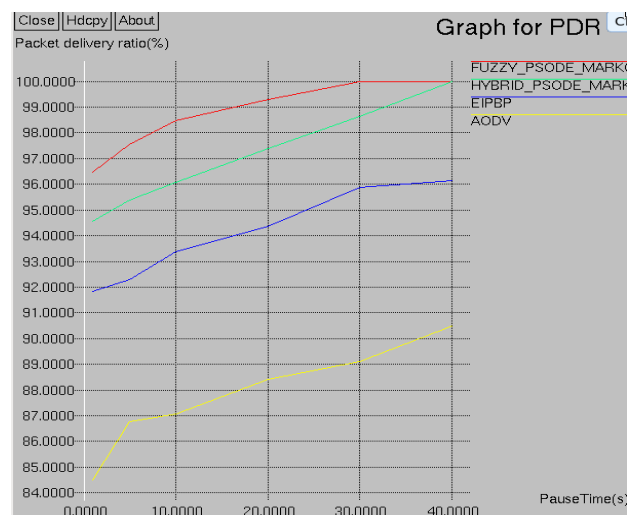**Figure 3: Mobility based Overhead computation**

Figure 4: Mobility based PDR computation

Figure 2: Flow diagram of proposed FCMM model

The Final layer of cluster the network state is by defuzzification layer. In first layer, final attempts to transform variables to exact output. Fifth layer output is evaluated as in Eq. 10:

$$O_j^{(5)} = \sum_{j=0}^{N} \varphi_j O_j^4; \qquad \sum_{j=0}^{N} \varphi_j = 1 \qquad (10)$$

where ωj is jth rule to classification outcomes, and N is fuzzy rules.

IV. SIMULATION RESULTS

Here, performance metrics of anticipated routing protocol termed as Fuzzy based Markov chain Cluster (FMCC) is measured. These metrics are utilized to examine the performance such as mobility control, mobility delay, mobility PDR, and mobility energy. Similarly, metrics such as pause time delay, pause time control, pause time PDR and pause time energy is also examined. The simulation was performed in MATLAB. Parameter settings are provided in table given below:

Table I: Simulation setup

Parameters	Value
Size	3 * 3 km^2
Total nodes	20, 30, 40, 50, 60
Distance	2m
Mobility	Reference point
Time	10
Transmission range	Dynamic

Figure 5: Mobility based Energy computation

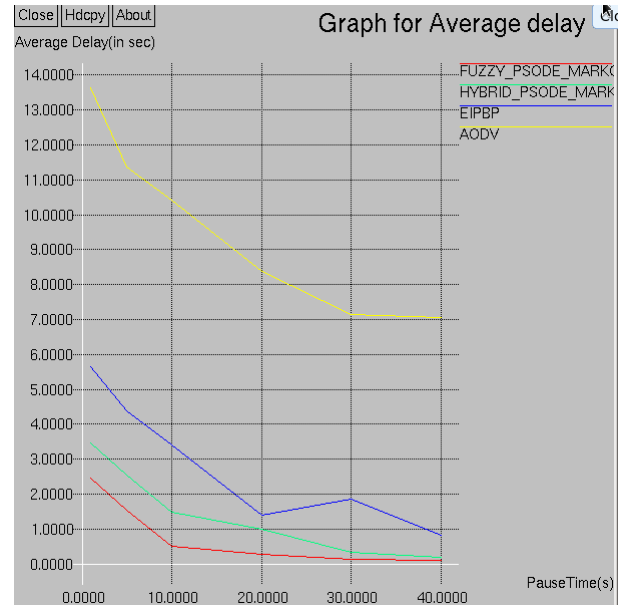**Figure 6: Pause time based Overhead computation**

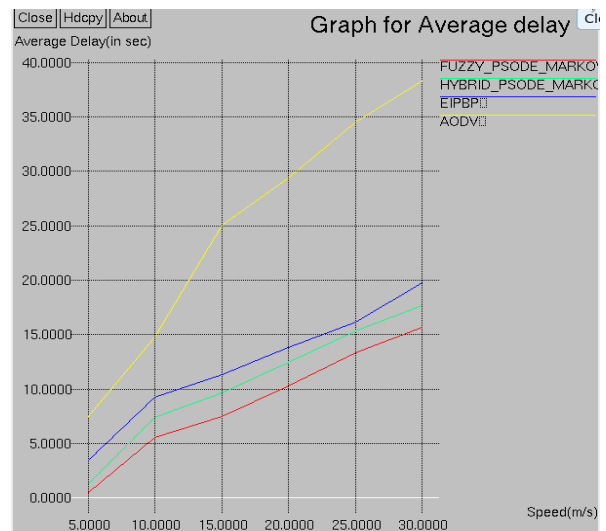**Figure 7: Pause time based PDR computation**

Figure 8: Mobility based Delay computation
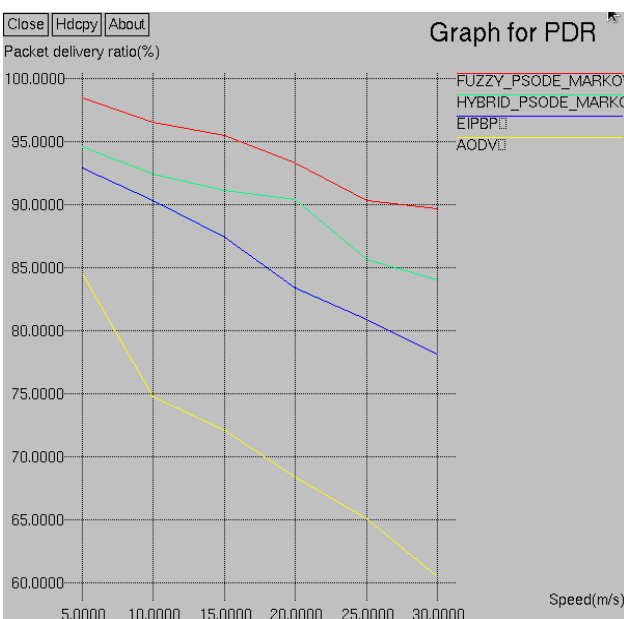

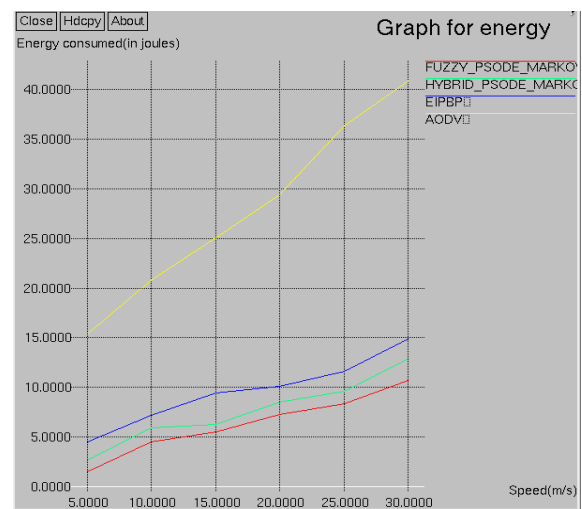**Figure 9: Pause time based Delay computation**

Figure 10: Pause time based Energy computation

Table II: Mobility Computation

NODES	AODV	EIPBP	HYBRID PSODE-MARKOV	FUZZY_PSODE_MARKOV
5	13.5	4.65	2.47	1.47
10	18.38	9.38	8.54	7.54
15	24.42	14.42	12.49	10.49
20	28.39	17.39	15.28	13.28
25	36.15	20.85	18.33	16.33
30	39.72	22.99	21.69	19.69

Table III: Pause Time Computation

Nodes	AODV	EIPBP	HYBRID PSODE-MARKOV	FUZZY_PSODE_MARKOV
5	17.65	8.65	6.47	4.47
10	15.38	7.38	5.54	3.54
15	14.42	6.42	4.49	2.49
20	12.39	5.39	2.28	1.28
25	9.15	2.48	1.33	0.33
30	8.05	1.19	0.69	0.19

4.2 Cluster formation time

Cluster formation time is known as the time taken by the proposed technique to carry out clustering. During clustering process, fitness value is considered as an input and elects CH and its corresponding members as output. Time elapsed between input and output is known as cluster building time. This determines the computational complexity of algorithm. UAV nodes have lesser computational power and memory.

Higher cluster size influences task oriented performance. It Consumes more energy and diminishes UAVs lifetime. Figure 10 shows the increase in number of nodes and cluster size corresponding to the proposed method. The ultimate cause of this is the random solution and iterative convergence towards optimal solution; moreover, it provides only one solution and reduces the delay to find an optimal route. It as well saves nodes energy during complex computations.

Table IV: Mobility based delay

Nodes	AODV	EIPBP	HYBRID PSODE-MARKOV	FUZZY_PSODE_MARKOV
5	7.49	3.49	1.34	0.47
10	14.76	9.28	7.38	5.54
15	25.07	11.37	9.67	7.49
20	29.43	13.83	12.48	10.28
25	34.57	16.18	15.33	13.33
30	38.34	19.74	17.69	15.69

Table V: Pause time based delay

Nodes	AODV	EIPBP	HYBRID PSODE-MARKOV	FUZZY_PSODE_MARKOV
5	13.65	5.65	3.47	2.47
10	11.38	4.38	2.54	1.54
15	10.42	3.42	1.49	0.49
20	8.39	1.39	0.98	0.28
25	7.15	1.85	0.33	0.13
30	7.05	0.83	0.9	0.09

4.3 Cluster Lifetime

Cluster lifetime is based on the energy consumed by nodes, i.e. elapsed time since cluster formation till destruction. During the completion of algorithm process, nodes determine the role of cluster head and take the responsibility of managing clusters. Cluster head reduces passage time. When it falls below threshold, clustering is performed. Shorter the cluster lifetime, then higher number of cluster recall. This enhances communicational and computational overhead in network. Figure 9 depicts energy utilization of nodes in cluster and also by CH. Table ii shows the mobility based energy consumption and pause time based energy consumption of nodes. Shorter cluster lifetime, more number of times cluster is recalled. This reduces communicational and computational overhead.

Table VI: Mobility based energy consumption

Nodes	AODV	EIPBP	HYBRID PSODE-MARKOV	FUZZY_PSODE_MARKOV
5	15.34	4.48	2.65	1.47
10	20.76	7.21	5.93	4.54
15	25.07	9.48	6.30	5.49
20	29.43	10.12	8.48	7.28
25	36.36	11.64	9.64	8.33
30	40.88	14.83	12.83	10.69

Table VII: Pause time based energy consumption

Nodes	AODV	EIPBP	HYBRID PSODE-MARKOV	FUZZY_PSODE_MARKOV
5	18.65	9.65	6.96	5.47
10	16.38	7.38	6.54	4.54
15	15.42	6.42	5.82	3.49
20	12.39	5.39	4.28	2.28
25	11.15	4.85	3.33	1.33
30	7.05	0.83	0.9	0.09

Table VIII: Mobility based PDR

Nodes	AODV	EIPBP	HYBRID PSODE-MARKOV	FUZZY_PSODE_MARKOV
5	84.49	92.85	94.56	98.47
10	74.76	90.29	92.38	96.54
15	72.07	87.38	91.09	95.49
20	68.43	83.38	90.39	93.28
25	65.11	80.89	85.65	90.33
30	60.48	78.13	83.99	89.69

Table IX: Pause time based PDR

Nodes	AODV	EIPBP	HYBRID PSODE-MARKOV	FUZZY_PSODE_MARKOV
5	84.49	91.85	94.56	96.47
10	86.76	92.29	95.38	97.54
15	87.07	93.38	96.09	98.49
20	88.43	94.38	97.39	99.28
25	89.11	95.89	98.65	100
30	90.48	96.13	99.99	100

V.   CONCLUSION

FANET offers an effectual real time communication solution for multiple UAV, however, it faces certain confronting crisis in networking and communications. This work anticipates an adaptive routing protocol known as Fuzzy based Markov chain Cluster (FMCC). The simulation outcomes demonstrate that the anticipated communication routing protocol outperforms existing protocols strategy and it ensures route establishment and successful packet delivery ratio with reduced delay. The initial contribution of this work is that the anticipated protocol can overcome routing failures during data transmission. The secondary contribution of this work is providing solution for communication operations in environmental and state evolution of flying UAVs. Last contribution is the reliable and robust protocol. At last, establish an intelligent and autonomous communication.

This investigation considers only the simplest mobility model, in future more mobility and pause time based UAVs should be anticipated. Optimization techniques can be involved to speed up the routing protocol, so as to enhance reliability and flexibility. FANET size can also be scaled up when nodes are placed randomly.

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