Flying Ad Hoc Network Framework using Fuzzy Inference System for Efficient Routing

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Abstract— **In the development of technology, network communication plays the important role to transfer data from every area, unmanned aerial vehicles (UAVs) is enhanced system for retrieving the data and provide real time communication from emergency situation or from remote areas. Multiple UAVs node form the flying ad hoc network where each UAVs capable to take decision to provide route from source to receiver in dynamic environment. Due to energy and high mobility of UAVs node rapid change the topology which increases the high average number of utilization and provide low network link connectivity. Those problem analyze by various existing technique out of those technique, we found that fuzzy reinforce technique is better perform with respect to number of hop uses during communication and link connectivity. In this paper use the same fuzzy logic system but take new input factor for fuzzy system development and fuzzy rule designing. The new factor is energy which is more important for route decision because without energy analysis cannot identify reliable path. In this paper take the three factor energy, stability rating and delay for fuzzy rule designing. From the analysis we found that proposed system is more reliable in terms of link connectivity, low number of hop involvement, percentage of data receiving, throughput, delay etc. The analysis are done through the network simulator -2 which simulate two environment fifty and hundred node scenarios.**

Index Terms*— *FANET, Fuzzy Logic, Routing, Energy, throughput, Delay

I. INTRODUCTION

Unmanned aerial vehicles (UAV) are becoming more common in our everyday lives as technology progresses. The Flying Ad Hoc Network (FANET) is taking shape. At the moment, UAVs are becoming increasingly important in disaster monitoring, geological surveys, traffic control, communications relays, and emergency communications. The more broadly it affects, the higher the level anticipated. The topology of the flying ad hoc network changes rapidly due to the high speed of the nodes and bursts of flying commands. The problem is that when a node needs to communicate with another, the expected node can be unable to establish secure communication links. What distinguishes FANET routing algorithms is that they not only locate the route but also pack and relay information to the destination node in order for the communication to succeed. So, the first concern should be which rule should be used to validate the next node.

Nowadays, many researchers use sophisticated technologies to enhance the communication efficiency of FANET, primarily MAC layer protocol, network layer protocol, and hybrid layer protocol, with the aim of routing algorithms in the network layer. Cai et al. [19] employ a token-based MAC protocol to reduce connection interference caused by high mobility.

Alshabtat et al. proposed a routing protocol called Directional Optimized Connection State Routing Protocol (DOLSR) in [20] and an adoptive MAC protocol with an omni-directional and a directional antenna in [21]. It will increase network efficiency because it incorporates the directivity and external parameters of the antenna system. According to Sahingoz in [22] using intelligent MAC and Optimized Link State Routing (OLSR) as MAC layer and network layer protocols, respectively, will provide better end-to-end delay and control overhead.

Temel and Bekmezci [23] suggested a FANET forwarding mechanism in to reduce redundant broadcasting and collision, thereby improving end-to-end delay and packet transmission rate. Shrestha [24] suggested a routing protocol in that uses OLSR and directional antennas to reduce the number of multiple relays and transmission delays while increasing throughput. Wang [25] proposed the Reverse Address Resolution Protocol (RARP) routing protocol in to improve the robustness and reliability of the existing routing path as well as communication efficiency. To put it another way, some of them recommend first confirming the relay nodes that can communicate directly with the starting node and send messages to them. Then repeat the procedure to locate the destination node. However, due to the high speed of the topology transition, this mechanized process produces poor results. The communication would fail if there are no relay nodes through which to communicate.

Paper are divided into multiple section, in section I describe about introduction, section II provide the literature survey, section III describe about our proposed work, section IV define the result discussion and section V describe about conclusion of proposed approach.

II. LITERATURE SURVEY

In this section discuss the existing work in the field of flying ad hoc network. Those works helps to provide new way for reliable and effiecient routing in flying ad hoc network.

Chenguang He, *et. al.*[1] "A Fuzzy Logic Reinforcement Learning-Based Routing Algorithm For Flying Ad Hoc Networks" in this paper adopts a fuzzy logic reinforcement learning-based routing algorithm for flying ad hoc networks. The fuzzy logic mainly determines the neighbor nodes of a node in real time. Reinforcement learning reduces the average number of hops of the route determined by fuzzy logic through continuous training. Compared with the ant colony algorithm optimization(ACO), the proposed FANET routing algorithm has significant improvement in both link success rate and average hop count. The situation is more perfect and it can better meet the requirements of the network.

T. Zhang, *et. al.* [2], Unmanned aerial vehicle (UAV)-assisted mobile edge computing (MEC) system is a prominent concept, where a UAV equipped with an MEC server is deployed to serve a number of terminal devices (TDs) of Internet of Things in a finite period. In this article, each TD has a certain latency-critical computation task in each time slot to complete. Three computation strategies can be available to each TD. First, each TD can operate local computing by itself. Second, each TD can partially offload task bits to the UAV for computing. Third, each TD can choose to offload task bits to access point via UAV relaying.

Q. Hu, *et. al.* [3], the UAV moves around above the ground users and provides computing service in an orthogonal multiple access manner over time. For each time period, we aim to minimize the sum of the maximum delay among all the users in each time slot by jointly optimizing the UAV trajectory, the ratio of offloading tasks, and the user scheduling variables, subject to the discrete binary constraints, the energy consumption constraints, and the UAV trajectory constraints. This problem has highly nonconvex objective function and constraints.

Y Wang, *et. al.* [4], in this system, we need to optimize the deployment of UAVs, by considering their number and locations. At the same time, to provide good services for all mobile users, it is necessary to optimize task scheduling. Specifically, for each mobile user, we need to determine whether its task is executed locally or on a UAV (i.e., offloading decision), and how many resources should be allocated (i.e., resource allocation). This article presents a two-layer optimization method for jointly optimizing the deployment of UAVs and task scheduling, with the aim of minimizing system energy consumption. By analyzing this system, we obtain the following property: the number of UAVs should be as small as possible under the condition that all tasks can be completed.

Oubbati *et al.,[*5] "A survey on position-based routing protocols for flying ad-hoc networks (FANETs)," proposed a classification and taxonomy of position-based routing protocols, including a detailed description of the routing schemes. Then, they proposed a comparative study for these protocols, and presented some new challenges in future research.

Arafat *et al.* [6] "A survey on cluster-based routing protocols for unmanned aerial vehicle networks," investigated cluster-based routing protocols for UAV networks and qualitatively compared these protocols in terms of outstanding features, characteristics, competitive advantages, and limitations.

Sharma *et al.* [7] "Distributed priority tree-based routing protocol for FANETs "considered the problem of network partitioning between the aerial ad hoc network and the ground ad hoc network, and proposed a routing protocol to handle transmission in mutually coordinated system. Based on a combination of three major schemes, viz., link quality scheme, traffic load scheme and spatial distance scheme,.

Gankhuyag *et al.* [8] "Robust and reliable predictive routing strategy for flying ad-hoc networks," proposed a combined omni directional and directional transmission scheme with dynamic angle adjustment, which can enable routing protocols in MANETs to be suitable for FANETs. In order to meet different data rate and timeliness requirements of different services in aeronautical network communications based on frequency and time-hopping mechanism,.

Fang *et al.* [9] "A QoS guarantee based hybrid media access control protocol of aeronautical ad hoc network," proposed a hybrid media access control protocol based on pre-allocation of transmission time slots and immediate access. The routing algorithms mentioned above only consider the reliability of transmission and ignore the delay constraint attached to the packets.

Guo *et al.* [10] "Joint optimal data rate and power allocation in lossy mobile ad hoc networks with delay-constrained traffics," proposed a cross-layer rate-effective network utility maximization (RENUM) routing policy by taking into account the lossy nature of wireless links and the constraints of power and average delay in a multi-hop manner. To provide the reliable and timely routing services for delay-aware applications in wireless sensor network with lost channel,

Xu *et al.* [11] "A cross-layer optimized opportunistic routing scheme for loss-and-delay sensitive WSNs," proposed a Cross-layer Optimized Opportunistic Routing scheme to improve the communication link reliability and reduce delay by exploiting the remaining energy in networks to increase the transmission power of most nodes.

Ploumidis *et al.* [12] "Flow allocation for maximum throughput and bounded delay on multiple disjoint paths for random access wireless multi-hop networks" explored the issue of multiple flow allocation on multiple paths in random-access wireless with multi-packet reception capabilities. The problem is formulated as a non-convex optimization problem and a distributed flow allocation scheme is proposed to maximize average aggregate flow throughput and reduce packet delay. Due to the requirement of network redeployment or replanning, existing solutions fail to handle QoS-aware data dissemination in next generation wireless networks;.

Hajiesmaili *et al.* [13] "Utility-optimal dynamic rate allocation under average end-to-end delay requirements." proposed a delay-aware dynamic network utility maximization algorithm as a dual-based solution to the rate control problem for real-time streaming and video surveillance systems. The algorithm strives to achieve the maximum network utility aggregated over a fixed time interval in a distributed fashion. In real-time multimedia applications, there is a fundamental issue that how to find a feasible path that satisfies multiple constraints. To solve this issue, **Torkzadeh *et al.* [14]** "Multi-constraint QoS routing using a customized lightweight evolutionary strategy, "in this title they proposed a novel multi-constraint QoS routing algorithm based on evolutionary strategies which is lightweight and finds feasible solutions in a very short time. **Yahiaoui *et al.* [15]** "An energy efficient and QoS aware routing protocol for wireless sensor and actuator networks," proposed a delay and energy sensitive routing protocol based on-demand routing approach that provides QoS in terms of end-to-end delay and energy consumption. These studies do not consider the network topology changes and time-varying channel states, and hence their performances are insignificant in FANETs without modification. However, these methods open a door in designing cross-layer optimization in Delay-Constrained FANETs. There are already many works proposed to solve the cross-layer optimization problem.

Tsiropoulou *et al.* [16] "Combined power and rate allocation in self-optimized multi-service two-tier femtocell networks," proposed a utility-based game theoretic framework for simultaneously optimizing users' uplink transmission power and rate in multi-service two-tier open-access femtocell networks, and their distributed algorithms are designed to obtain the corresponding equilibrium point.

Kim *et al.* [17] "Maximization of minimum rate for wireless powered communication networks in interference channel," studied a minimum rate maximization problem to overcome a severe imbalance in wireless powered communication networks with an interference channel. And they also proposed an algorithm that updates the time allocation and the users' transmit power based on the Lagrangian duality method and the Perron-Frobenius theorem.

Duan et al. [18] "Resource allocation optimisation for delay sensitive traffic in energy harvesting cloud radio access network," studied a resource allocation scheme for delay-sensitive applications in an energy harvesting-cloud radio access network, and proposed an optimal resource allocation algorithm to maximise users' utility while guaranteeing the delay bound. The optimization algorithms presented above do not consider either the changes in network topology or delay-constrained transmission, and hence they cannot be used directly to solve the optimization problem in delay-constrained FANETs.

III. Proposed Work

Multi-UAV system can form various types of networks depending upon the requirements and deploying environment. These types of networks use UAVs as key role players in the network formation. Thus, these types of networks are also termed as UAVs Oriented Network. The multi-UAV system can be a simple collection of UAVs with autonomous capabilities or controllable by remote pilots. Proposed system uses the technique of fuzzy logic to provide efficient routing for reliable communication in flying ad hoc network. Fuzzy logic work based on fuzzy inference system that includes the system rule base, input membership functions that fuzzy the input variables and the output variable de-fuzzification process. Fuzzification is a procedure where crisp input values are represented in terms of the membership function, of the fuzzy sets. The fuzzy logic controller triangular membership functions are defined over the range of the fuzzy input values. Fuzzification process the inference engine determines the fuzzy output using fuzzy rules that are in the form of if then rules. De-fuzzification is then used to translate the fuzzy output to a crisp value. Proposed fuzzy system take input parameter as energy of node, stability rating, delay between source to destination, those input value range 0 to 1 (include 0 and 1) which classified into three classes low, medium and high as per evaluation of outcome which shows in respective membership graph. Based on their composite value IF-THEN fuzzy rule develop those rule help to translate fuzzy output to a crisp value by De-fuzzification process. Our outcome crisp values are useful to decide which route is better and which is bad or not useful for the communication.

A. Fuzzification:

Fuzzification is a process to evaluate best relay node in the network which provide the best route based on inference outcome. In our fuzzy system there are three factors for evaluate best relay node i.e. energy remain (ER), delay measure (DM) and stability rating (SR). Collaborative inference value provide best relay node for route decision.

A.1 Energy Remain (ER):

Any flying device active or perform any task based on energy, while energy value is sufficient than device is fly and perform communication activity. Remain energy evaluate based on three classes Low, Medium and High. While node energy level less than 0.3 it will be consider in Low class and node not capable to provide UAV to UAV communication so low energy node not participated in route decision. In medium node energy consider in between 0.3 to 1 represented by red line other side while energy value in between 0.3 to 1 it also consider high level but is inverse of medium class and represented by blue line in the figure 1.

ER Evaluation:

$$ER = \begin{cases} 1 \; Nre(x) \geq 90 \, joule \\ \frac{1}{Nre}, \quad Otherwise \end{cases} \qquad (1)$$

Where the Nre(x) refers to the x number of node in route which shows the energy remains value.

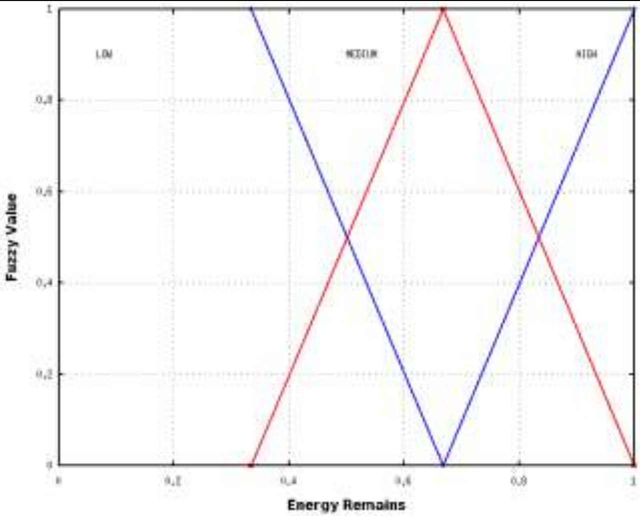

Figure 1: Remaining Energy of UAV

A.2 Delay Measure:

In flying ad hoc network delay is important parameter for route establishment process because of delay is change with respect to node movement. In the communication process required the minimum delay with request to efficiency.

DM formulation:

$$DM\, e(x) = \begin{cases} \frac{d(x,c)}{R}, & d(x,c) < R \\ 1, & d(x,c) \geq R \end{cases} \qquad (2)$$

Where d(n, c) refers the distance between the node x and the node c. In our proposed system we consider the transmission delay between the start and end nodes and don't consider the switching time between the beam antennas, so delay measure DM will determined by distance. The membership function of the transmission delay is shown in figure 2.

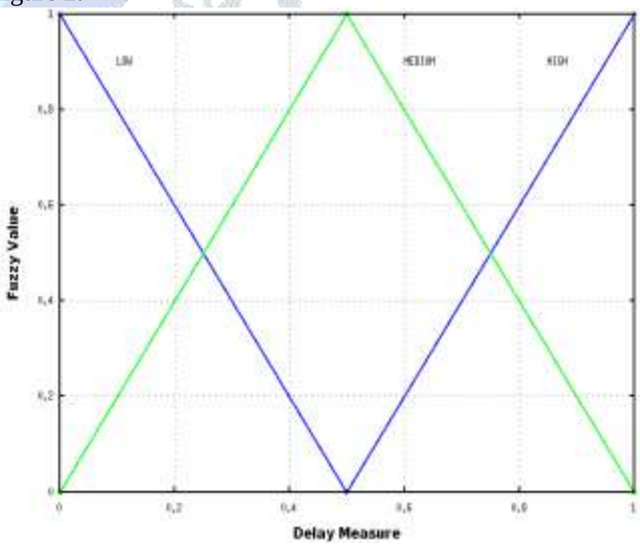

Figure 2: Delay Measure of UAV

A.3 Stability Rating:

Stability rating is depends on node movement while movement is lower node stability rating is higher else stability rating is lower. In our proposed system SR classify by the three classes low, medium and high.

Calculation of Stability Rating (SR)

$$SR(s,x) = \frac{|v(x)| - miny \in Ns \, |v(y)|}{maxy \in Ns \, |v(y)|} \qquad (3)$$

Where v(x) is the speed of the UAV node, Ns is the set of the neighbor nodes of the current UAV. The higher the SR is, the more stable the neighbor node will be. And the initial value of SR is zero.

$$SR(s,x) = (1-\alpha)SR_i - 1 + aSR_i(s,x) \qquad (4)$$

Where α is smooth factor set as 0.7, which is decided by previous researches and analysis. The membership function of the stability rating is shown in figure 3.

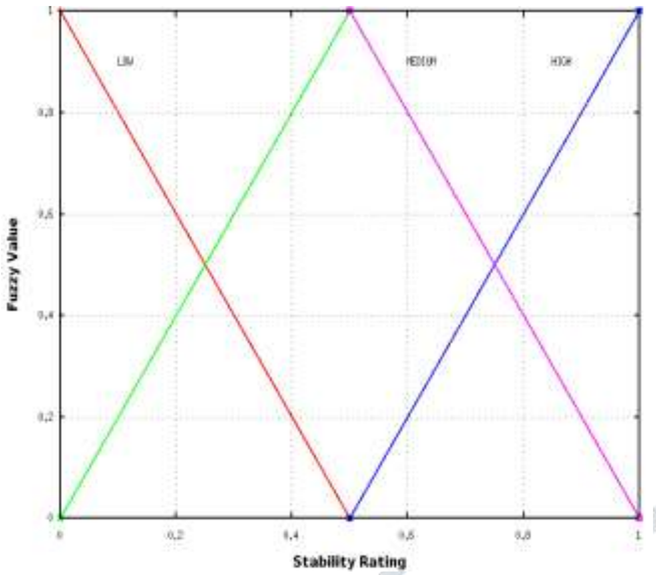

Figure 3: Stability rating of the link

B. Fuzzy Rule:

In our propose approach choose IF/THEN rules to be the fuzzy rules. IF means the condition, and THEN means the consequences. As is mentioned above, we can obtain the concrete numbers of ER, DM and SR. The sender nodes define these outputs into perfect, good, acceptable, not acceptable, bad, very bad these six levels according to the IF/THEN rules. For instance, as the chart shown below, the first rule is defined: ER is high, DM is low and SR is high, then the output level is perfect. Other rules are listed in the IF/THEN rules chart.

Table 1: Defining Fuzzy IF/Then Rules

	ER	DM	SR	LEVEL
Rule1	HIGH	LOW	HIGH	Prefect
Rule2	MEDIUM	LOW	HIGH	Good
Rule3	LOW	LOW	HIGH	Not Acceptable
Rule4	HIGH	LOW	MEDIUM	Good
Rule5	MEDIUM	LOW	MEDIUM	Acceptable
Rule6	LOW	LOW	MEDIUM	Bad
Rule7	HIGH	LOW	LOW	Not Acceptable
Rule8	MEDIUM	LOW	LOW	Bad
Rule9	LOW	LOW	LOW	Very Bad
Rule10	HIGH	MEDIUM	HIGH	Good
Rule11	MEDIUM	MEDIUM	HIGH	Acceptable

C. De-fuzzification:

In fuzzy logic, defuzzification is the last step of fuzzification. The output language set obtained from IF/THEN rules will be transferred into concrete numbers. In this paper, we will use the COG (Center of Gravity) method to accomplish defuzzification. The main theory of COG is taking the center of gravity of the area enclosed by the output membership function curve and the abscissa as the final output value of the fuzzy control. For continuous domain, the formulation is as followed:

$$Out = \frac{\int_v v\mu v(v)dv}{\int_v \mu v(v)dv} \quad (5)$$

With the analysis of fuzzification, we can obtain the membership function and its shown as figure 4. The membership function is shown below:

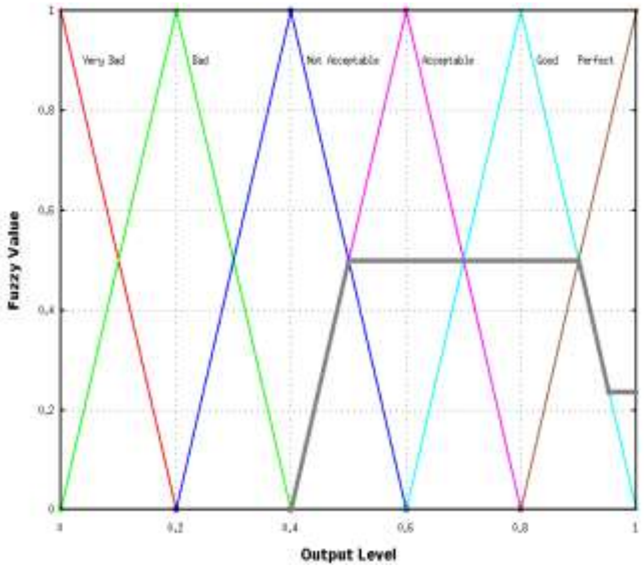

Figure 4: COG method to realize De-fuzzification

D. Proposed Algorithm:

Algorithm: Flying Ad Hoc Network Framework using Fuzzy Inference System for Efficient Routing

Input: Energy remain (ER), Delay Measure (DM), Stability Rating (SR)

Output: Efficient Route with low average number of hops, high connectivity, higher throughput, PDR and low delay

Procedure:

1. Initialize ER: 0, DM: 0 and SR:0
2. Use Routing Protocol and assign value ER, DM, SR ∀hop in route
3. Take value of ER, DM & SR in real time
4. Use IF/THEN fuzzy rules of fuzzification for ER, DM & SR
5. Use COG method for de-fuzzification
6. Execute action at in the system and obtain reward value r_t
7. Select route bases on reward value
8. **Return** Efficient route
9. Send Data from Source to Destination by selected route

End Procedure

IV. RESULT DESCRIPTION

A. Simulation Parameter

Flying ad hoc network is a collection of flying device which is known as UAVs communicate with each other with multi-point based technique and send real time information to ground station. FANET is two type UAVs to UAVs based communication and other is UAVs communicate through ground base satiation. In our simulation FANET create network based on UAVs to UAVs based communication which is infrastructure less mechanism to transfer data from flying device to ground base station. FANET network simulated through network simulator-2.31 and configure network through the given parameter in table 2.

Table 2: Simulation Parameter for FANET Analysis

Parameters	Configuration Value
Simulation Tool	NS-2.31
Routing Protocol	AODV
Simulation Area	2400m*1000m
Network Type	FANET
Number of Nodes (UAVs)	50,100
Ground Control Station	5
Physical Medium	Wireless, 802.11
Simulation Time (Sec)	250Sec
MAC Layer	802.11
Antenna Model	Omni Antenna
Traffic Type	CBR, FTP
Propagation radio model	Two ray ground
Energy (Initial)/J	100 Joule

B. FANET Scenario

In this section represent flying network architecture which defines the number of UAVs in network which is moveable. Each UAVs moves in define line of sight and communicate each other through UAVs radio range based method. All UAVs configure by routing protocol which is on demand based routing strategy. The network animator shows the hundred fly devices which send the data to ground base station using multipoint methodology. The FANET is semi infrastructure based system where network topology is change with respect to UAVs system but ground base station is fixed. In this scenario blue blinked circle represent RTS/CTS message generation by source node which sense the neighbour UAVs to established the route from source to destination with the help of routing protocol. In the FANET data is transmitted in two ways such as TCP or UDP based transport protocol while route are established.

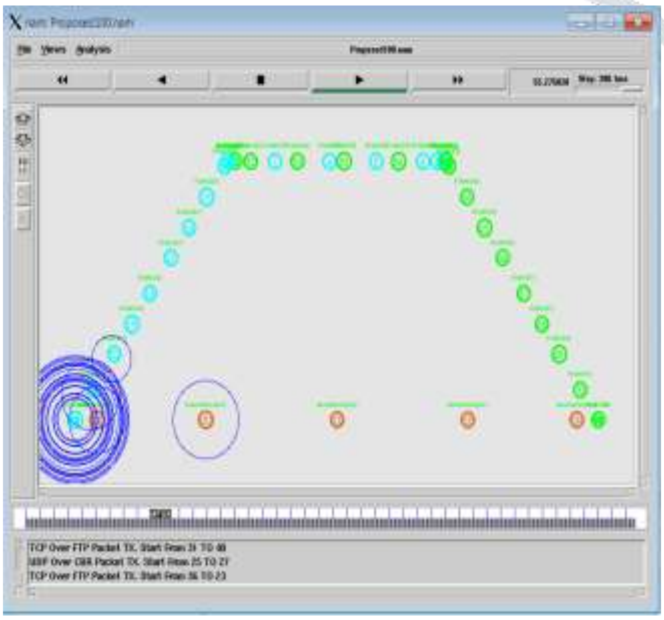

Figure 5: FANET Scenario with Ground Control System

C. Number of Hops in Communication

In order to verify the proposed algorithm, simulation architecture are implemented. We take the network size is 2400mX1000mX2400m with respect to X, Y and Z coordinates where Flying devices move in particular line of sight with fix speed. The proposed fuzzy algorithm constructs the route and validate by outcomes of network parameters, from out of those parameter number of hops in communication one of the important parameter to validate our algorithm. In the result graph four different results are represented where blue and pink line shows the result at proposed fuzzy system time for respective 50 and 100 device scenarios. Similarly red and green line represent number of hops in communication during existing fuzzy-reinforce learning case for respective 50 and 100 node scenarios. While number of hops uses in communication is lower it means network perform better with respect to bandwidth, energy and route stability which is our network input parameters. In this graph X-axis shows simulation time which range 0-to-250 seconds and Y-axis shows the number of hops uses for the communication. While we compare number of hops uses during proposed fuzzy system in both 50 and 100 scenarios with existing fuzzy reinforce technique respectively. Through the result conclude that our proposed system take lesser number of hop count which is better out come as compare to exiting system.

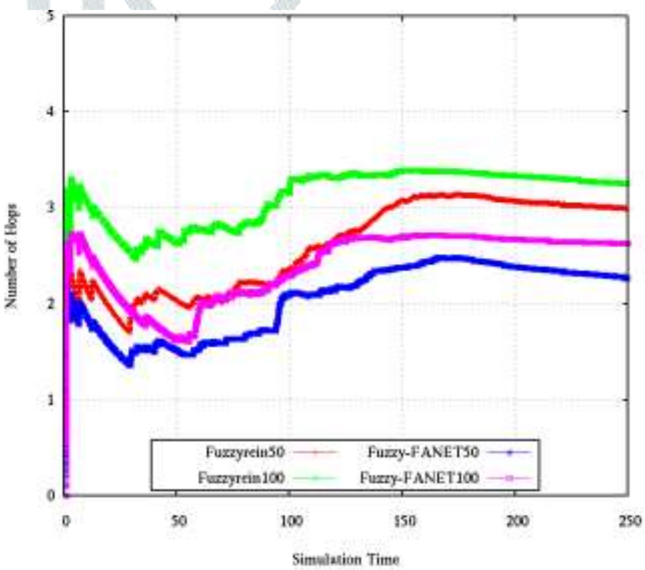

Figure 6: Number of Hops in Communication Path

D. Link Connectivity

Link connectivity is a one of the important parameter for network reliability detection. In the result link reliability measured based on fuzzy logic system, which range in between 0 to 1 shows in Y-Axis. Other side X-Axis shows the simulation time in seconds. The link connectivity is more reliable while the value is higher, in this graph link connectivity retrieve in two different network scenarios 50 and 100 node and compare two algorithm existing fuzzy reinforce with proposed fuzzy rule based technique. In the result graph 7 while compare 50 and 100 node scenario in existing technique with proposed fuzzy-FANET then get the average link connectivity of fuzzy FANET provide higher in both scenario. The resultant graph validate through two different scenario using network scenario and conclude that proposed fuzzy-FANET system is more reliable in any scenario.

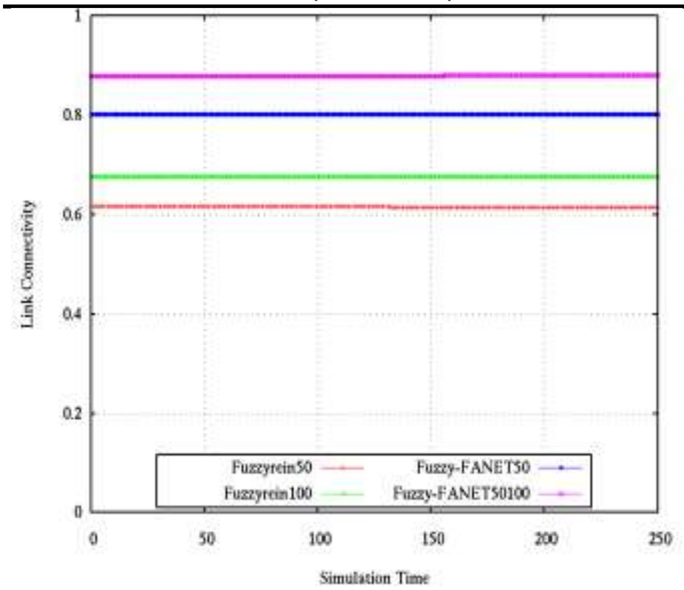

Figure 7: Analysis of Link Connectivity

E. Percentage of Data Receives

In any communication successful data receiving in destination side is important to measure the network reliability. In our proposed fuzzy-FANET system take the three criteria to select the route which is energy, stability rating and delay. All three parameters quantized and form three classes LOW, MEDIUM and HIGH and at the end de-fuzzification process retrieve the inference of fuzzy system. The Proposed system apply in routing decision and select the best route based on rule and selected route provide more reliable communication as compare to existing system. In the resultant graph 8 compare percentage of successful data receive in destination. Result retrieve in two scenario 50 and 100 nodes and compare existing with proposed system, in fifty node scenario existing system provide 74.98% data receiving and proposed system provide 92.83% similarly hundred node scenario existing system give 83.92% data receiving and proposed provide 95.88%. In the result outcome based conclude that proposed fuzzy-FANET provide higher data receiving as compare to existing system in all scenarios.

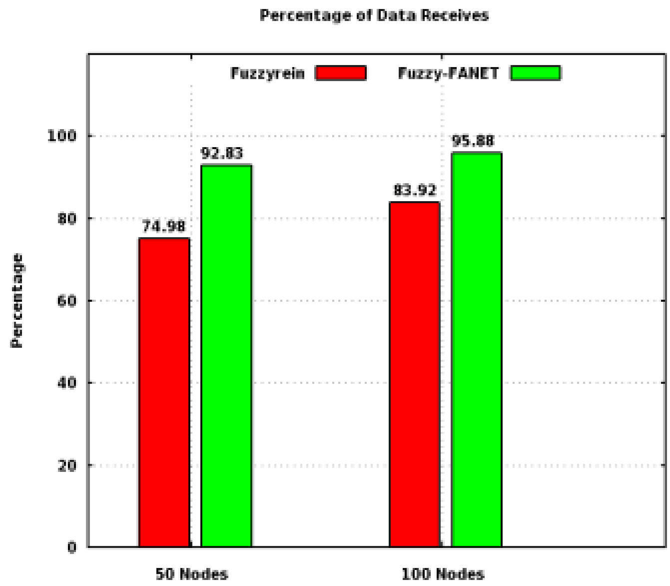

Figure 8: Percentage of Data Receive Analysis

Table 3: Percentage of Data Receives

No of Nodes	FuzzyRein	Fuzzy-FANET
50	74.98	92.83
100	83.92	95.88

F. Average Delay in [ms]

Fly ad hoc network is a semi infrastructure based technique where UAVs are dynamical move from one location to another in defined zone where UAVs also capable to decide route. Other side ground base station also handles the UAVs and established the communication from UAVs. Due to node UAVs mobility network topology changes in every discrete time interval which effect to delay parameter. In the below resultant graph 4 and their respective table 4 shows the average network delay in two scenarios fifty and hundred nodes with existing fuzzy reinforce technique and proposed fuzzy-FANET. In the graph red bar graph shows the existing system result and green bar graph shows proposed system result, while we compare analytically average delay in fifty node case during existing system which is 0.19 ms and proposed system reduces the average delay which is 0.11ms. Similarly at hundred node scenario existing system give 0.33ms average delay and proposed system reduce the average delay which is 0.26ms. Through the result conclude that proposed fuzzy system decreases the network delay which provides prefect adoptability for FANET system.

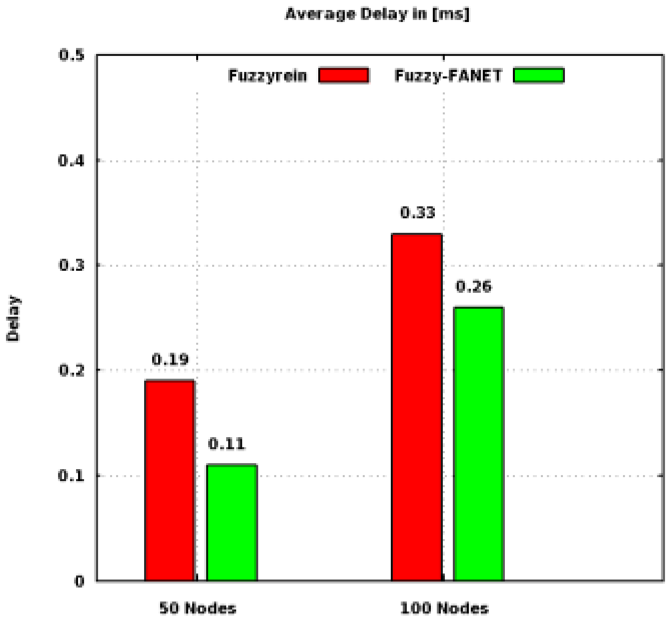

Figure 9: Average Delay Analysis [ms]

Table 4: Average Delay Analysis [ms]

No of Nodes	FuzzyRein	Fuzzy-FANET
50	0.19	0.11
100	0.33	0.26

G. Average Throughput [kbps]

In the communication between the devices, throughput plays the important role for measure the efficiency of the network. Throughput is a number of packets receive in per unit time, in this result throughput measure in unit of Kbps. The result in the figure 10 compare with two techniques existing fuzzy reinforce and proposed Fuzzy FANET under fifty and hundred flying node scenarios. Existing system provide 876.75Kbps and 1043Kbps but proposed system improve the throughput performance which is 1408.46Kbps and 1533.76Kbps in the respective of fifty and hundred node scenario. Comparative result concludes that proposed system improve the throughput performance it means that provide efficient communication between UAVs to ground base station.

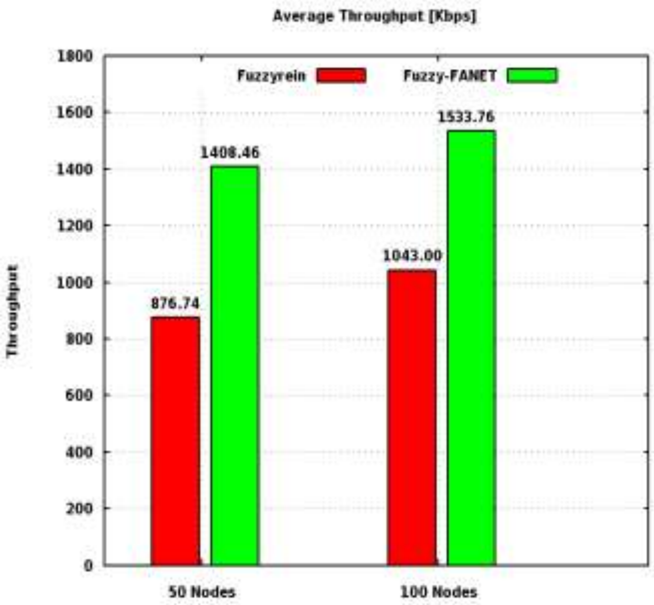

Figure 10: Average Throughput Analysis [kbps]

Table 5: Average Throughput Analysis [kbps]

No of Nodes	FuzzyRein	Fuzzy-FANET
50	876.74	1408.46
100	1043	1533.76

H. Overall Network Analysis

In this section summarize the outcome with various factor, fuzzy logic system is a form of multi valued logic in which truth value of variable be any real number in between 0 to 1 both inclusive. The fuzzy system work rule and class based mechanism which inference are adopt for future behavior system. In our approach Fly Ad hoc network simulate through fuzzy logic based technique to decide route and data communication path for better reliability and network QoS. The result table 6 summarizes the outcome of existing and proposed system, for the analysis two scenario are created fifty and hundred node and conclude that proposed fuzzy FANET is better than existing fuzzy reinforce strategy in every respective of network parameters which is given in table 6.

Table 6: Comparative Analysis of Fuzzy-Rein Vs Fuzzy-FANET

Parameters	No of Nodes	Fuzzy-Rein	Fuzzy-FANET
Data Receives	50	14966	21309
	100	19214	24903
Data Drop	50	4832	1582
	100	3673	1060
PDR	50	74.98	92.83
	100	83.92	95.88
Routing Load	50	12176	12217
	100	16161	18206
Delay [ms]	50	0.19	0.11
	100	0.33	0.26
Throughput [kbps]	50	876.74	1408.46
	100	1043	1533.76

V. Conclusion

Unmanned aerial vehicles (UAV) are becoming more common in our everyday lives as technology progresses. The Flying Ad Hoc Network (FANET) is taking shape. At the moment, UAVs are becoming increasingly important in disaster monitoring, geological surveys, traffic control, communications relays, and emergency communications. In this paper integrates fuzzy logic decision based on energy, stability rating and delay and compare with existing fuzzy reinforce learning into FANET routing algorithm. Proposed system fuzzification done by three factor energy, stability rating and delay, in the defuzzification outcome measure by link connectivity, number of hop involve in communication, data receives, throughput, percentage of data receives, delay and data drop etc. The analysis result conclude that proposed fuzzy inference system better perform as compare to fuzzy reinforce system which as adoptable in real time system.

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