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Performance Analysis of FANET for Different Routing Protocol using Ricean Fading

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ABSTRACT: An Ad-Hoc network is a network that is a collection of individual devices communicating with each other directly. FANET is a gathering of Unmanned Air Vehicles (UAVs) which finished their work without human negotiation. FANETs are adaptable, cheap also, quick to send. This makes them an exceptionally alluring innovation for some regular citizen and military applications. This paper attempts to identify the best routing protocol based on some Quality of Service (QoS) metrics for free space in ricean fading models. The simulation has been performed for the number of times with different routing protocols such as AODV, ZRP and OLSR for ricean fading models with varying a node density. Experimental results have been carried out by using simulation tool Qual Net (version- 6.1).

Keywords: Ad-hoc Network, FANET, Routing protocol, QOS parameters, fading models.

I. INTRODUCTION

Ad-hoc networks are decentralized type of wireless networks. They don't depend on a previous infrastructure, such as access points in infrastructure wireless networks or routers in wired networks. Inferable from this decentralized nature of wireless ad-hoc networks, they are appropriate for an assortment of uses and may enhance the scalability of systems when contrasted with wireless managed networks.

FANETs are a special case of mobile ad hoc networks (MANETs)[1].In a FANET, the topology of the network can change all the more much of the time as contrast with MANET or vehicle ad hoc network (VANET).

A standout amongst the most essential outline challenges for the multi UAV systems is the communication. Unmanned Aerial Vehicle (UAV) systems fly self-sufficiently without conveying any human help. Utilization of UAVs guarantees new routes for both military and regular citizen applications [2].

The establishment of multi-hop, wireless, inter-UAV communication network is termed as a Flying Ad-hoc Network (FANET). It is a relatively easy task to use UAVs in an Unmanned Aerial System (UAS) for increasing communication range and data aggregation capability of nodes in a system.

FANET nodes have higher mobility degrees, and it results in more frequent changes in the topology of FANETs. Moreover, the distances between the nodes in FANETs are longer in comparison to the nodes in other ad-hoc networks.

In FANETs, the node became UAV [1]. The single UAV system cannot create an FANETs network; therefore, it is valid for multi-UAVs systems. On the other hand, it cannot call any multi-UAVs systems FANETs; if each UAV is connected to a base ground or satellite, it does not have a FANETs network. FANETs must contain UAVs which communicate between each other using ad hoc network and at most one of them connect to infrastructure.

Flying ad-hoc networks are infrastructure less networks with no central control. On the other hand, despite the restricted capabilities like power, sensing, communication and computation.

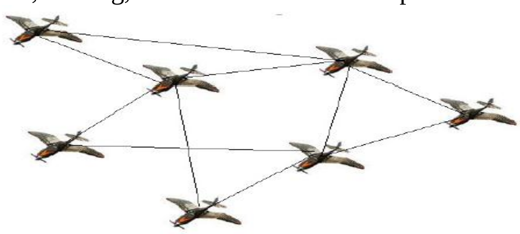

Figure 1: Flying Ad-hoc Network [3]

II. LITERATURE REVIEW

2.1 Anuradha Chauhan, Ms. Renu Singla 2016 [4]

In this paper, Flying Ad-Hoc Networks (FANETs) are reviewed which is an ad hoc network linking the UAVs. The differences between MANETs, FANETs and VANETs (Vehicle Ad-Hoc Networks) are explained first, and then the significant FANET design issues are proposed. Along with the available FANET protocols, open research issues are also talked about.

2.2 Dr. Ilker Bekmezci et al 2015 [5]

In their paper presented a method FANET test bed implementation study. One of the most important design problems for the multi unmanned aerial vehicles systems is communication between UAVs In this study, on the implementation of a FANET network architecture test environment are presented. FANET architecture can provide coordination between UAVs in order to complete the mission successfully. This study presents a cost-effective and easily repeatable test environment implementation.

2.3 Md. Hasan Tareque et al [6]

in their paper proposed Flying Ad-Hoc Networks are surveyed along by means of its challenges compared to traditional ad hoc networks In recent years, UAVs are being used in increasing number of civil applications, such as policing, fire fighting, etc. FANET must support both peer-to-peer communication and converge cast traffic at the equivalent time. The distances among FANET nodes are much higher than in FANETs or VANETs. So higher range of communication is needed. FANETs are then classified into six major categories which are critically analyzed and compared based on various performance criteria. In this paper researcher issue related to fanet routing protocol to inspire researcher work on these open problems.

2.4 Ilker Bekmezci et al [7]

In their paper presented a new multi UAV task planning heuristic is proposed for FANETs to visit all target points in a minimum time, while preserving all time network connectivity. The aim of the connected Multi UAV task planning problem is to collect information from the target points and relay the collected information without any delay by the help of the FANET structure. The number of UAVs in U is denoted as [U]. Even if there is no direct link between the two UAVs, they can communicate with each other by the help of the ad hoc network. In this study, we have presented an effective connected task planning strategy for FANETs to minimize the total time needed to visit all targets.

2.5 KuldeepSingh et al [8]

Experimental analysis is carried out on AODV, DSDV and OLSR routing protocol for FANET environment using NS2 simulator. Role of Mobile Ad-hoc Networks have rapidly evolved NS2 can simulate both types of networks wired and wireless and NS2 can simulate various types of communication protocol like UDP, TCP. In FANET, MA Vs changes position very frequently. Due to this there is a rapid change in topology. So it is very necessary challenging task to find a suitable routing technique for FANET In this paper show olsr protocol is better than other two protocols.

2.6 Dr. İlker Bekmezci et al [9]

In this paper presented the location information between UAVs is circulated through tokens to resolve the problem of location information sharing in multi-UAV system. This study shows the effectiveness of multi token usage for location information sharing in Fanet. Location Information Sharing (LIS) is the most important challenges in FANETs. In order to achieve LIS with minimum delay, it is planned to increase the number of UAVs, and the number of tokens circulating in the network simultaneously. Token package circulation in FANET is an alternative solution for location information sharing in multi UAV systems. Information to be contained in the token to be circulated through the FANET. This study shows the effectiveness of multi token usage for location information sharing in FANETs.

III. AN OVERVIEW OF ROUTING PROTOCOL

The routing protocols are a usual method or standard rule according to which it is to be determined that how a node decides that which way to forward the data packets from one host to another host in the mobile ad-hoc network environment. FANET is a subclass of VANET and MANET; therefore, firstly typical MANET routing protocols are preferred and tested for FANET.

These protocols can be categorized in four main classes-

• **Static protocols** have static routing tables there is no need to refresh these tables.
• **Proactive protocols**, also known as table driven protocols, are periodically refreshed routing tables.
• **Reactive protocols**, also called on-demand protocols, discover paths for messages on demand.
• **Hybrid protocols** use both proactive and reactive protocols.
Fig. 2 shows the classification of routing protocol in hierarchy manner.

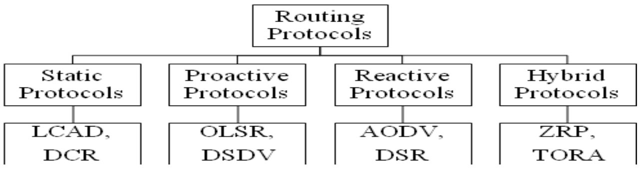

Figure – 2 Hierarchical Model of Routing Protocol

3.1 Ad Hoc on demand Distance Vector Routing (AODV) Protocol

There are different approaches for discovering routes in on demand algorithms AODV is amongst them. AODV relies on per-node sequence numbers for loop freedom and for ensuring selection of the most recent routing path. AODV nodes maintain a route table in which next-hop routing information for destination node is stored.

To start route discovery, the source node creates a route request (RREQ) packet. This packet contains the destination node's IP address, the last known sequence number for that destination, the source's IP address and current sequence number. After creating this message, the source broadcasts the RREQ to its neighbours. When a neighbouring node receives a RREQ, it first creates a reverse route to the source node. The node from which it received the RREQ is incremented by one to get the hop distance from the source. In this manner, the RREQ floods the network in search of a route to the destination.

Once the source receives the RREP, it can utilize the path for the transmission of data packets. AODV contains a number of optimizations and optional features. When a link break along an active path occurs, the node upstream of the break invalidates the routes to each of those destinations in its route table. It then creates a route error (RERR) message and also broadcasts the data packet to its neighbours. AODV doesn't broadcast update information of network topology in entire network periodically.

Only when a data arrives from upper layer and it needs a route to the destination. AODV searches a route for the data and maintains the route. It is a reactive protocol that has some characteristic as DSR with differences in the routing table [10 – 12]. Fundamental Route discovery Process of AODV is shown below in the Fig. 3.

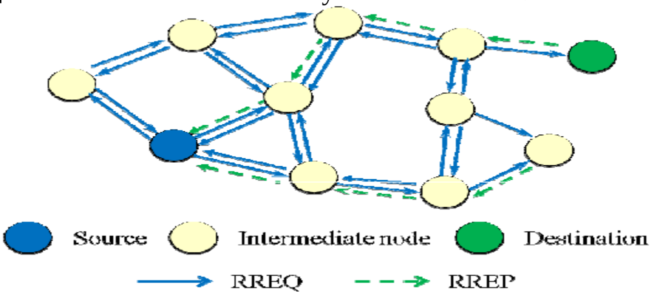

Figure – 3 Fundamental Route Discovery Process of AODV[15]

3.2 Optimized Link State Routing (OLSR)

OLSR is a proactive link-state routing protocol, which uses two types of messages (hello and topology control messages) to discover neighbours [13]. Hello messages are used for detecting neighbour nodes in the direct communication range.

This message contains the list of known neighbours, and it is periodically broadcast to one-hop neighbours. On the other hand, topology control messages are used for maintaining topological information of the system. These messages are used periodically to refresh topology information; therefore, each node can re-calculate the routes to all nodes in the system.

This periodic flooding nature of the protocol results a large amount of overhead. Therefore, to reduce this overhead Multi Point Relay (MPR) mechanism is used. In this mechanism, each node selects its own MPRs from its neighbours and only those nodes are responsible for forwarding the routing messages [13]. Fig. 4 shows the multipoint relay selection in OLSR.

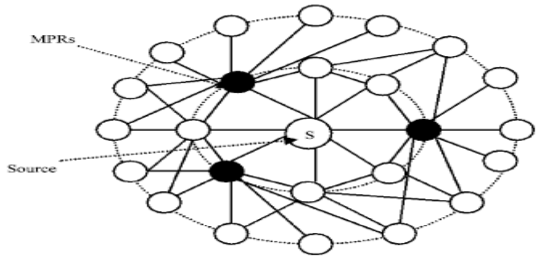

Figure – 4 Multipoint relay selection in OLSR [14]

3.3 Zone Routing Protocol (ZRP)

The Zone Routing Protocol (ZRP) combines the advantages of both reactive and proactive protocols into a hybrid scheme, taking advantage of pro-active discovery within a node's local neighbourhood, and using a reactive protocol for communication between these neighbourhoods. In a FANET, it can safely be assumed that the most communication takes place between nodes close to each other.

The routing inside the zone is called as intra-zone routing, and it uses proactive approach to maintain routes. If the source and destination nodes are in the same zone, the source node can start data transmission immediately. The inter-zone routing is responsible for sending data packets to outside of the zone. It uses reactive approach to maintain routes.

The delay caused by the route discovery is minimized by using border casting. Border casting is used instead of traditional broadcasting, and reply messages are only produced by border nodes of a zone. These border nodes then repeat either inter- or intra-zone routing as needed [16].

IV. AN OVERVIEW OF PROPAGATION MODEL

Radio channels are much more complicated to analyze than wired channels. Their characteristics may change rapidly and randomly. There are large differences between simple paths with line of sight (LOS) and those which have obstacles like buildings or elevations between the sender and the receiver (Non Line of Sight (NLOS). Due to multipath propagation of radio waves, small movements of the receiver can have large effects on the received signal strength [17].

4.1 Free Space Model

This is a large scale model. The received power is only dependent on the transmitted power, the antenna's gains and on the distance between the sender and the receiver. It accounts mainly for the fact that a radio wave which moves away from the sender has to cover a larger area. So the received power decreases with the square of the distance. The free space propagation model assumes the ideal propagation condition that there is only one clear line-of-sight path between the transmitter and receiver. H. T. Friis presented the following equation to calculate the received signal power in free space at distance d from the transmitter [18] [19] [20][21].

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L}$$

Where P_t is the transmitted signal power. Gt and Gr are the antenna gains of the transmitter and the receiver respectively. L ($L \geq 1$) is the system loss, and λ is the wavelength. It is common to select $G_t = G_r = 1$ and $L = 1$ in *ns* simulations.

4.2 Ricean and Rayleigh fading models

These two models are fading models, meaning that they describe the time-correlation of the received signal power. Fading is mostly caused by multipath propagation of the radio waves. If there are multiple indirect paths between the sender and the receiver, Rayleigh fading occurs. If there is one dominant (line of sight) path and multiple indirect signals, Ricean fading occurs [21].

V. SIMULATION ENVIRONMENT

The simulations were carried out with **QualNet 6.1** simulator. For the simulation setup we have created five scenarios with 10 – 50 no. of nodes in a terrain size of 1500m X 1500m. The traffic was generated through CBR in which 512 bytes of data at data rate of 2mbps is sent over the network. In the design scenario all the nodes are randomly placed. In order to understand the effect of routing protocol in FANET by the various QoS

parameters, especially Packet Delivery Ratio, Throughput, End to End Delay, Jitter and Packet Loss Ratio, we use Ricean Fading Model with different no. of nodes to analyse the result.
The following metrics were employed for the purpose of performance analysis of protocols:

Packet Delivery Ratio (PDR): It is the ratio of actual packet delivered to total packets sent. In other words, the ratios of packets received at the destination node to those of the packets generated by the source node.

$$PDR = \frac{\sum N_R}{N_G}$$

Where
N_R = Number of Received Packet
N_G = Number of Generated Packet

Throughput: It is the number of packets/bytes received by source per unit time. In other words, it is the amount of data per measure that's delivered from one node to a special via a communication link and it is measured in bits per second.

$$Throughput = \frac{\sum P_R}{\sum t_{st} - \sum t_{sp}}$$

Where
P_R = Received Packet Size
t_{st} = Start Time
t_{sp} = Stop Time
It is an important metric for analyzing network protocols.

End to End Delay: It is the calculation of typical time taken by packet to cover its journey from the source to the destination end. It covers all of the potential delays like route discovery buffering process, varied middle queuing stays etc. throughput the complete trip of transmission of the packet.

$$End\ to\ End\ Delay = \sum t_{pr} - \sum t_{ps}$$

Where
t_{pr} = Received Packet Time
t_{ps} = Sent Packet Time

Jitter: It describes standard deviation of packet delay between all nodes.

Packet Loss Ratio: The amount of packet loss during the transmission is packet loss.

$$PLR = 1 - PDR$$

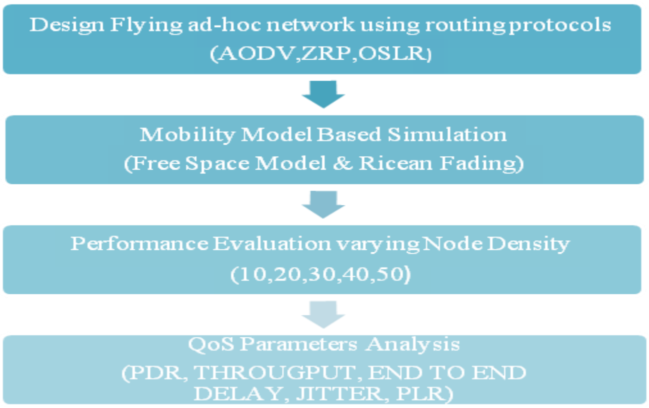

Figure – 5 Working Procedure for Simulation of FANET's

The following table – 1 shows the values of the various parameters used during simulation.

Table:-1 Simulation Parameter and values.

S.N0.	PARAMETER	VALUE
1.	Simulation Software	QualNet 6.1
2.	Simulation Time	300sec
3.	MAC Protocol	802.11
4.	Simulation Area	1500 X 1500
5.	Propagation Model	Free Space
6.	No. of Nodes	10,20,30,40,50
7.	Traffic Source	CBR
8.	Fading Model	Ricean
9.	Mobility Model	File
10.	Data rates	2 mbps
11.	Routing Protocol	AODV,OLSR,ZRP

VI. RESULTS AND DISCUSSION

6.1 PDR

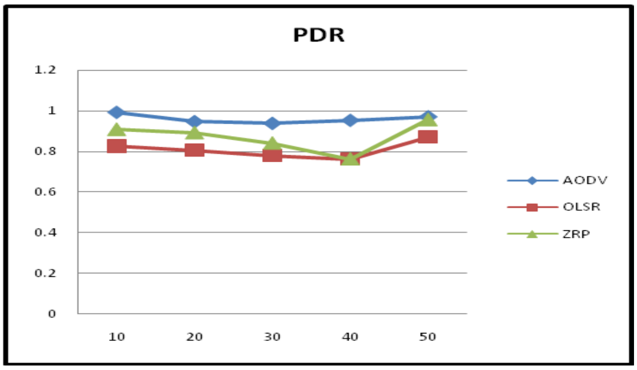

Figure – 6 Comparison of PDR for AODV, OLSR, ZRP in Ricean Fading Environment

Fig. 6 shows that the PDR of Reactive routing protocol (AODV) is better as compared to Proactive (OLSR) and Hybrid (ZRP) routing protocol in the Ricean Fading model under the Flying Ad-Hoc Network. It means that maximum packets are delivered in case of Reactive (AODV) Protocol in FANET when node density is varied and fading is applied.

6.2 Throughput

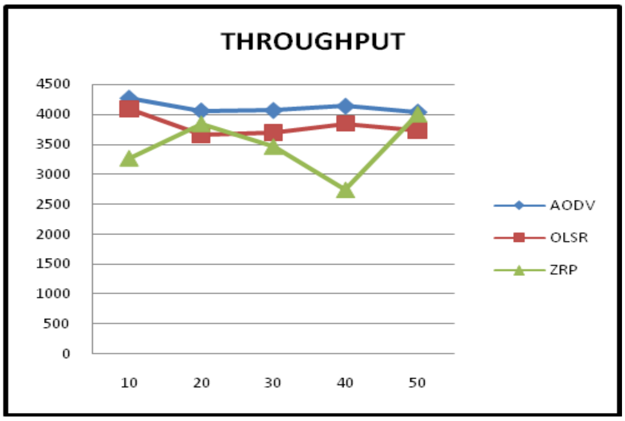

Figure – 7 Comparison of Average Throughput for AODV, OLSR, ZRP in Ricean fading environment

Fig. 7 shows that the variation of throughput against routing protocol applied by varying node density. It is observed that Reactive (AODV) routing protocol is perform very well as compared to Proactive (OLSR) and

Hybrid (ZRP) routing protocol taken into account in the figure. Out Of all the routing protocol taken into account under ricean fading ZRP give the worst performance. As due to the nature of protocol as node density increases the value goes up and down due to fading.

6.3 End to End Delay

Fig. 8 shows the variation of End to End Delay against routing protocol applied at different node density. It is observed that overall Proactive (OLSR) is best as there is least delay in case of OLSR. This result can also be used to choose the best protocol under Ricean fading model when nodes are in the FANET model.

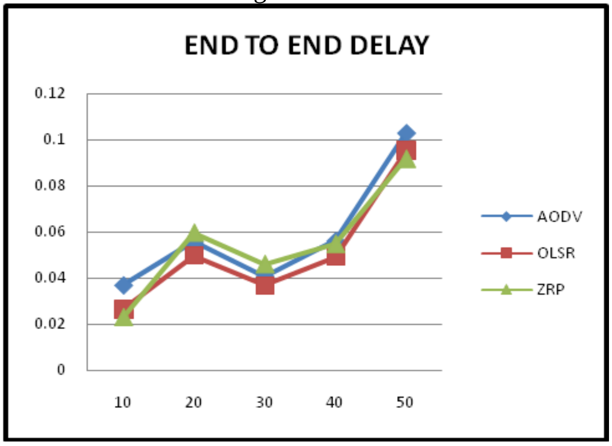

Figure – 8 Comparison of End to End Delay for AODV, OLSR, ZRP in Ricean Fading Environment

6.4 Average Jitter

Fig. 9 shows that the variation against different routing protocol it is observed and came to the conclusion that Proactive (OLSR) routing protocol is performing more effectively as compared to other two routing protocol in presence of Ricean fading model.

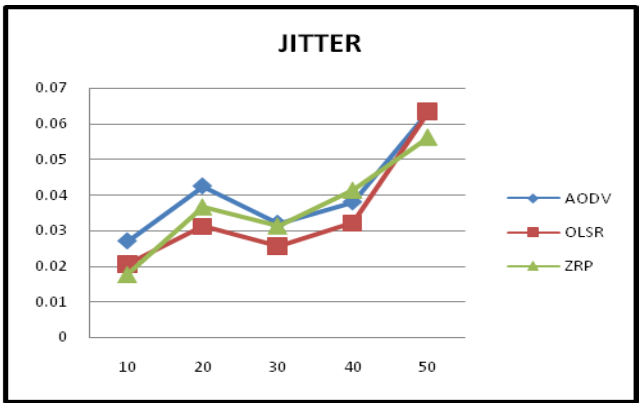

Figure – 9 Comparison of Average Jitter for AODV, OLSR, ZRP in Ricean Fading Environment

6.5 PLR

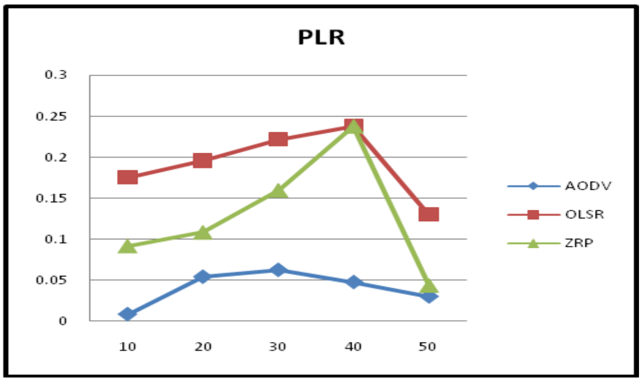

Figure – 10 Comparison of PLR for AODV, OLSR, ZRP in Ricean Fading Environment

Fig. 10 shows that the packet loss ratio of Reactive (AODV) is best in the presence of Ricean fading when node density is increasing as shown in the fig. It means that the minimum packet loss is observed in AODV routing protocol.

VII. CONCLUSION

In this study, we have examined the impact of routing protocols in FANET. Also we have taken Ricean Fading model into account with varying node density and analyse it on the basis of following metrics PDR, Throughput, End to End Delay, Jitter and PLR. We observed that the performance of AODV is best as compared to ZRP and OLSR. This also verifies the conceptual study of various routing protocols. In the future work it can be extended to investigate the performance in Rayleigh, Fast Rayleigh fading model by changing battery model, antenna polarization etc.

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