Journal of Basic and Applied Engineering Research
Print ISSN: 2350-0077; Online ISSN: 2350-0255; Volume 2, Number 16; April-June, 2015 pp. 1388-1393

http://www.krishisanskriti.org/jbaer.html

Performance Analysis of AODV with Fuzzy based Active Route Timeout Interval in MANET

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Abstract—*Mobile Ad-hoc network (MANET) is an infrastructure-less wireless network which contains different nodes connected in dynamic manner. In MANET due to node movement the topology of the network changes, so the routing becomes a challenging task.*
In this paper the performance of AODV protocol has been analyzed with optimized active route timeout interval using fuzzy logic controller. The fuzzy logic controller has been proposed that decides the value of active route timeout to be used in conventional AODV using the transmission power and mobility of the nodes. The performance of the network using AODV with this fuzzy based active route timeout interval has been compared with conventional AODV in terms of average throughput, average end to end delay and average jitter. It has been found from the simulated results that performance of the network using AODV with fuzzy based active route timeout interval has been improved. The simulation has been done using qualnet 6.1 simulator.

Keywords*: MANET, AODV, Fuzzy Logic Controller, Active Route Timeout (ART) Interval, AODVFART, Qualnet Simulator.*

1. INTRODUCTION

A MANET is a network with no predefined or fixed infrastructure such as access point or base stations [1]. MANET consist of a group of nodes which are able to communicate with each other without any centralized manner [2]. For the purpose of routing in MANET the routing protocols are mainly classified into three different categories namely proactive, reactive and hybrid routing protocols.

AODV(Ad-hoc on demand distance vector) routing protocol is a popularly used reactive routing protocol[3]. Active route timeout is an important parameter of AODV protocol that defines the interval of time to which the route is remain active. Selection of route life time value is one of the necessary parameter during the design of AODV protocol. The routing table does not make any attempt to discover a new route and/or delete a current route with in the period of active route timeout. If the route lifetime is too long it may lead to retardation in updating the routing table. While smaller value of route lifetime may remove some active paths from the routing table and the number of attempt to discover a new route are increase this may increase the routing delay and also traffic overhead[1]. So, the value of active route life time should be chosen adaptively. The default value of active route timeout in AODV protocol is 3 seconds[10].

In this paper an optimized value of active route timeout interval to be used in AODV has been selected using fuzzy logic controller.

2. CONVENTIONAL AODV PROTOCOL

AODV falls in the category of reactive routing protocol. In AODV routing protocol routes are established whenever needed. The working of AODV protocol may be explained in two phases. One is the process of route discovery and the other one is route maintenance [2]. Route discovery process is started by creating route request (RREQ) packet through the source node and pass it to the neighboring nodes. Via these intermediate nodes the RREQ message finally reaches to the destination node. The destination node creates route reply (RREP) packet and send it in the direction of source[3]. Fig. 1 shows the format of RREP message.

Type	**R**	**A**	**Reserved**	**Prefix Size**	**Hop Count**
Destination IP address					
Destination Sequence Number					
Originator IP address					
Lifetime					

Fig. 1: Format of RREP message.

The life time field of RREP message is initialized by active route lifetime interval[10]. Each node remains in this state for a predefined time duration which is specified by an ART value. The timer is reset back to ART whenever a route is used, the parameter ART defines how long a route is remained in the routing table after the last packet transmission on this route. Source changes its route information when it receives only up-to-date route information. In this way a route is established [2].

In the route maintenance phase each node of the route periodically transmits hello messages it indicates the presence of node in the active route[3]. If a node does not receive hello message from its neighbor in predetermined time interval then the node assumes that the link from its neighbor is failed. Then the node generates route error message (RERR) and send it to all the predecessors nodes which are still using the failed link for transmitting data. The intermediate nodes receive RERR message and pass it towards the source. When the source receives this information it reinitiate the route discovery process [4].

The increase in the value of ART may lead the utilization of a broken route this may damage the performance of data delivery. While smaller value of ART may increase the delay in the transmission of data.

3. AODV PROTOCOL WITH FUZZY BASED ACTIVE ROUTE TIMEOUT INTERVAL

The function of fuzzy logic controller is to map the crisp input values to the crisp output values on the basis of some set of rules and the membership function of linguistic variables. The fuzzy logic controller works fully on the experiences and thinking of human. This reduces the complexity of mathematical calculation[9].

The fuzzy logic controller contains mainly three parts: fuzzifier, inference system and defuzzifier. The work of fuzzifier is to map the crisp input data values to its corresponding fuzzy sets that can be defined using fuzzy rule base. The fuzzified values are further processed by the inference system which consists of a rule base and a number of ways for inferring these rules. These rules can be constructed by human thinking and can be defined on the basis of their membership functions. All the rules of a rule base are processed in parallel manner. The defuzzifier converts the output fuzzy sets to a single crisp output[5].

Fig. 2 shows the block diagram of proposed fuzzy logic controller.

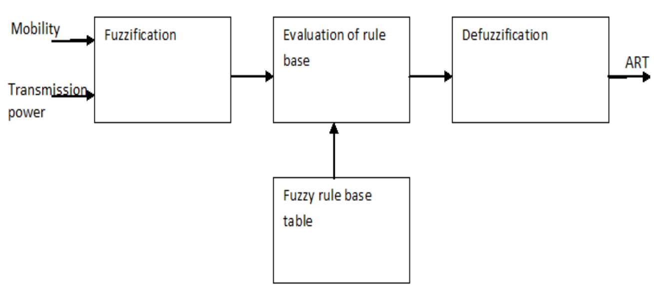

Fig. 2: Proposed fuzzy logic controller.

Mobility and transmission power are considered as input and active route timeout (ART) interval is considered as the output linguistic variable for the proposed fuzzy controller. The fuzzy membership functions of all input and output parameters are divided into three subsets namely: {low, medium, high}. In the proposed work to define low and high subsets gauss2mf(Gaussian membership function) has been used because it has the advantage of being smooth and non zero at all points and for medium subset trimf(Triangular membership function)has been used because of its simplicity for both input and output variables. Membership functions of all parameters are shown below: Fig. 3, 4, 5, shows fuzzy subsets and membership functions for variables; mobility, transmission power and active route timeout interval respectively.

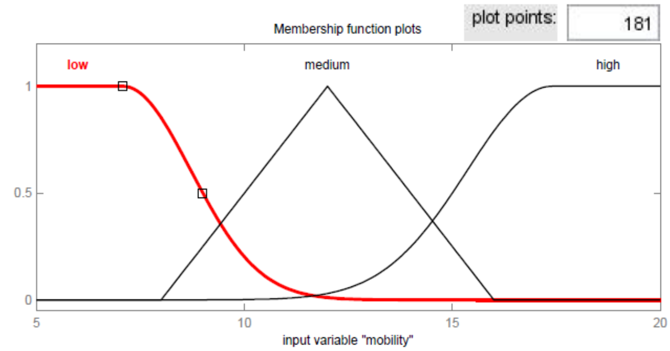

Fig. 3: Membership function plot of mobility.

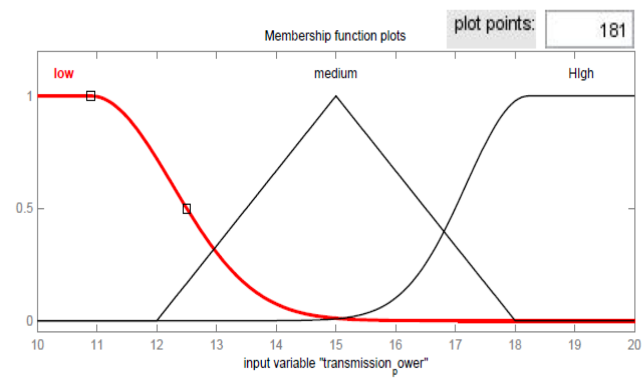

Fig. 4: Membership function plot of transmission power.

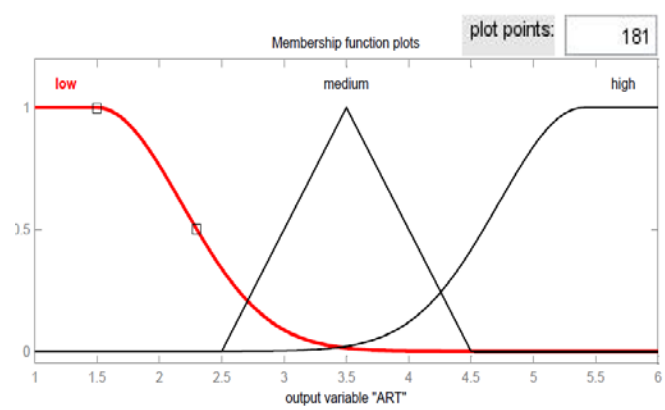

Fig. 5: Membership function plot of active route timeout interval.

The method for making the rules for proposed fuzzy controller is given below.

3.1 Effect of Mobility over ART

In MANET, the link between two nodes breaks frequently because of mobility of the nodes. The link failure rate is increases as the node mobility increases. Since, the nodes are connected through wireless link in the route, the increase in the link failure rate reduces the route lifetime[7]. The link failure rate between two nodes can be calculated as[8]-

$$\gamma = \frac{8v_0}{\pi^2 R}$$

Where v_0 is the speed of the nodes and R is the radius of area covered by a node circle. The probability of route failure can be calculated as[6]-

$$P_r = 1 - (1 - P_l)^k$$

Where P_l is the probability of link break and k is total number of links in a route. Consequently the following rules are proposed-

1) If mobility is high then ART must be low.
2) If mobility is medium then ART must be medium.
3) If mobility is low then ART must be high.

3.2 Effect of Transmission Power over ART

The value of route lifetime used by the nodes in the wireless network is very sensitive to the transmission power of those nodes. In the proposed work, signal power degradation is modeled by the free space propagation model. In this model the transmission range can be calculated as[6]-

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

Where P_t and P_r are transmitted and received power respectively, G_t and G_r are the antenna gain respectively, λ is the carrier wavelength and L is the loss factor. It is clear from the above equation that large transmission means larger the transmission range. If the transmission power of a node is very low, then its signal will reach to very few neighbor nodes and its link with those nodes maybe very weak and going to break easily. Larger transmission power a node will lead to large number of neighbor nodes and hence the lifetime of its link is high[1]. Consequently the following rules are proposed-

1) If transmission power is high then ART must be high.
2) If transmission power is medium then ART must be medium.
3) If transmission power is low then ART must be low.

Consequently the above rules can be written in a two dimensional form as:

Table 1: Rule base for proposed fuzzy controller.

Mobility	Transmission power		
	Low	Medium	High
Low	Medium	High	High
Medium	Low	Medium	High
High	Low	Low	Medium

4. SIMULATION SETUP

The simulation has been done through Qualnet Simulator 6.1 over window platform by varying pause time. Qualnet simulator is a discrete event simulator that is capable of simulating wired or wireless scenarios. Fig. shows the simulation scenario. In the simulation model 50 nodes have been placed in a random manner which are connected each other through wireless subnet. The simulation area of 1500m×1500m has been chosen as flat terrain area. The complete simulation has been run in 300sec. There are 7 CBR connections, Random way point type mobility model and data rate of 2 Mbps have been used in this simulation. Omni directional antenna is used to transmit the signals and data. The performance has been evaluated on the basis of performance matrices like average throughput, average jitter, average end to end delay.

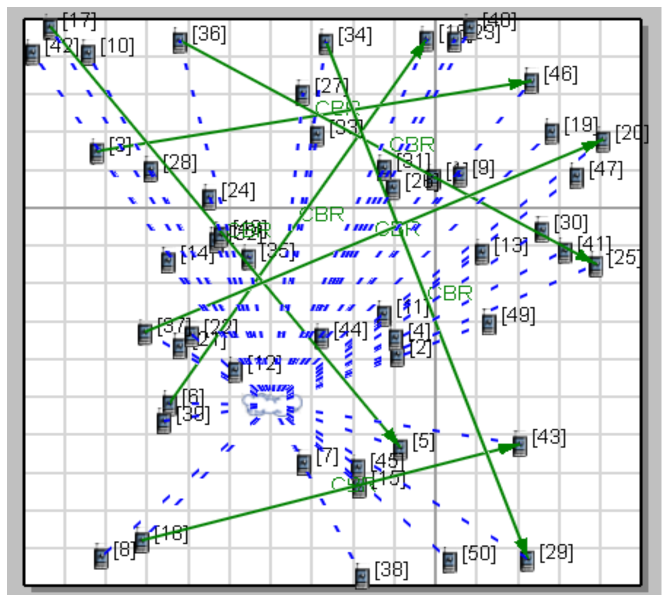

Fig. 6: Simulation scenario.

5. SIMULATION PARAMETERS

Common simulation parameters for conventional AODV and AODV with fuzzy based ART (AODVFART) are listed below:

Table 2: Simulation parameters.

Parameters	Value
Simulator	Qualnet 6.1
No. of nodes	50
Simulation time	300sec
Mobility model	Random way point
Pause time	5,10,15,20,25sec
Data rate	2Mbps
Radio type	802.11b radio
Antenna model	Omni directional
Item size	512 bytes

End time	250sec
Channel frequency	2.4GHz
No. of CBR	7
Number of packets to send	100
Simulation Area	1500m×1500m
Packet rate	1(packet/sec)

6. PERFORMANCE METRICS

In the proposed work following metrics for the evaluation of performance have been used:

- **Average End to End Delay**

This is the time taken by the packet to reach the destination from the source. End to end delay includes all the possible delay occurs during transmission and reception of the packets. It is measured in seconds and should be as low as possible.

- **Average Jitter**

It is the time that defined as the delay variation between each received data packet. Average Jitter should be as low as possible for better performance.

- **Average Throughput**

It is defined as the average number of successfully received data packet at destination per second and measured in (bit/sec). Throughput should be as high as possible.

7. SIMULATION RESULTS

To analyze the performance of AODV and AODVFART, the following two cases of transmission power and mobility have been taken into consideration. In first case the value of mobility of 5mps and transmission power of 15dbm have been taken for these values first the default value of ART (3sec) and then the value found from fuzzy logic controller (5.21sec) have been used in the simulation and the results for these values has been compared with each other. In the second case the value of mobility 12mps and transmission power of 14dbm have been taken for these values first the default value of ART (3sec) and then the value found from fuzzy logic controller (3.33sec) have been used in the simulation and the results for these values has been compared with each other. The results for both the cases are given below separately.

7.1 Results with 5mps Mobility and 15dbm Transmission Power

Fig. 7 shows the average throughput for mobility 5mps and transmission power 15dbm. From the Fig. 7 it is clear that the average throughput of AODV protocol with fuzzy based active route timeout interval is larger than conventional AODV. This is because the increase in the value of ART interval gives longer time to remain the route active this reduces the routing overhead and keeping more active path in routing table.

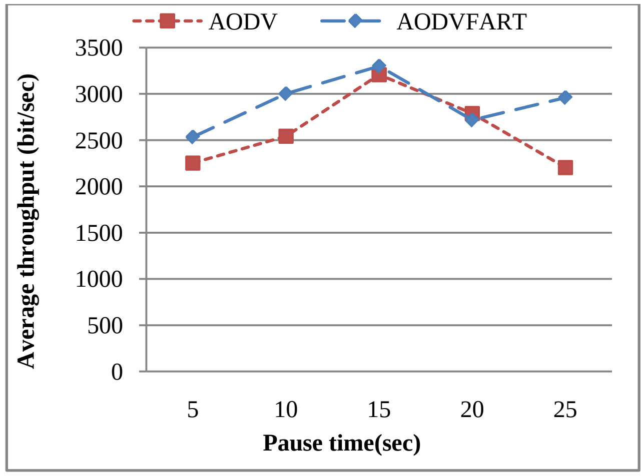

Fig. 7: Average throughput for mobility 5mps and transmission power 15dbm.

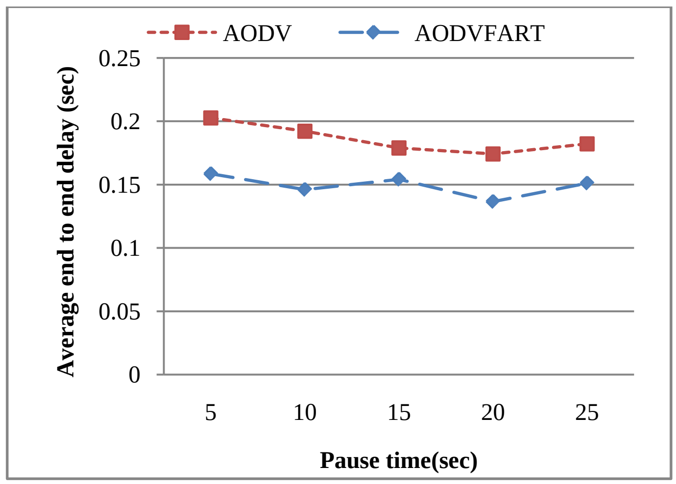

Fig. 8: Average end to end delay for mobility 5mps and transmission power 15dbm.

Fig. 8 shows the average end to end delay for mobility 5mps and transmission power 15dbm. From the Fig. 8 it is clear that the average end to end delay of AODV protocol with fuzzy based active route timeout interval is smaller than conventional AODV. This is because the increase in the value of ART interval gives longer time to remain the route active so the time delay in searching new routes is also reduced.

Fig. 9 shows the average jitter for mobility 5mps and transmission power 15dbm. From the Fig. 9 it is clear that the average jitter of AODV protocol with fuzzy based active route timeout interval is smaller than conventional AODV. This is because the increase in the value of ART interval gives longer time to remain the route active so the variation in the delay to reach the packets to the destination is reduced.

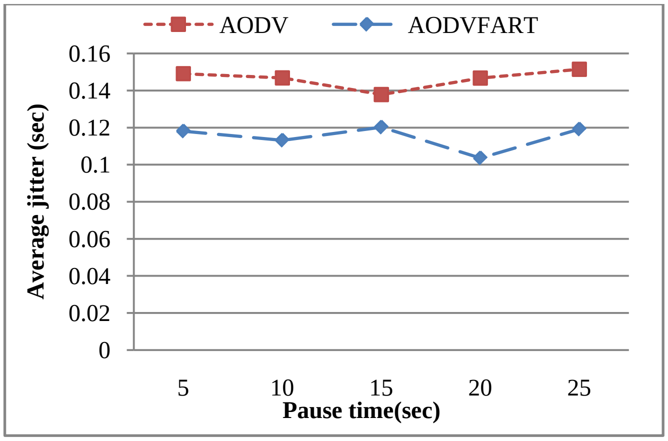

Fig. 9: Average jitter for mobility 5mps and transmission power 15dbm.

7.2 Results with 12mps Mobility and 14dbm Transmission Power

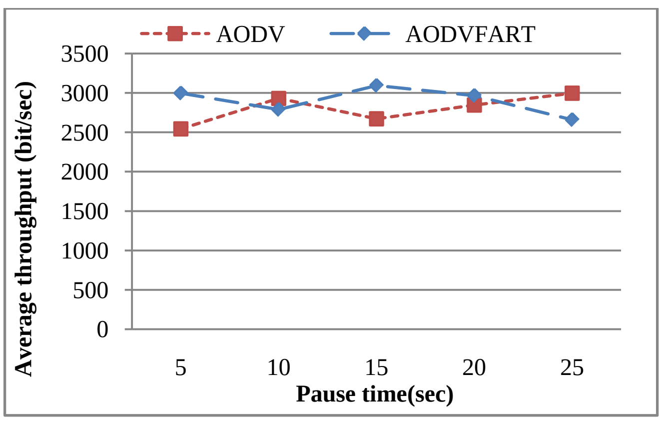

Fig. 10: Average throughput for mobility 12mps and transmission power 14dbm.

Fig. 10 shows the average throughput for mobility 12mps and transmission power 14dbm. From the Fig. 10 it is clear that the average throughput of AODV protocol with fuzzy based active route timeout interval is larger than conventional AODV. This is because the increase in the value of ART interval gives longer time to remain the route active this reduces the routing overhead and keeping more active path in routing table.

Fig. 11 shows the average end to end delay for mobility 12mps and transmission power 14dbm. From the Fig. 11 it is clear that the average end to end delay of AODV protocol with fuzzy based active route timeout interval is smaller than conventional AODV. This is because the increase in the value of ART interval gives longer time to remain the route active so the time delay in searching new routes is also reduced.

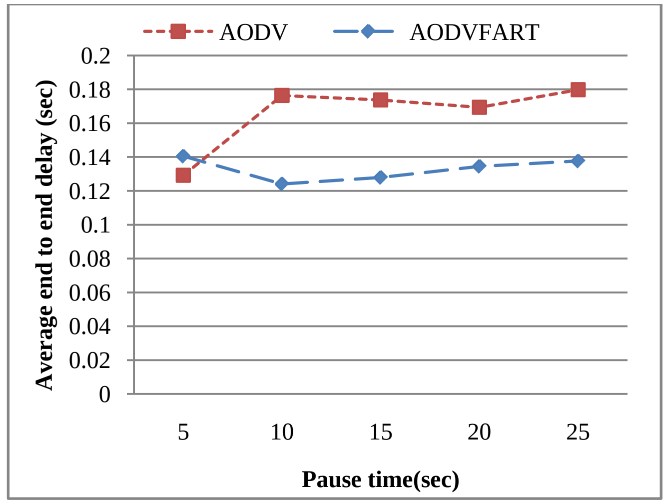

Fig. 11: Average end to end delay for mobility 12mps and transmission power 14dbm.

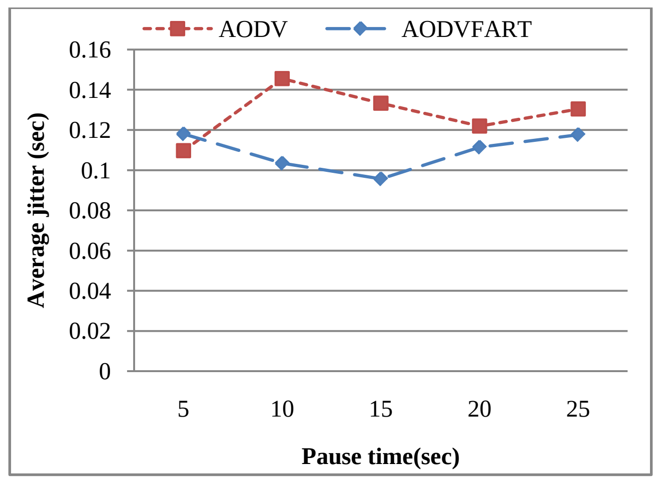

Fig. 12: Average jitter for mobility 12mps and transmission power 14dbm.

Fig. 12 shows the average jitter for mobility 12mps and transmission power 14dbm. From the 7Fig. 12 it is clear that the average jitter of AODV protocol with fuzzy based active route timeout interval is smaller than conventional AODV. This is because the increase in the value of ART interval gives longer time to remain the route active so the variation in the delay to reach the packets to the destination is reduced.

From all the results it has been found that for both the cases, AODV protocol with fuzzy based active route timeout interval gives better results than conventional AODV protocol.

8. CONCLUSION

In the proposed work, an efficient approach to optimize the interval of active route time out of AODV protocol using fuzzy logic controller has been proposed. The performance of net work in terms of average throughput, average end to end delay and average jitter using conventional AODV and AODV with fuzzy based ART have been compared. From the simulation results it can be concluded that AODV protocol with fuzzy based active route timeout interval performs better in terms of average throughput, average jitter and average end to end delay. Through this work it can be concluded that instead of default value of ART, this value can be determined accurately and dynamically through fuzzy logic controller and this gives better results than default.

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