International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-4, November 2019

Fuzzy Logic Based Raodv Routing Protocol

K Santhi, K Thinakaran

Abstract: ***Fuzzy Logic system comes as a very efficient and important tool that is used to make intelligent decisions when inadequate data is available. This research work is focused on the enhancement of Fuzzy based RAODV routing protocol. It is very efficient to select the optimal paths for data packet transmission between source and desitnation node and also increse the network life time. Fuzzy Logic control is generally designed on three fuzzy variables of energy, hop count and queue length which is also enhance the rule of Fuzzy logic to improve the lifetime of the network. Optimal paths are traced and selected which is depends on these fuzzy variables, used to improvise and enhance the process of Reverse Ad hoc on Demand Distance Vector (RAODV) routing protocol and also helpful to improve the lifetime of the network. NS2 Simulator are used to analyze the concert of RAODV and Fuzzy based Reverse Ad hoc on demand Distance Vector (FRAODV) routing protocol which is based on packet size and round time of network using the parameters of Packet delivery ratio, energy consumption and end to end delay , performance results shows that FRAODV is more accomplished and improves the lifetime of the network.***

Keywords* : *Energy , Fuzzy based Reverse Ad hoc On demand Distance Vector (FRAODV), Fuzzy logic, Reverse Ad hoc On demand Distance Vector (RAODV).

I. INTRODUCTION

Mobile Ad hoc network (MANET) is the main type of Ad hoc network, all the nodes on this type of network has mobile nodes which is acts like router also because it promoted data to the next neighbor nodes. Many more routing protocols are available for wired and wireless network, basically routing protocols are divided into flat routing protocols, hierarchical routing protocols and geographic position based routing protocols. Proactive routing protocols and Reactive routing protocols are based on the category of flat routing protocol, in the proactive routing protocol, each node on the network knows about the whole topology of the network and other nodes on the network; at the same time each node periodically update the routing table for data packet transmission, DSDV (Destination Sequenced Distance Vector Routing Protocol) is one of the example of proactive routing protocol. In the Reactive routing protocol, source node discovered the routing path to destination node then only starts data transmission to destination node that means source node establishes the routing path to destination node only when it needs but not all the times, popular Ad hoc On demand Distance Vector Routing protocol is an example of reactive routing protocol. Reverse Ad Hoc On-Demand Distance Vector Routing Protocol (RAODV) [1] which is the extension of AODV routing protocol [2] and it is helpful to avoid Route Reply packet loss from the destination node. This protocol is under the type of Reactive routing protocol that means source node set up routing path to destination node only when it wants to send data packet to destination. Source node uses Route Request (RREQ), R-RREQ (Reverse Route Request) packets for route innovation to destination node. Source node broadcasts RREQ packet within the transmission range, intermediate nodes obtain and forward these RREQ packets to the next neighbors and these processes continually, RREQ packet finally reach to destination node. Destination node create and broadcast R-RREQ packet immediately within the transmission range of the destination node, neighbor nodes receive and forward R-RREQ packet and these process continues and then finally reaches to source node, which collects multiple node disjoint path details to the routing table. RAODV and AODV protocol is not select optimal traversal path for data transmission; source node receives the first R-RREQ packet from the destination and then immediately starts for data transmission using the minimum hop count path but not consider the efficient path, if the nodes on the link has minimum energy means, current link is failed then only source node choose another path on the routing table for data transmission in RAODV protocol. Randomized Reverse AODV protocol [3][4] is the extension of RAODV protocol which collects the multiple path and these path are selected randomly for data transmission, not use the same path for data transfer, but this protocol is not select the efficient or optimal traversal path for data transmission.

In this research work focused on the enhancement of fuzzy based RAODV (FRAODV) protocol [5], fuzzy logic method is helped to choose the efficient and optimal path for data transmission to destination node; similarly many more rules are added in the inference engine to enhance the performance of Fuzzy based RAODV protocol.

II. RELATED WORK

Tamandani & Bokhari [6] proposed SEPFL routing protocol which one is based on Stable Election Protocol(SEP), it has three fuzzy logic variables like distance of nodes from base station, density and battery level of nodes are used to enhance the lifetime of the Wireless Sensor Networks. Gupta et al [7]

Manuscript published on November 30, 2019.
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proposed an algorithm which has three fuzzy logic variables like energy, centrality and concentration of a node for the selection of cluster head and BS that is based on the fuzzy logic rules.

Imad et al [8] proposes routing method for wireless sensor networks to extend the network life time using a fuzzy logic approach and an A-Star algorithm that is used to decide on an optimal routing path base on highest remaining battery power, less number of hops and traffic loads. BS calculates the routing schedule and broadcast it and every node follow this rule to find the optimal path. Lee & Cheng [9] proposed fuzzy logic based clustering approach with energy prediction to prolong the lifetime of wireless sensor network by evenly distribute the workload.

Anno et al [10] used different fuzzy descriptors for path selection such as remaining battery power, number of neighbor nodes, network traffics and distance from cluster centroid. Xie [11] et al proposed CRT2FLACO clustering routing protocol for WSN, probability of the node to be a candidate Cluster Head, BS broadcasts a control signal to fixed power level to all sensor nodes, according to the strength of the received signal, sensor nodes calculate the distance to BS and then transmit the distance and residual energy information to BS.

Mohammad et al [12] applied Fuzzy logic technique to improve the quality of service in the audio and video applications. Parameters like delay, jitter, throughput, packet loss and both are combined into a single value that is the input of fuzzy inference system. Sabeetha et al [13] proposed a novel encounter based fuzzy logic routing scheme to maximize the message delivery with less overhead.

Tabatabaei et al [14] proposed one routing protocol which is helped to improve system performance based on the fuzzy input variables and also remained energies of the nodes, bandwidth, node mobility to select a stable route. Senthil & Ram [15] selected best path depends on sent, received packets, transmission time and dropped packets were predictable for each path.

III. Fuzzy Logic Based RAODV Protocol

Fuzzy logic systems are applied in RAODV protocol which is used to select the best optimal traversal paths for data transmission between source and destination. Optimal traversal paths are selected based on the fuzzy input variables like energy, hop count and queue length of the intermediate nodes, destination node wait for some time interval to collect the RREQ packet and calculate the average of these input variables, it choose two paths for data transmission based on these variables, one for data packet transmission and another is back off for future data transmission, if the current link is failed then only choose another path for data transfer.

This protocol performance has compare to RAODV protocol, network performance are analyzed based on the parameters like packer delivery ratio, throughput, end to end delay and average energy consumption depends upon on number of nodes and speed. In this protocol uses three linguistic variables like low, medium and high, using only 9 rules are applied to select optimal traversal path, so performance of the network is slightly decreased.

Proposed work is the extension of Fuzzy based RAODV protocol, it also uses the same fuzzy input variables that is energy, hop count and queue length, but it uses 27 rules and five linguistic variables are used that is low, medium, high, very low and very high, so it select the very efficient and optimum path for data transmission. In this work, remained energy of intermediate nodes are high, hop count length is decreased that means delay time reduced, packet delivery ratio and throughput is high and average energy consumption rate is high compare to RAODV Protocol based on the packet size and round time of network.

Fuzzy logic system has four Models that are fuzzification, defuzzification, inference engine and fuzzy rules. In fuzzification process, inputs with crisp value are transformed into fuzzy sets, Fuzzy rules means applying If then rule, Fuzzy inference engine is used with fuzzified input values and applying If then rule to simulate the human reasoning procedure, defuzzification means fuzzy inference value is deciphered with crisp values. Block diagram of Fuzzy structure with input variables are represented in the Fig.1.

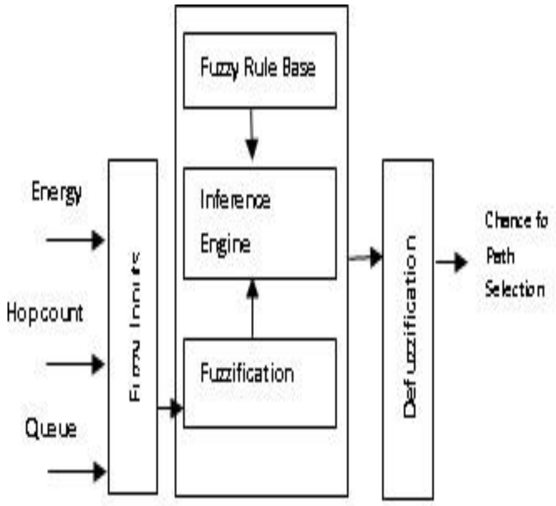

Fig. 1. Block Diagram of Fuzzy Structure with input variables

Above figure represents 3 input variables that is energy, hop count and queue length, these crisp values are converted into Fuzzy sets which is called fuzzification process. Inference engine accepts the fuzzy sets and using 27 fuzzy rule to select the optimal traversal path for data transmission between source and destination. Nearest neighbor nodes are selected based on these Fuzzy variables for data transmission, energy, hop count and queue length both are low means the probability of path selection is very low. Hop count and energy is low and queue length is high means the probability is very low, because energy of intermediate nodes is low, but more data packets are wait on the queue, so the probability of path selection is very low. At the same time hop count is low, energy is high and queue length is low means the probability is very high, because queue length is low but energy of the nodes is high, so energy is not exhausted more. Fuzzy rules are represented in Table I.

International Journal of Recent Technology and Engineering (IJRTE)
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Table- I: Fuzzy Logic Rules

Hop count	Energy	Queue Length	Probability
Low	Low	Low	Very Low
Low	Medium	Low	Medium
Low	Medium	Medium	Medium
Low	Low	Medium	Low
Low	Low	High	Very Low
Low	Medium	High	Medium
Low	High	Low	Very High
Low	High	Medium	High
Low	High	High	High
Medium	Low	Low	Low
Medium	Medium	Medium	Medium
Medium	Medium	Low	Medium
Medium	Low	Medium	Low
Medium	Low	High	Very Low
Medium	Medium	High	Medium
Medium	High	Low	Very High
Medium	High	High	High
Medium	High	Medium	High
High	Low	Low	Low
High	Medium	Medium	Medium
High	Low	High	Very Low
High	Medium	High	Medium
High	High	Low	Very High
High	High	Medium	High
High	High	High	High
High	Low	Medium	Low
High	Medium	Low	Medium

IV. MATERIALS AND METHODS

Evaluate the performance of RAODV protocol with applying fuzzy logic in RAODV protocol. Detailed performance analysis of FRAODV and RAODV protocols is conceded out using the parameters like Packet delivery ratio, average end-to-end delay and average energy consumption based on the packet size and round time of network. Two different circumstances are used to evaluate the performance of RAODV protocol and extension of Fuzzy based RAODV protocol. The simulation parameters environment is represented in Table II.

Table- II: Simulation Parameters

Parameter	Value
Simulator	ns-2.34
Protocols	RAODV,FRAODV
Number of nodes	60, 70, 80, 90, 100
Simulation Area	1000m X 1000m
MAC Layer	IEEE 802.11
Simulation Times	100s
Radio Transmission range	250m
Movement Model	RWP (Random Way Point Model)
Traffic type	CBR
Mobility	10ms
Propagation	Two ray ground
Agent	UDP agent
Data Payload	512 bytes/packet
Transmission Power(TxPower)	0.02
Receiving Power(RXpower)	0.01

A.Scenario 1 – Network with varying Packet Size

RAODV and FRAODV protocols are analyzed based on various parameters like packet delivery ratio, end to end delay and average energy consumption using various packet size of a network.

Packet Delivery Ratio: It is represented in Fig 2. Average packet delivery ratio of RAODV protocol is 64% but in FRAODV has 91%. FRAODV protocol selecs best optimal traversal paths based on the fuzzy variables, so packet delivery ratio rate is elevated compare to RAODV protocol. Average efficiency of FRAODV protocol is 44% over RAODV routing protocol.

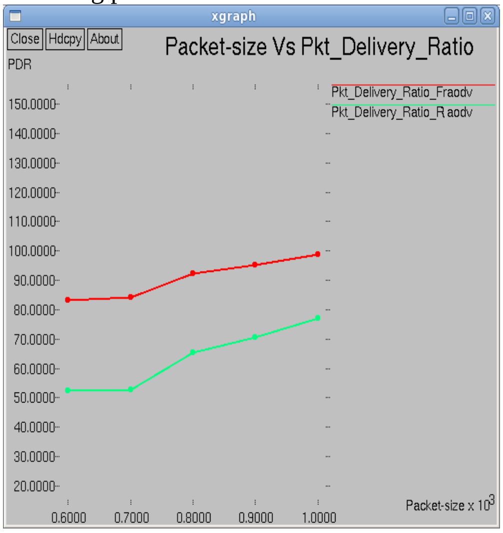

Fig. 2. Packet delivery ratio Vs Packet Size

End to End Delay : Delay time reduction is so high in FRAODV protocol. Average delay time of RAODV protocol is 0.46ms but FRAODV protocol has 0.02ms and also average efficiency of end to end delay in FRAODV protocol has 95% over RAODV protocol, since all the data packets are travel through the optimal, efficient and node disjoint paths for data packet transmission. It is represented in Fig 3.

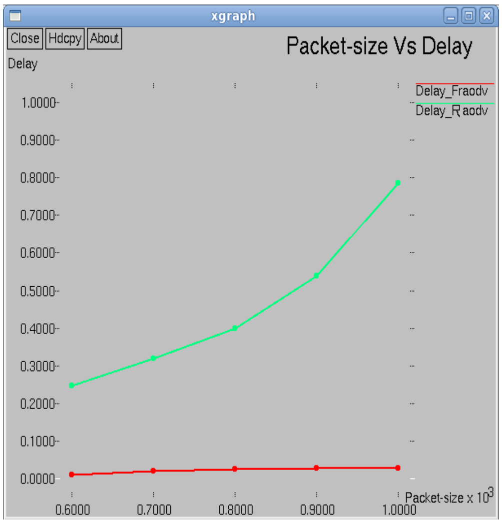

Fig. 3. End to End Delay Vs Packet Size

Average energy: Average energy consumption rate of data packet transmission is calculated between source and destination. Energy is one of the vital parameter of wireless network, intermediate nodes are easily exhaustible when the energy rate of intermediate node is decreased. More energy is avail on the intermediate nodes has only forwarded the data packets to the destination node. Average energy consumption rate of RAODV protocol has 0.31% and FRAODV protocol has 0.17, so energy consumption rate is very much reduced in FRAODV protocol. It is represented in Fig 4.

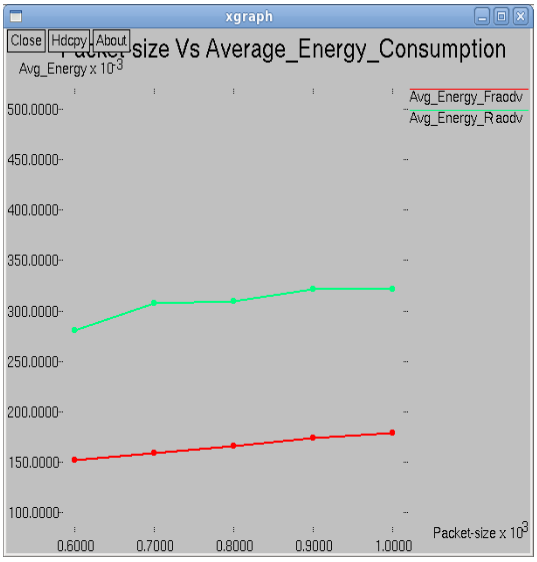

Fig. 4. Energy Consumption Vs Packet Size

B. Scenario 2 – Network with varying Round Time of nodes

Packet delivery ratio, end to end delay and Average energy consumption are analyzed in RAODV and FRAODV routing protocols based on varying round time.

Packet Delivery Ratio: Fig 5 shows the Packet delivery ratio Vs Round Time of RAODV and FRAODV routing protocols. Round Time of the node is increased then packet delivery ratio is high in FRAODV routing protocol compare to RAODV protocol, Average rate of packet delivery ratio in RAODV protocol has 74% at the same time FRAODV has 96% and also the average efficiency is 33% over RAODV protocol.

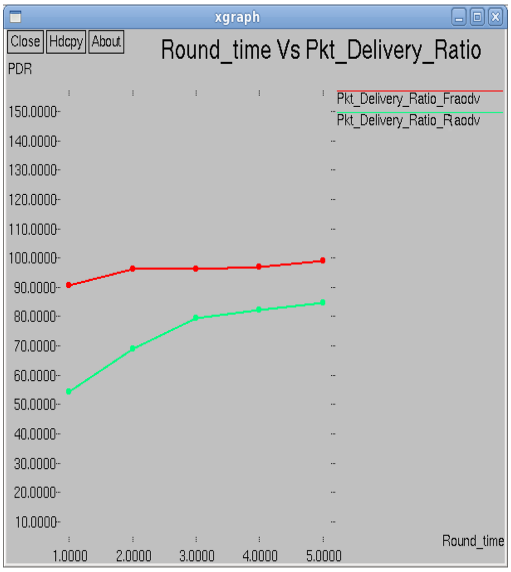

Fig. 5. Packet delivery ratio Vs Round_Time

End to End Delay : In Fig 6 represents end to end delay of RAODV and FRAODV routing protocol. Average delay of FRAODV has 0.02% , but RAODV has 0.19% , Delay time is very much reduced in FRAODV protocol.

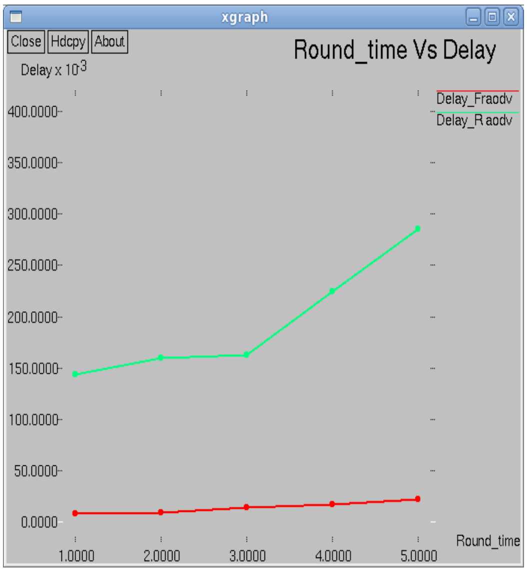

Fig. 6. End to End Delay Vs Round_Time

Average energy: Energy consumption of FRAODV protocol and RAODV protocol is represented in Fig 7. Average energy consumption rate of FRAODV protocol has 0.15 Joules and RAODV protocol has 0.19 Joules, so energy consumption rate is reduced in FRAODV protocol compare than RAODV protocol.

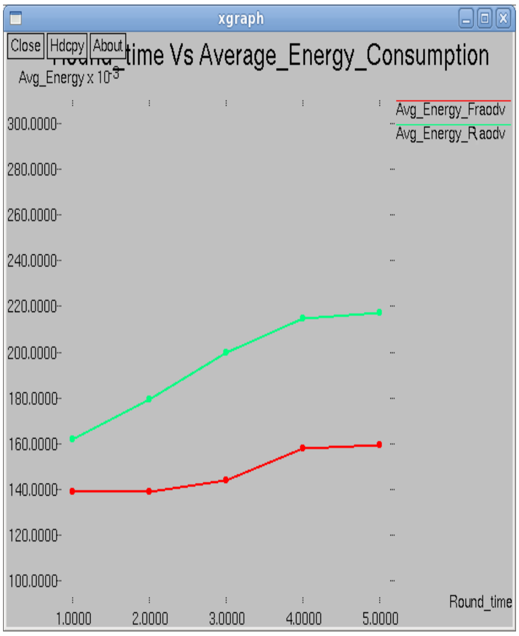

Fig. 7. Average energy Consumption Vs Round_Time

V.RESULTS AND DISCUSSION

Performance of RAODV and FRAODV protocols are analyzed with respect to packet size is represented in Table III . In this analysis, packet delivery ratio of FRAODV protocol is 44 % over RAODV protocol, end to end delay is 95% less than RAODV protocol and Average energy consumption is 46% less than RAODV protocol because FRAODV uses optimal path for data packet transmission.

Table- III: Performance Analysis of RAODV and FRAODV routing protocols with respect to Packet Size

Packet Delivery Ratio (%) VS Packet Size (bytes)			
Packet Size	**RAODV**	**Fuzzy Logic RAODV**	
600	52.5529	83.3176	
700	52.5765	84.1412	44.48 % more than RAODV
800	65.4941	92.1412	
900	70.5882	95.2118	
1000	76.9882	98.7412	
End to End Delay (ms) VS Packet Size			
Packet Size	**RAODV**	**Fuzzy Logic RAODV**	
600	0.248035	0.0106809	
700	0.318620	0.0198166	
800	0.398366	0.0243595	94.98% less than RAODV
900	0.539118	0.0269153	
1000	0.786521	0.0273259	
Average Energy VS Packet Size			
Packet Size	**RAODV**	**Fuzzy Logic RAODV**	
600	0.280679	0.151948	
700	0.307639	0.158888	46.15% less than RAODV
800	0.309101	0.165565	
900	0.320988	0.173781	
1000	0.321436	0.179190	

Analysis of RAODV and FRAODV routing protocols with respect to round time is represented in Table IV. In this experimental result, packet delivery ratio of FRAODV protocol is 33% over than RAODV protocol, end to end delay is 87% less than RAODV protocol, at the same time energy consumption of FRAODV protocol is 24% less than RAODV protocol.

Table- IV : Performance Analysis of RAODV and FRAODV routing protocols with respect to Round_Time

Packet Delivery Ratio (%) VS Round_Time (m/s)			
Round time	**RAODV**	**Fuzzy Logic RAODV**	
1	54.1647	90.8	
2	68.9647	96.2235	32.56% more than RAODV
3	79.6353	96.3529	
4	82.3765	96.9059	
5	84.5529	98.9294	
End to End Delay (ms) VS Round_Time (m/s)			
Round_Time	**RAODV**	**Fuzzy Logic RAODV**	
1	0.103946	0.018354	
2	0.149603	0.019140	86.71% less than RAODV
3	0.182216	0.023698	
4	0.224491	0.026497	
5	0.284808	0.031827	
Average Energy(Joules) VS Round_Time (m/s)			
Round_Time	**RAODV**	**Fuzzy Logic RAODV**	
1	0.161959	0.138744	
2	0.179210	0.138920	23.57% less than RAODV
3	0.199767	0.144048	
4	0.214698	0.157762	
5	0.217057	0.159217	

VI. CONCLUSION

Performance of Fuzzy based RAODV protocol are analyzed in this paper, extra fuzzy rules are added in FRAODV protocol to monitor the performance of RAODV and FRAODV protocols, it give the good result in the QoS parameters like packet delivery ratio, delay and energy consumption based on packet size and also round time on a network. This protocol is helpful to select the optimal paths for data packet transmission between source and destination in a network based on energy, hop count and queue length. In the future work to enhance the fuzzy input variables are reliable on a link and security of node on a link.

ACKNOWLEDGEMENT

My Sincere thanks to my supervisor "Dr.B. Parvathavarthini" and my heart-felt thanks to my family, friends and colleagues who have helped me for the completion of this work.

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Retrieval Number: C4163098319/2019©BEIESP
DOI:10.35940/ijrte.C4163.118419
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