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Analysis of QoS based Routing Algorithm in MANET Using Fuzzy logic

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Abstract: A mobile adhoc network (MANET) is a self-configuring infra- structure less network. The emergence of real-time applications such as multimedia services, disaster recovery etc., and the widespread use of wireless and mobile devices has generated the need to provide quality-of-service (QoS) support in MANET. But QoS provisioning in MANETs is a very challenging problem. This is because of wireless multi-hop communication, limited battery power, each device in a MANET is free to move independently in any direction, range of mobile devices as well as the absence of a central coordination authority. Therefore, an effort has been done to create a new QOS based Stable Energy Aware Ad hoc Routing protocol (QSEAAR). To analyze overall performance of QSEAAR, the inputs are fed into an efficient system based on **fuzzy logic** theory to choose the adaptive values of the protocol depending on the two inputs.

Keywords: AOMDV, RREQ, RREP, MANET, ADHOC,QSEAAR, SEAAR

1. Introduction

MANET is a wireless infra structureless network having mobile nodes. Each node will act as a router and forward data packets to other nodes. Adhoc networking is becoming very popular nowadays and will emerge as an effective complement to wired or wireless LANs, and even to wide-area mobile networking services, such as Personal Communication Systems (PCS). The most important design criterion for any type of network is guaranteeing Quality of Service. QoS measures include bandwidth, delay and delivery guarantee. Different classes of traffic (e.g. voice, data, image, video, etc.) have different bandwidth and delay requirements. QoS-aware routing takes into consideration multiple QoS requirements, link dynamics, as well as the implication of the selected routes on network utilization, rendering QoS routing a particularly challenging problem. However, the unique features of MANETs, namely dynamically varying network topology, imprecise state information, lack of central coordination, error-prone shared radio channel, hidden terminal problem and time-varying capacity exacerbate the already complex routing problem. More importantly, node mobility causes frequent failure and reactivation of links, effecting a reaction to the changes in topology from the networks routing, thus increasing network control traffic and saturating the already congested links. Hence, all these aspects necessitate a cost-effective QoS-aware routing [1].

To support QoS, a service can be characterized by a set of measurable pre specified service requirements such as minimum bandwidth, maximum delay, maximum delay variance and maximum packet loss rate [2]. However, many other metrics are also used to quantify QoS and in this paper bandwidth, hop count and error count are used to calculate QOS requirements. The main objective of this paper is to analyze QSEAAR protocol for various inputs and select the appropriate input to get the optimum value of output parameters.

2. RELATED WORK

A fairly comprehensive overview of the state of the field of QoS in networking was provided by Chen in 1999 [3]. Chakrabarti and Mishra [4] later summarized the important QoS related issues in MANETs in 2001 and their conclusions highlighted several significant points in MANET research. It includes admission control policies and protocols, QoS robustness and QoS preservation under failure conditions. In 2004, Al-Karaki and Kamal published a detailed overview [5] and the development trends in the field of QoS routing. They highlighted some areas such as security and multicast routing requiring further research attention. They were categorized the QoS routing solutions into various types of approaches: Flat, Hierarchical, Position-based and power aware QoS routing. Reddy et al. [6] provided

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a thorough overview of the more widely accepted MAC and routing solutions for providing better QoS in MANETs. L.Chen et al. proposed QOS aware routing protocol [7]. The authors introduce the bandwidth estimation by disseminating bandwidth information through Hello messages. The authors compare two different methods of estimating bandwidth. The IEEE 802.11E [8] standard MAC (Medium Access Control) enhancements enables some QOS guarantees through MAC level service differentiation. The QOS routing protocol should respond quickly in case of path breaks and recompute the broken path or bypass the broken link without degrading the level of QOS. This is a complex and difficult issue because of the dynamic nature of the network topology and generally imprecise network state information [9].

Lei Chen et al. [10] proposed network architecture to support QOS in Manet. Heni Kaaniche et al. [11] suggest an approach to estimate available resources which is based on the estimation of the busy ratio of the shared canal. Anelise Munaretto, Mauro Fonseca [12] proposed the QOLSR protocol which includes quality parameters to the standard OLSR. Muhammad Ibrahim et al. [13] discussed some problems that may occur in providing QoS to Mobile nodes in Mobile Adhoc networks and solution for managing those problems, like dynamic topologies that change continuously and unpredictable at any time. L.Hanzo (II.), R. Tafazolli [14] include a thorough overview of QoS routing metrics, resources, and factors affecting performance and described their interactions with the medium access control (MAC) protocol. CH. V. Raghavendran [19] describes the challenges and approaches for QoS aware routing techniques. Bhagyashri. R. Hanji et al. [20] gives detailed survey of strength, weakness and applicability of existing QoS routing protocols. N. Sarma and S. Nandi[21] presents a route stability-based multipath QoS routing protocol for mobile ad hoc networks to support throughput and delay sensitive real-time applications in these networks.

B. Vamsee Mohan et.al.[22] propose a novel Reliable Routing Algorithm (RRA) in mobile ad hoc network using fuzzy Petri net and its reasoning mechanism. Dhafer R. Zaghar et.al [23] used the fuzzy technique to simplify the QoS factor and summarize it in a simple form or in a single value for each application. C. Gomathy et al [24] designed a fuzzy-based priority scheduler to determine the priority of the packets. Onifade O.F.W et.al[25] proposed Fuzzy Self Organizing Map(FSOM) provide very efficient algorithmic tools for transmitting packet in an efficient manner by taking the most efficient route and also the bandwidth, latency and range are considered to determine how good is the data delivered. Abduladhem A. Ali et al [29] proposed fuzzy routing method is evaluated and compared with conventional AODV routing in terms of packet delivery ratio, average of end to end delay, and average of energy consumption. M. Marimuthu et al [30] proposed Fuzzy Cost Based Power Aware QoS Routing (FCPAQR) protocol to select an optimal path by considering multiple independent QoS metrics

3. QOS BASED SEAAR (QSEAAR)

In this section Stable Energy Aware Adhoc Protocol (SEAAR) with power aware and stability concept in [26] is extended by including QoS parameters and new protocol QSEAAR is proposed. In QSEAAR protocol, IEEE 802.11 MAC layer is taken and the same MAC layer bandwidth is considered for the transmission. With this, available bandwidth estimations are done. The parameters considered for QOS are explained below.

Error Count (EC) -The EC is the maximum value between set of node error counts (linkage break and node failure) for the feasible path. The smaller EC represents the more reliable routing path.

Hop Count (HC)-The HC is the number of hops for the feasible path. The smaller HC represents the more reliable and less cost of routing path.

BandWidth(BW)-Bandwidth estimation is a basic function that is required to provide QOS in MANETs. It is a way to determine the data rate available on a network route. It is of interest to users wishing to optimize end-to-end transport performance, overlay network routing, and peer-to-peer file distribution

Techniques for accurate bandwidth estimation are also necessary for traffic engineering and capacity planning support. QOS is calculated using equation given below,

$$\mathrm{QOS} = \mathrm{C}_1 \times \frac{\mathrm{EC}}{\mathrm{Max(EC)}} + \mathrm{C}_2 \times \frac{\mathrm{HC}}{\mathrm{Max(HC)}} + \mathrm{C}_3 \times \frac{\mathrm{BW}}{\mathrm{MAX(BW)}} \quad (1)$$

Where |C1|+|C2|+|C3|=1, EC=error count, HC= hop count, BW=bandwidth, C1, C2, C3 are the values which can be chosen according to the system needs. For example, bandwidth is very important in MANETs, thus the weight of C3 factor can be made larger. C1, C2 factor related to path error and hop count reduce the weight of path so C1 and C2 factor can be made smaller [19]. In QSEAAR protocol, the value of C1, C2 & C3 are chosen as C1=0.10, C2=0.10 & C3=0.80.

QOS values are calculated for the selected path and the source node tends to select the path with the high QoS value from multiple paths and data is forwarded in that path.

4. RESULTS AND DISCUSSION

Mobile ad hoc networks (MANETs) have been widely studied in the literature. Due to the nature of self-

organization, the dynamic topology caused by mobility and transmission power control, and the multiple-hop routing in MANETs, it is difficult to build a complete analytical model to study the network performance. On the other hand, a real test bed is expensive. Therefore, the simulation study of MANETs is important. Different simulation tools such as ns-2 with CMU monarch extension, GloMoSim and its commercial successor QualNet, OPNET, and SWANS have been developed for MANET evaluation. The simulation study presented in this paper is based on ns-2 (NS2.34) under LINUX platform because it is open source and is widely used in both academia and industry [22]. Using a simulator written in C++, topologies are randomly generated, and perform the computations on these fixed graphs, which represent snapshots of the Ad-Hoc network state.

Table 1: Simulation Environment

Simulation Time	100s
Topology Size	500m x 500m
MAC Type	MAC 802.11
Radio Propagation Model	Two Ray Model
Radio Propagation Range	150m
Pause Time	25s
Initial Energy	100J
Transmit Power	0.4W
Receive Power	0.1W
Traffic Type	CBR
Packet size	1000bytes
Bandwidth	Based on the analysis in this section, the available link bandwidth is computed as follows: Each node is randomly assigned an "idle time" ranging from 0 to 1. The available link bandwidth between two nodes is equal to the minimum of their idle time x maximum bandwidth. Here, we consider that in the Ad-Hoc network, each link has the same maximum bandwidth, 2 Mbps. For example, if node a's idle time is 0.5 and node b's idle time is 0.3, then the available bandwidth over link ab is: 0.3 x 2Mbps = 600 kbps.
Routing Protocol	AOMDV

A. Network Scenario

The table 1 shows the important parameters chosen for the NS2 simulation. An effort has been done to create a new protocol QSEAAR by adding quality of service with the concept of SEAAR protocol which provides path stability, residual energy consumption. QSEAAR protocol was also analyzed in terms of packet

delivery ratio, energy consumption, packet loss, throughput and end to end delay. The performance of QSEAAR protocol was compared with existing protocol AOMDV and SEAAR which shows that QSEAAR outperforms than other protocol in most of the case.

B. Simulation Parameters

RFC 2501 describes a number of quantitative metrics that can be used for evaluating the performance of a routing protocol for mobile wireless ad-hoc networks. Some of these quantitative metrics [23] are defined as follows:

1. Packet delivery ratio

The packet delivery ratio is defined as the ratio of number of data packets received at the destinations over the number of data packets sent by the sources as given in equation (2). This performance metric is used to determine the efficiency and accuracy of MANET's routing protocols.

$$\text{Packet Delivery ratio} = \frac{\text{Total data packets received}}{\text{Total data packets Sent}} \text{x100} \tag{2}$$

2. Energy consumption

This is the ratio of the average energy consumed in each node to total energy as given in the equation (3).

$$\text{Energy consumption} = \frac{\text{Energy remaining in the node}}{\text{Total energy}} \tag{3}$$

3. End to end delay

This is the average time involved in delivery of data packets from the source node to the destination node. To compute the average end-to-end delay, add every delay for each successful data packet delivery and divide that sum by the number of successfully received data packets as given in equation (4). This metric is important in delay sensitive applications such as video and voice transmission [24].

$$\text{Average End to end delay} = \Sigma \frac{(\text{Time received} - \text{time sent})}{\text{Total data packets received}} \tag{4}$$

4. Throughput

The throughput metric measures how well the network can constantly provide data to the sink. Throughput is the number of packet arriving at the sink per ms. A network throughput is the average rate at which message is successfully delivered between a destination node (receiver) and source node (sender). It is also referred to as the ratio of the amount of data received from its sender to the time the last packet reaches its destination. Throughput can be measured as bits per second (bps), packets per second or packet per time slot. For a network, it is required that the throughput is at high level. Some factors that affect MANET's throughput are unreliable communication, changes in topology, limited energy and bandwidth.

5. Number of Packets dropped

This is the number of data packets that are not successfully sent to the destination during the transmission. In this study the time versus number of packets dropped have been calculated. Packet loss occurs when one or more packets being transmitted across the network fail to arrive at the destination. It is defined as the number of packets dropped by the routers during transmission. It can be shown by equations (5) to (7).

Packet Loss = Total Data Packets Dropped (5)

Packet Loss = Total Data Packets Sent – Total Data Packets Received (6)

$$\text{Packet loss}(\%) = \frac{\text{Total data packets dropped}}{\text{Total data packets Sent}} \text{x100} \tag{7}$$

C Simulation Results

The performance of the following protocols is compared and applied them to the randomly generated network snapshots:

1) Adhoc on demand multipath routing protocol (AOMDV)
2) Stable Energy aware adhoc routing protocol (SEAAR)
3) QoS based SEAAR (QSEAAR)

The performance of SEAAR and QSEAAR is compared with the existing protocol AOMDV and the results are shown below. Fig 4.1 shows the comparison of packet loss ratio versus nodes for AOMDV, SEAAR and QSEAAR protocols in terms of packet loss. The observation is that at 60 nodes, the packet loss is less in QSEAAR and more in SEAAR. But at 120 nodes packet loss is same as AOMDV. Higher the packet loss, less efficient is routing protocol and in this figure, AOMDV gives high packet loss than QSEAAR and SEAAR.

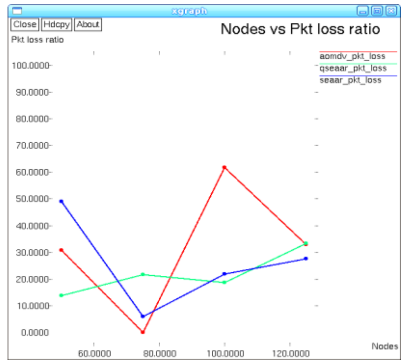
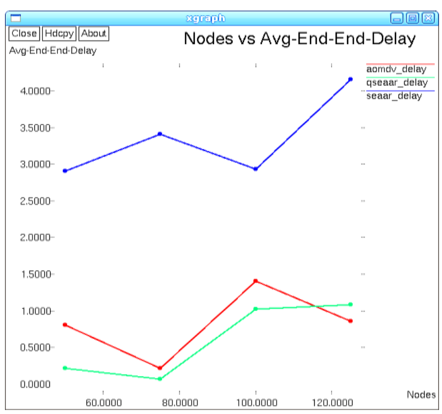


Fig 4.1 Comparison of packet loss ratio versus nodes

Fig 4.2 shows the comparison of end to end delay versus nodes for AOMDV, SEAAR and QSEAAR protocols. It shows that the end to end delay of network using QSEAAR is minimum as compared to SEAAR and AOMDV with 60, 80 and 100 nodes. At 120 nodes QSEAAR has slightly more delay as compared to AOMDV. On an average performance of QSEAAR is better.

Fig 4.3 shows the comparison of residual energy versus nodes for AOMDV, SEAAR and QSEAAR protocols. It shows that the residual energy of network ie the energy remaining in the node using SEAAR is maximum compared to AOMDV and QSEAAR. Energy remaining in QSEAAR is better when number of nodes is less and energy decreases as number of nodes increases. On an average QSEAAR is better as compared to existing AOMDV and slightly inferior as compared to SEAAR.

Figure 4.4 shows the comparison of throughput versus nodes for AOMDV, SEAAR and QSEAAR protocols. It shows that the throughput of network using SEAAR and QSEAAR is maximum compared to AOMDV. The protocol having high network throughput is more efficient and in this figure, SEAAR and gives high throughput than AOMDV.



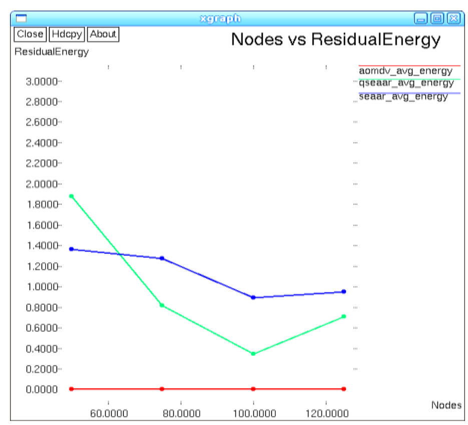


Fig 4.2 Comparison of end to end delay versus nodes.

Fig 4.3 Comparison of residual energy versus nodes.

Fig 4.5 shows the comparison of packet delivery ratio versus nodes for AOMDV, SEAAR and QSEAAR protocols. It shows that the packet delivery ratio of network using SEAAR and QSEAAR is maximum compared to AOMDV. Therefore QSEAAR outperforms AOMDV in terms of throughput, delay, energy remaining, pack loss and packet delivery ratio.

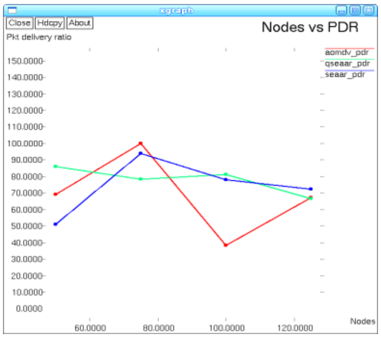


Fig 4.4 Comparison of throughput versus nodes

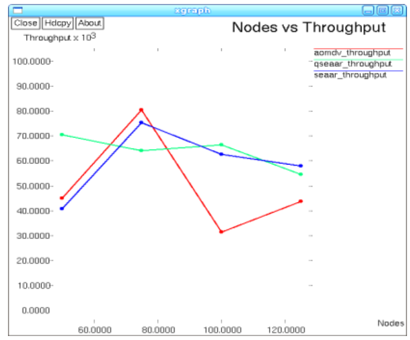
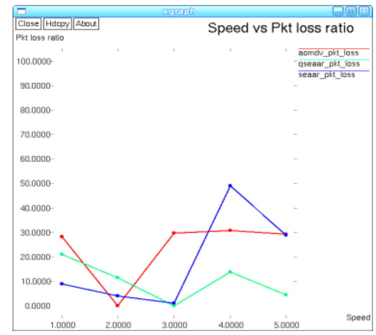


Fig 4.5 Comparison of packet delivery ratio versus nodes.



4.6 Comparison of packet loss ratio versus speed

The performance of the protocol is analyzed with different types of mobility of the nodes. Fig 4.6 shows the comparison of packet loss ratio versus speed for AOMDV, SEAAR and QSEAAR protocols. It shows that the packet loss of network using QSEAAR is minimum as compared to AOMDV and SEAAR when nodes are moving with more speed and in low mobility environment it is comparable with AOMDV.

Fig 4.7 shows the comparison of end to end delay versus speed for AOMDV, SEAAR and QSEAAR protocols. It is observed that the end to end delay of network using QSEAAR is minimum as compared to AOMDV and SEAAR when nodes are moving with more speed and in low mobility environment it is higher than AOMDV and less than SEAAR

Fig 4.7 Comparison of end to end delay versus speed.

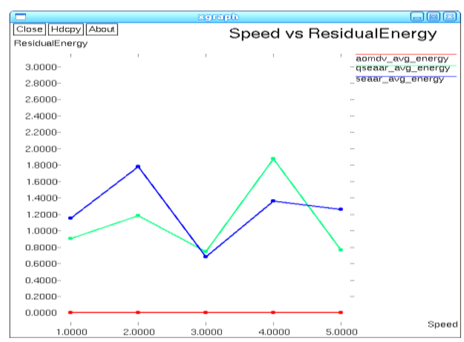


Fig 4.8 Comparison of residual energy versus speed.

Fig 4.8 shows the comparison of residual energy versus speed for AOMDV, SEAAR and QSEAAR protocols. It shows that the energy remaining in the nodes using QSEAAR is more as compared to AOMDV and SEAAR when nodes are moving with more speed and in low mobility environment it is higher than AOMDV and less than SEAAR.

Fig 4.9 shows the comparison of throughput versus speed for AOMDV, SEAAR and QSEAAR protocols. It shows that the throughput of network using QSEAAR is maximum compared to AOMDV and SEAAR and slightly inferior to SEAAR when nodes are moving with less speed

Figure 4.10 shows the comparison of packet delivery ratio versus speed for AOMDV, SEAAR and QSEAAR protocols. It shows that the packet delivery ratio of network using QSEAAR is maximum compared to AOMDV and SEAAR slightly inferior to SEAAR when nodes are moving with less speed

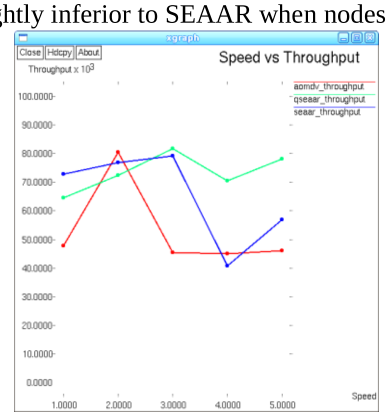


Fig 4.9 Comparison of throughput versus speed

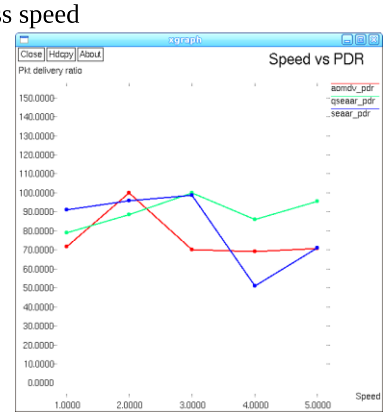


Fig 4.10 Comparison of packet delivery ratio versus speed

D Trace file analysis

C++ coding is written to include all the above concepts. This is linked with Tcl script written in ns-2. When the simulation is started, the working of the protocol is displayed in terminal window and the same is stored in a trace file. Some part of the output is given below. Here 50 nodes are used and each node calculate Node lifetime (NLT) and link lifetime(LLT) for all the neighbour nodes. Here sample output for node 0 is given. Node 0 calculates LLT &NLT for its neighbours 13, 11, 16

Node: 0 NLT

13 0.00079145613 node_lifetime: 126313
11 0.00077532311 node_lifetime: 128868
16 0.0013526916 node_lifetime: 73892.8

Node: 0 LLT
13 link_lifetime 65.3779
11 link_lifetime 104.393
16 link_lifetime 55.3369

The source node is taken as 39 and destination is taken as 10. Node 39 want to establish a path to 10 and it sends rote request to 10 through nodes 2,6,0,21 and 10. During that time the value of cost, bandwidth, hop count and error count are updated as shown below

Node: 39 send Route req to 10 at 29.8
Path:39 2 6 0 21 10
Path_bw:1.19993e+07, cost:500.753, Error_count:6

Node 10 sends route reply via the reverse path as shown below.

Node: 10 send Route reply
10 21 0 6 2 39
Reply Forward to : 21 dst: 39
Received route reply 21 from 10
Forward to : 0

Once route is established each node will have path table with updated next hop, bandwidth, cost and QOS values. Then data transfer starts. During that time node send data via path with higher QOS value. For example node source 39 forwards data via node 2 to the destination 10. Node 2's immediate neighbors are 41 & 6. Node 41 is having higher QOS. So node 2 selects node 41 to transfer the data.

Node: 39 Forward data to : 2
Path_table
Dst:10 nhop:41 bw:1.3999e+07 cost:420.102 qos:0.927523
Dst:10 nhop:6 bw:1.19993e+07 cost:500.753 qos:0.664288
Node: 2 Forward data to : 41

5. PERFORMANCE ANALYSIS USING FUZZY LOGIC

A Fuzzy Inference Structure Model

Using fuzzy logic approach for academic performance evaluation is in general fairly new; it has reached a wide range of application areas [27]. According to the tradeoff between parameters, vague of information (*i.e.* unpre- dicted mobility of the nodes), and applications requirements, QoS in MANET cannot be calculated certainty but there is a range of acceptance to the QoS. To deal with this problem soft computing [28] will be involved; the most important part of soft computing is fuzzy logic. Fig 5.1 shows fuzzy interference system (FIS) model.

B Fuzzy Logic System Analysis

Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping then provides a basis from which decisions can be made, or patterns discerned. A fuzzy inference system is created based on the known output range and this utilizes the Mamdani Fuzzy logic System. The parameter depending on their availability are fed into a fuzzifier (Fig 5.2) in which they are converted into fuzzy sets. A fuzzy set contains varying degree of membership in a set. The membership values retrieved for a particular variable into a membership function. Membership function is designed for each quality of service condition which is a curve that defines how each point in the input space is mapped to a membership value. The general structure of the FIS editor is shown in Figure 5.3, where the system has two types of inputs, Speed of mobile nodes and number of nodes in the network. The output of the system is energy remaining, delay, throughput, packet delivery ratio and packet loss which represents the performance of Ad-hoc protocol in the network.

Input Variables with their value range
No. of Nodes [60 120], Speed [1 5]
Output Variables with their value range
Energy remaining [1 5], Delay [0 40], Throughput [0 100], Packet delivery ratio [0 30], Packet loss [0 80]

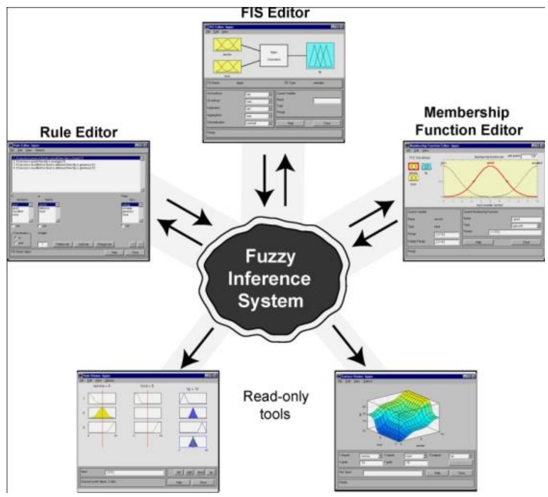


Fig 5.1: Fuzzy Inference System Model

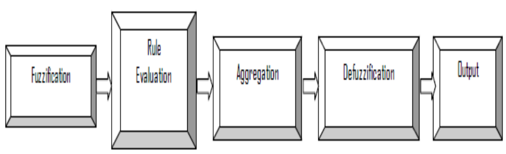


Fig 5.2 Stages in Fuzzy inference system

C Rule Evaluation

This is the second step where the fuzzified inputs are applied to the antecedents of the fuzzy rules. Since the fuzzy rule has multiple antecedents, fuzzy operator (AND or OR) is used to obtain a single member that represents the result of the antecedent evaluation. Here AND fuzzy operation (intersection) is applied to evaluate the conjunction of the rule antecedents. Rules added to this system are derived by mapping the two inputs to one of the five output by using conjunction. The Rule editor shown in fig 5.4 is used to add, change or delete rules, as the name implies. The rules are entered automatically using the GUI tools Examples of some of the rules are:

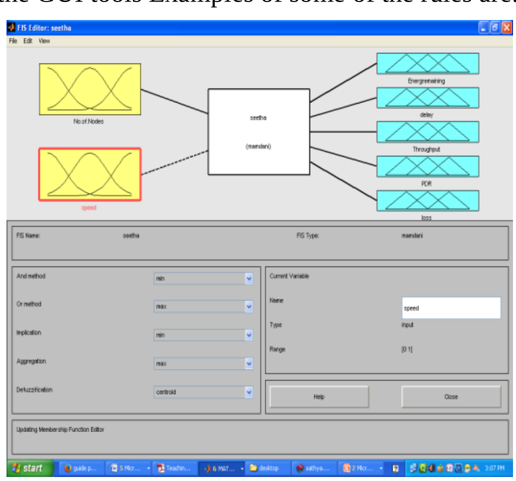


Fig 5.3 General structure of FIS Editor

1. If (No.of.Nodes is less) and (speed is less) then (Energremaining is less)(delay is less)(Throughput is bad)(PDR is less)(loss is max)
2. If (No.of.Nodes is less) and (speed is less) then (Energremaining is more)(delay is more)(Throughput is ok)(PDR is less)(loss is max)
3. If (No.of.Nodes is less) and (speed is more) then (Energremaining is averge)(delay is less)(Throughput is good)(PDR is satisfactory)(loss is min)
4. If (No.of.Nodes is less) and (speed is more) then (Energremaining is averge)(delay is less)(Throughput is good)(PDR is good)(loss is min)

The rule viewer in figure 5.5 displays a roadmap of the whole fuzzy inference process. It shows a graphical representation of each of the variable through all the rules, a representation of the combination of the rules, and a representation of the output from the defuzzification. It also shows the crisp value of the system. Data are entered for analysis through the rule viewer at the input text field. Each column of plots (yellow) shows how the input variable is used in the rules. The input values are shown at the top, and the column of the plots (blue) shows how the output variable is used in the rules. Sliding the red line changes your input values, and generate a new output response although the edit field allows you to set the input explicitly. The last output plot, a blue triangle having a red line in between, the red line provides a defuzzified value, while the plot shows how the output of each rule is combined to make an aggregate output and then defuzzified

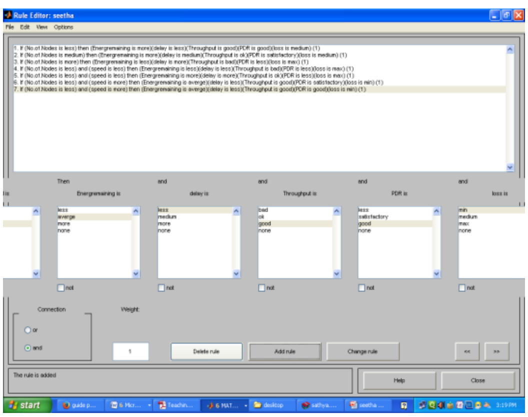
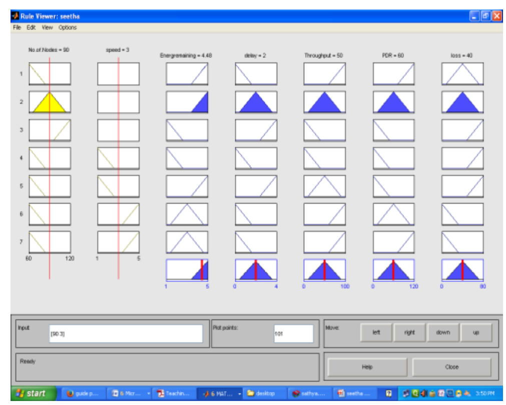


Fig 5.4 Rule Editor



5.5 Rule Viewer

D Aggregation Rule Output

This is the process of unification of the outputs of all rules. In other words, we take the membership functions of all the rules consequent previously scaled and combine them into single fuzzy sets (output). Thus, input of the aggregation process is the list of scaled consequent membership functions and the output is one fuzzy set for each output variable

E Defuzzification

This is the last step in the fuzzy inference process, which is the process of transforming a fuzzy output of a fuzzy inference system into a crisp output. Fuzziness helps to evaluate the rules, but the final output this system has to be a crisp number. The input for the defuzzification process is the aggregate output fuzzy set and the output is a number. This step was done using centroid technique because it is most commonly used method of Defuzzification (DefuzzMethod='centroid').

F Membership function editor

The Membership Function Editor is used to define the shapes of all the membership functions associated with each variable. Figure 5.6 is the window through which the input or the output of the membership function can be changed and membership function can be added or removed. The graph field displays all the membership functions of the current variable. Click on a line in the graph and it is possible to change any of its attributes, including name, type and numerical parameters. The pop-menu right in front of type lets you change the type of the current membership function. The status line describes the most recent operation.

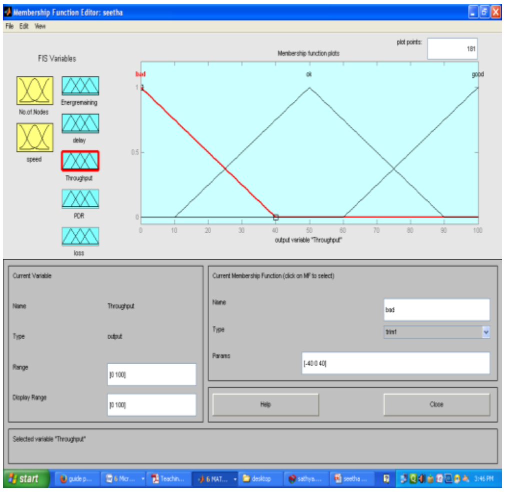


Fig 5.6 Membership function specification

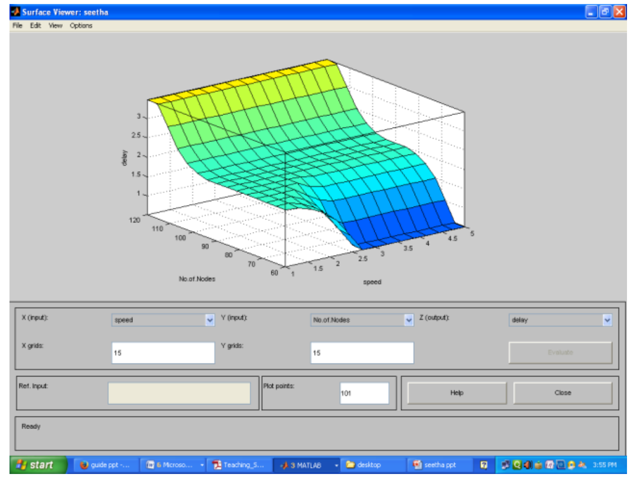


Fig 5.7 Surface Viewer

G Surface Viewer

Figure 5.7 is a three dimensional curve that represents the mapping of two input. This is a two input one-output systems as they generate three dimensional plots that MATLAB can adeptly manage. The surface viewer is equipped with pop-up menus that let you select any two inputs and any one output for plotting. In figure 5.7 delay is selected as output and analyzed with two inputs. Just below the pop-up menus are two text input fields that determines how many x-axis and y-axis grid lines to include. The surface viewer has a special capability that is very helpful in cases with two (or more) inputs and one output: Thee axes can be grabbed and reposition them to get a different three-dimensional view on the data.

H Analysis of QSEAAR using Fuzzy

Table 2. FUZZY analysis input vs output

No. of Nodes	Speed	Energy remaining(J)	End-end delay(ms)	Throughput (ms^{-1})	Packet delivery Ratio (%)	Packet loss (%)
60	1	3	2	50	60	49
	2	2.42	1.58	57.4	72.5	44.7
	3	2.40	0.52	87	104	40
	4	1.21	0.52	87	78.9	35.3
	5	0.95	0.52	87	73.5	31
80	1	3.0	2	50	60	49
	2	2.67	1.93	51.1	62.1	45.1
	3	2.41	1.88	52.9	63.5	40
	4	1.78	1.88	52.9	63.5	37.6
	5	0.78	1.88	52.9	63.5	37.6

The performance of QSEAAR protocol can be analyzed using Fuzzy and the results are shown in Table 2. For the given number of input nodes with varying mobility from 1 to 5 m/s how the output parameters are varying can be judged from the values given in table 2. For an example only 60 and 80 number of nodes is considered. Any number of nodes can be analyzed.

6. CONCLUSION

An on-demand QoS routing protocol based on AOMDV is developed for mobile adhoc networks. In the persistent data forwarding period, a source node tends to select the path with the high QOS value from multiple paths as a source route for data forwarding. It's performance is compared with that of the original AOMDV protocol with simulations. In the simulations the QoS routing protocol can produce higher throughput, less power consumption, better packet delivery ratio, lower delay and packet loss than AOMDV and SEAAR. It works the best in large networks under high network mobility. Incorporation of fuzziness in the input and output of the proposed model was seen to result in better performance.

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