Analysis of Fuzzy Technology based Scheduler in MANETs

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***Abstract* - An ad-hoc network consists of wireless nodes communicating in a distributed way where all nodes potentially contribute to the routing process. The mobility of nodes and the error prone nature of the wireless medium pose many challenges like frequent route changes and packet losses. Such problem increases packet delay and decrease throughput. To improve the performance and maintain the Quality of Service of MANET, the packet scheduler can be used.**

Existing packet schedulers of wireless ad hoc networks serve data packets in FIFO order. In this project, a fuzzy priority calculation module to calculate priority of packet is proposed and designed based on various network parameters like data rate, queue length, expiry time, congestion and packet size.

The performance of the proposed scheduler will be studied by incorporating the designed fuzzy priority calculation module in an experimental setup of 4 to 5 nodes. The network parameters like packet delivery ratio and end-to-end latency are measured and the obtained results will be compared with those obtained by without using the scheduler.

***Keywords* - MANETs, Aggregation, Activation, Accumulation**

I. INTRODUCTION

A mobile ad hoc network is a system of mobile nodes connected using wireless links. A node communicates with all the nodes present in its communication range and can communicate with a node outside the communication range through multi hop routing. In ad hoc networks, there is no centralized administration for the process of routing of packets from one node to other node. Each node involves in the process of routing packets from source to destination by maintaining its own routing information. As all the nodes can't be present inside communication range, each node acts as a forwarder to move packets to intermediate nodes present in the routing path.

Due to wireless nature of connectivity between nodes and the mobile feature of nodes, two nodes might suffer from low strength link or a node might move outside communication range leading to loss of connectivity [2]. The routing protocol should monitor the nodes within communication range, update the status of the dynamic links, maintain the routing information and should provide a shortest route to destination.

Once the route is established, the scheduler schedules the packets on packet by packet basis. The simplest scheduling policy is First in First out where it fails to determine the packets which are at the verge of expiry and differentiate between control and data packets. Scheduling algorithm determines which packet to schedule next from a group of packets present in a queue [6].

The scheduler used in is a fuzzy priority scheduler, which calculates the priority of each packet in the queue based on the network parameters like data rate, queue length, expiry time, congestion and packet size. The packets are sorted in a priority order inside the queue. We found the increased packet delivery ratio and less delay as scheduler is able to schedule the packets which are at the verge of expiry at a high priority.

II. ROUTING PROTOCOL

Reactive routing protocol also known as on demand routing protocol, discovers the route to destination whenever the source has a data to send. If the source has the data to send and it doesn't contain the routing information then it initiates the route discovery process to discover the route. Route discovery process consists of network wide flooding of route request message. Reactive routing protocols include Ad hoc On-demand Distance Vector protocol [1].

AODV is an on demand distance vector protocol and it uses destination sequence numbers to determine the freshness of the routing information. AODV maintains routes in a distributed fashion and each node present in the route path maintains its own routing table. Intermediate nodes forward the data packets to the next node in the path, mean while they maintain the information of previous node to forward the reply packets back to the source. AODV uses a technique called route expiry in which the routing table expires after a predetermined period of time, after which the node needs to initiate fresh route discovery process.

III. FUZZY SCHEDULER

For improving the performance of the mobile ad hoc network, scheduler can be used. Scheduler decides which packet to be scheduled next from a group of packets present in a queue [4]. At present techniques like drop tail are used to drop the packets whenever congestion occurs in the network. In FIFO scheduling, also known as no priority scheduling services both control and data packets in first in first out manner [3]. In priority scheduling, control and data packets are stored in separate queue and higher priority is given to control packets than data packets [7].

Due to distributed nature of mobile ad hoc network, an intermediate node receives packets from more than one node and may not be able to determine which packet to be forwarded next. A node may be unaware of having a high priority packet in its queue and might be involved in forwarding the low priority packets. In multi hop ad hoc networks where packets are forwarded across multiple nodes, it becomes challenging to meet the end to end QoS requirements [5].

The proposed fuzzy scheduler which calculates the priority index of the packet based on the parameters like expiry time, data rate, link congestion, packet size, queue length. The packets with high priority are scheduled first. The application of fuzzy logic to find the priority index of the packets is found to improve the performance of mobile ad hoc network. This led to design of fuzzy priority scheduler.

Fuzzy logic

In Fuzzy Logic, linguistic values and expressions are used to describe physical variables, instead of the names, numbers. If an input variable is described by linguistic terms, it is referred to as a linguistic value. Each linguistic term is described by a Fuzzy Set N. It is thus defined mathematically by the two statements basic set G and membership function μ.

Some of the notations used to describe Fuzzy Sets are:

For finite sets: as unordered, paired sets in incremental form:

N = {(x1,μN(x1)), (x2,μN(x2)),,..,(xn,μN(xn))}, xi € G, i=1,2,..n

The μN (xi) are listed as numerical values.

For infinite sets:

N = {x, μN(x)}, x € G

For example the input variable expiry time is described by linguistic terms L (low), M (medium), H (high).

Each linguistic term is evaluated in terms of fuzzy set.

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FUZZIFY exptime
   TERM L: = (0, 1) (25, 0);
   TERM M: = (15, 0) (30, 1) (45, 0);
   TERM H: = (35, 0) (50, 1) (65, 0);
END_FUZZIFY
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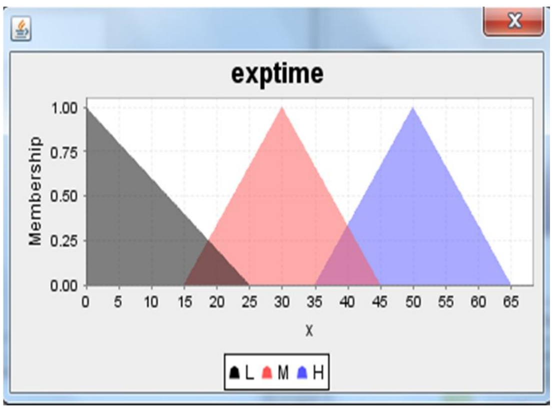
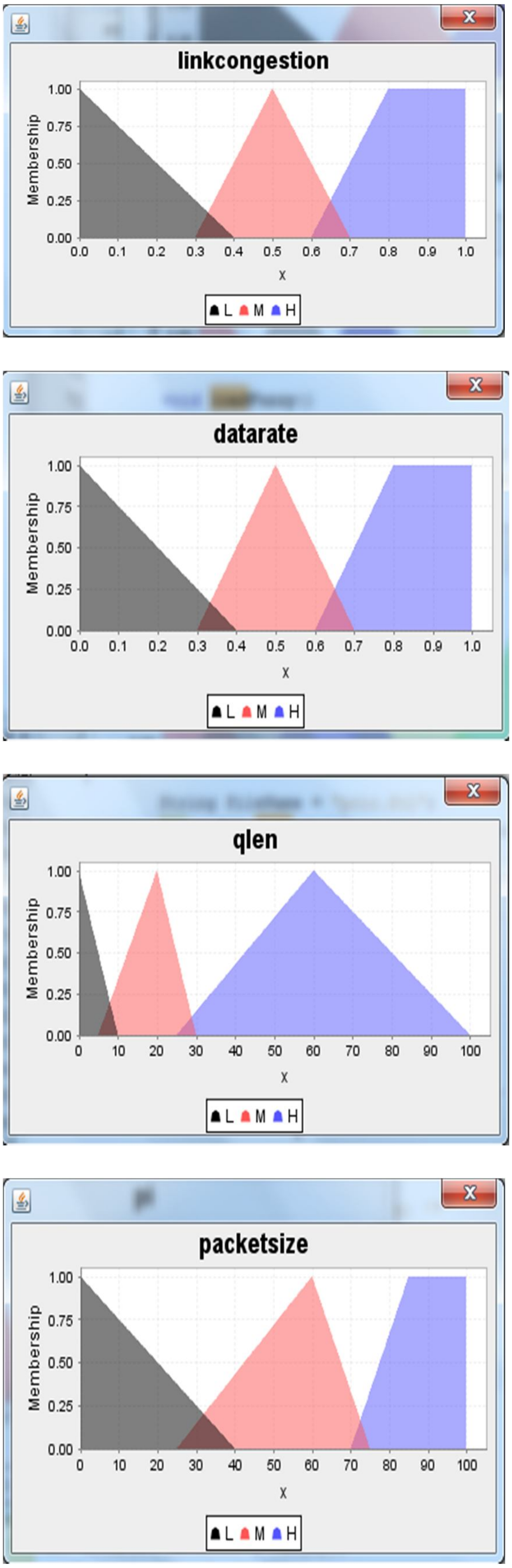
In figure 1, the x-axis shows the values of linguistic variable and y-axis shows the membership function value for the corresponding x value.

The linguistic terms L, M and H and their membership function value are as shown in different colours.

The linguistic variables expiry time, link congestion, data rate, queue length and packet size are input variables. The linguistic variable pi (Priority) is an output variable.

In this way we fuzzify the input and output variables. The process of finding a crisp priority index based on the input values like expiry time, data rate, link congestion, queue length and packet size involves three steps





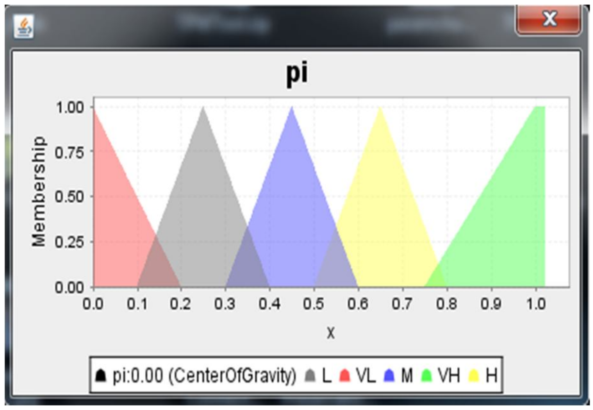


Fig. 1: Membership Function with input and output variables.

1. Fuzzification
2. Inference
3. Defuzzification

The figure 2, describes the application of fuzzy logic to calculate the output Y based on fuzzified input X and the rule base.

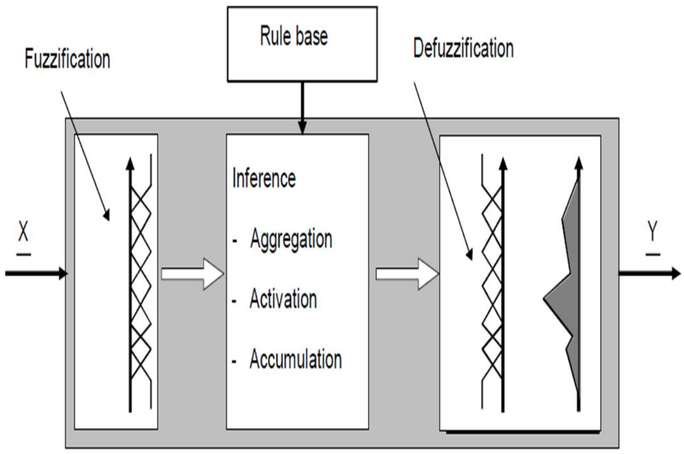


Fig. 2: Application of fuzzy logic

After fuzzification, we use the rule base and methods like aggregation, activation and accumulation to determine the degree of membership associated by values of output variable.

The algorithms used for aggregation, activation and accumulation method are as shown in table I.

TABLE I
ALGORITHMS FOR INFERENCE

Inference step	Operators	Algorithms
Aggregation		
for AND	Minimum	$a_k = Min\{a_{K1}(x), a_{K2}(x)\}$
for OR	Maximum	$a_k = Max\{a_{K1}(x), a_{K2}(x)\}$
activation		
conversion of the IF-THEN-conclusion		
	Minimum	$c_K{'} = Min\{a_K, \mu_{\propto}(u)\}$
weighting factor of each rule		
	Multiplication	$c_k = Mult\{\omega_K, c_K{'}\} = \omega_K \times c_K{'}$
Accumulation	Maximum	$\mu_{accu}(u) = MAX\{c_i(u)\}$

Then we apply "center of gravity" defuzzification method to determine the crisp output value from the fuzzy result of inference. The formula used to calculate the output value U is

$$U = \frac{\int_{Min}^{Max} u*\mu(u)*du}{\int_{Min}^{Max} \mu(u)*du}$$

Where $\mu(u)$ is the memebership function associated with output variable.

IV. PERFORMANCE EVALUATION

In this paper, we have setup an experimental test bed using 4 to 6 nodes. Each node is connected to Wi-Fi using 802.11-g protocol. Each node runs a customized AODV routing protocol to provide the on demand routing functionality to each node. This customized AODV protocol is implemented in java. The fuzzy priority calculation module is integrated with the customized AODV routing protocol. Now the integrated module is run on each node and the performance metrics like packet delivery ratio and end to end delay are evaluated. The performance metrics obtained with and without using fuzzy priority scheduler are compared as shown in figure 3 and 4.

Packet Delivery Ratio: Packet delivery ratio is the ratio of the number of data packets actually delivered to the destination to the number of data packets supposed to be received. It represents the effectiveness of the protocol.

Average end-to-end delay: It is the delay incurred by the packet to travel from the source to the application layer of the destination.

The performance metrics are measured against multicast group size 3, 4, 5 and 6 and are obtained as below.

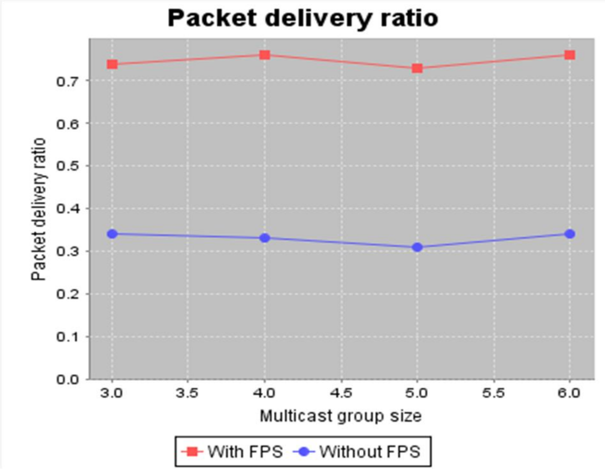


Fig. 3: AODV packet delivery ratio

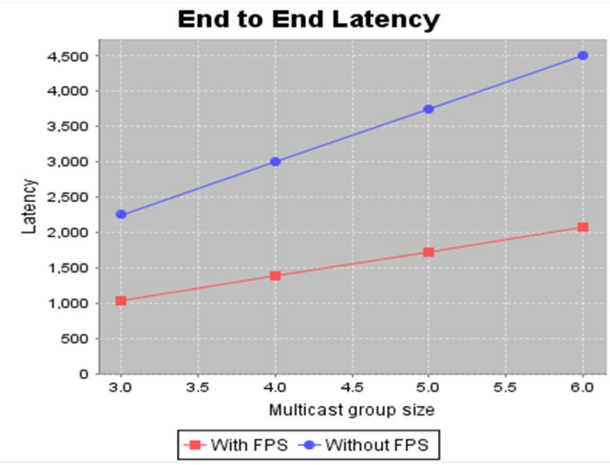


Fig. 4: AODV end to end latency

V. CONCLUSION

In this paper we have analysed the performance of fuzzy based priority scheduler, which improves the quality of service parameters in mobile ad hoc networks. The fuzzy priority scheduler calculates the crisp priority index for each packet based on inputs like data rate, queue length, packet size, expiry time of packets and congestion in the link, which are derived from the network. This work can be extended with the inclusion of fuzzy priority module with different multicasting routing protocols.

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