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Fuzzy Queue Scheduling Based Crosslayer Congestion Control for Manet

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Abstract: A MANET is a type of ad hoc network that can change locations and configure itself on the fly. Because MANETS are mobile, they use wireless connections to connect to various networks. Due to large topology, there is a high packet loss, end to end delay and many more challenges in MANET. In this paper to improve the QoS of MANET, fuzzy scheduling algorithm is used based on its priority index and to identify the optimal path BEE routing algorithm is used. Simulation results show that this paper enhance the performance of MANET.

Keywords: Ad hoc networks, Fuzzy Logic, Scheduling algorithm

1. Introduction:

A mobile ad hoc networks (MANETs) consist of a collection of mobiles (or) wireless nodes that forms a network temporarily without preexisting infrastructure. Adhoc networks provide more flexibility since they enable nodes or devices to move between various networks freely. Commonly, there are many implementations, one of those is Bluetooth which can be used to communicate instantly i.e., to provide the highly secured adhoc network and fast data transmission but limited to communication range within short span. Another known widely used device is laptop, which is equipped with wireless PCI cards it establishes an ad hoc network by activating ADHOC mode. It is highly useful for business meeting where no infrastructure exists and which completely put an end to the need of cables and routers.

Because of the instability and frequent disconnection between nodes which are connected either directly or indirectly, these adhoc networks faces failure in routes, high packet loss and end to end delay it can also minimizes through out of the networks and it is very tedious to maintain QoS target. In MANET, all nodes have the ability to be a source, sink or just a relay. Apart from traditional wired networks, these nodes have enormous functionalities, data will produce varying queuing behavior. Therefore by the use of scheduling algorithm, we can determine which packet or queue has to be served next, the performance of the overall network is able to be enhanced. First in first out (FIFO) is the default scheduling algorithm for packets in MANET and in addition the conventional available scheduling algorithms are priority queueing, weighted fair queueing and many more.

2. Related work:

The popularity of MANET now a days leads to the need for real time applications of multimedia have enhanced. It requires Quality of Service i.e., throughput, end-to-end delay and packet delivery ratio[4]. An enormous number of research work has been done to improve the Quality of Service (QoS) of MANET.

Research work[6] proposed on routing protocol to enhance link stability ,end-to-end delay and optimization of bandwidth. Paper[7] did some research work on fuzzy inference system with two input variables and a single output. The input variables are capacity of a channel and data rate, they are used to find the priority index of packets which are to be scheduled.

Research paper[8] introduced a fuzzy logic scheme to enhance the performance of MANET. In addition, [8] proposed AODV algorithm on fuzzy logic for better performance in high – mobility environment. Paper [9] discussed a problem connected to packet scheduling and traffic assignment in MANET. It modelled each and every path as a multiple node M/M/1 network .It assume the end – to-end delay follows the normal distribution. Also metrics like resequencing delay and end-to-end delay are discussed in the paper. If the average arrival rate λ is increased, then the time of every queue is also increased by which delay of resequencing is increased Paper[10] proposed an effective queueing architecture, which is supported by both elastic and inelastic traffic. In inelastic flows, the packets are stored ahead of those that in the elastic. When a link is loaded critically due to the inelastic traffic, it results in larger delays and elastic traffic may also have some delay constraints which are non-negligible. The virtual queue algorithm decreases the delay experienced by virtual queues which were served at a fraction of the actual service rate and by the use of the value of virtual queue – length in the utility function.

Paper[13] introduced a artificial bee colony ABC optimization model. [14] is a new epitome of swarm intelligence, for routing it requires two types of agents scouts, which find on-demand path (new routes) to the destination and foragers, which takes data packets and meanwhile it determines the quality of the discarded router depended on amount of energy to be consumed along the path. The state of the network is sensed by the foragers. In MANET, it utilizes the metrics to rate different routes. Afterwards, with the aim of maximizing life time of the network, it chooses the optimal path for routing the data packets.

Paper[15] introduced the PEEBR (Predictive Energy Efficient Bee Routing) which is a reactive routing algorithm for MANET inspired from the food search natural bees behaviors. Based on the goodness ratio, PEEBRs determine the optimal routing path. The goodness ratio is a combination of two parameters: the consumption of the expected energy and the nodes batteries residual power for each potential path.

Paper[16] dealt with the performance of the PEEBR which can be improved by optimized path selection in MANET based on prediction of energy consumption and throughput. It use ABC optimization technique and two types of bee agents scout for exploration phase and the forager for evaluation and exploitation phases.

3. Proposed work:

3.1 Fuzzy scheduling algorithm

The proposed fuzzy scheduling algorithm had three input variables which were data rate, queue size and S-N-R of individual nodes that the packet is related in Fig.3.1. The input were fuzzified, inference values were calculated and defuzzified to find the crisp value which was the output i.e., priority index.

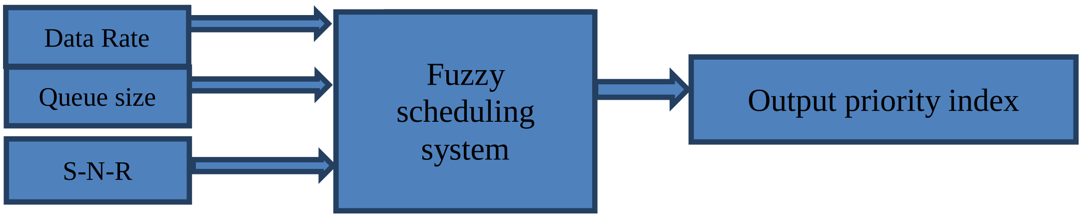

Fig.3.1 Fuzzy Logic System

After defining the fuzzy linguistic 'if-then' rules, the membership function corresponds to each element in the linguistic set should be defined. A number of membership functions are available those are trapezoidal, triangular, piecewise linear, Gaussian and singleton.

In this study, we chose the triangular membership function which represents the input and output variables. The linguistic variables involved in the input variable were low(L), medium(M) and high(H). For the output priority index very low(VL), low(L), medium(M), high(H) and very high(VH) were the five linguistic variables. Triangular membership functions as shown in Figs. 3.2 is used for representing these variables.

The triangular membership function is specified by three parameters (a, b, c) as follows:

$$\text{Triangular-MF } (x;a,b,c) = \begin{cases} \left(\dfrac{x-a}{y-b}\right), \ a \le x \le c \\ \left(\dfrac{c-x}{c-b}\right), b \le x \le c \\ \quad 0, \ otherwise \end{cases}$$

where a, b, c are the parameters that are adjusted to fit the desired membership function data.

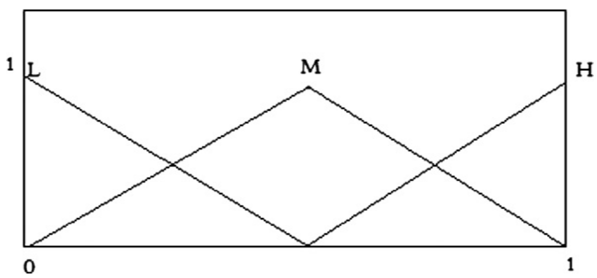

Fig. 3.2 Fuzzy memberships function for bandwidth, delay and hop count.

3.2 Bee Ad hoc routing protocol

[19] gave a new routing protocol for Mobile Ad hoc networks which is the behavior of honey bee called Bee Ad hoc routing protocol. This protocol is very simple and needs mainly two kinds of message for the routing: the scout and the foragers.

The Bee Ad hoc routing protocol is shown in Fig. 4 takes each node in the network as a hive. Each node sends out bee agents periodically. Scouts to explore the network and gather information about the available food sources without the knowledge of their quality. The exploration process done by the scout bees can be found and mapped onto the following procedures in MANET: scout are broadcasted. A time to live (TTL) packet is created for every scout. Then scout return to the hive (source) on the same route. Finally scouts recruit foragers while they return to the live by performing dance to guide them from the hive to the direction of food (angle).

Bee Ad Hoc routing protocol takes the routing tables as the dance floor where the bee agents give the information regarding the path quality they have traversed. Then the process of exploitation shall be performed by the foragers and the main workers. From the transport layer, foragers get data packets and after finding the quality of the path ,they give it to the main workers also by dance .At last ,the main workers those who get packets from the transport layer are recruited by the foragers in order that each and every worker get a source of food.

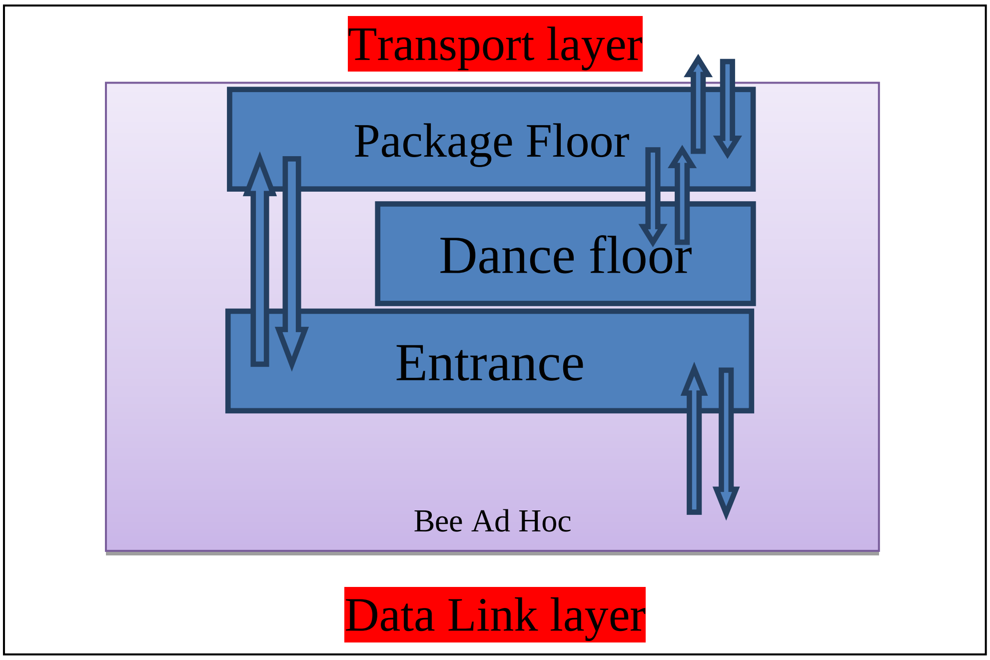

Fig. 3.4 Bee Ad Hoc routing protocol

BeeIP achieves scale normalization of values by performing linear transformation. If α_1, β_1 and α_2, β_2 the minimum and maximum numbers of the first and second scale respectively, and χ is the number to be normalized to ψ then, first place

$$\psi = \frac{\alpha_2 + (\chi - \alpha_1) * (\beta_2 - \alpha_2)}{(\beta_1 - \alpha_1)}$$

By using above four parameters we calculate the weight of the node using following formulae.

$$rel_{local} = pow' * w_{pow} + speed' * w_{speed} + energy' * w_{energy} + qd' * w_{qd} + txd' * w_{txd}$$

Wpow → rssi

Wspeed→moving speed
Energy→energy of node.
Wqd→queue size.
Wtxd→ delay

And then to identify the quality of the link and to choose best path we use following formulae

$$rel_{global} = \sum_{n=1}^{m} (rel_{local-new_{N_{n+1} \to N_n}} - rel_{local-prev_{N_{n+1} \to N_n}})$$

where m is the total number of nodes in an numerically ordered path, and Nn+1 ! Nn the pair of nodes with direction towards the source node (N1).

Using Pearson's correlation coefficient we are allowed to make predictions based on the strength of the linear dependence between the two. The correlation coefficient r is defined by the formula:

$$r = \frac{\sum_{i=1}^{k}(t_i - \mu t)(rel_{global_i} - \mu rel_{global})}{\sqrt{\sum_{i=1}^{k}(t_i - \mu t)^2}\sqrt{\sum_{i=1}^{k}(rel_{global_i} - \mu rel_{global})^2}}$$

where t_i the time of receiving relglobali, t the mean of the time column values, and k the matrix row number, we kept 10 as default for matrix row

3.2 Cross layer congestion detection

We proposed a mechanism called congestion window modification via contention detection, which gives the most accurate method of determining the status of contention and depended on that determination of congestion window is modified to limit the window size from overshooting. In actual phenomena, the parameter called VCRH is used to determine the MAC degree contentions. After every new ack is received ,the value of VCRH is updated. To determine the problem of overshooting, the above parameter improves the TCP congestion window modification phenomenon. However this phenomenon may sometimes results in calculation of VCRH overhead and in addition its performance might degrade while there is small quantity of segments in network.

Implement of congestion window adaptation through contention detection:

1. Actual round –trip time is divided into two parts :
   a. Congestion RTT and
   b. Contention RTT
   The contention RTT is not doing anything with the BDP and the congestion RTT is only used to determine BDP.
2. A new parameter called the variance of contention RTT per hop (VCRH) estimate the MAC degree contentions. After every new ACK is received, the VCRH value is updated. To solve the overshooting problem ,this parameter improve the TCP congestion window modification phenomenon.
3. Select the threshold parameter VCRH_th and if the VCRH exceeds this threshold, contention degree is considered to be severe and congestion window(cwnd) is degraded by one maximum segment size (MSS).
4. If retransmission time out (RTO) expires, it shows that the network is in bad contention status and congestion. Afterwards check whether the VCRH is larger than or equals VCRH_th.
5. If VCRH is large, the status of network is very critical and reset the cwnd to 2*MSS and enable the slow start step.
6. If the contention status is not so bad, then halve the cwnd.

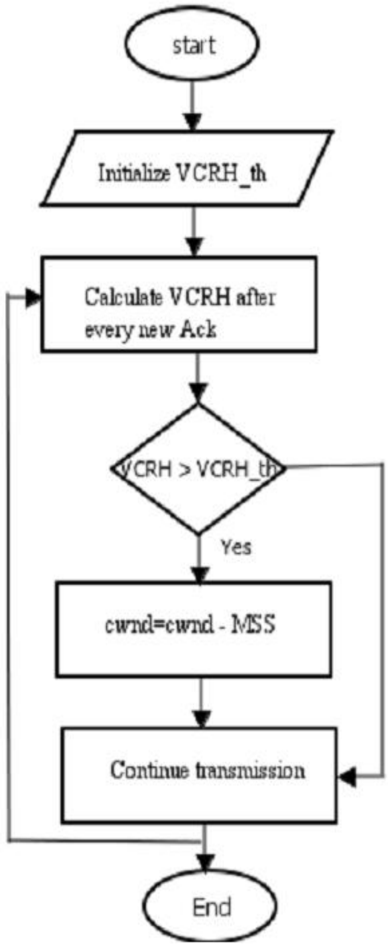

Fig 3.5

Modifcation in VCRH calculation

• In above mechanism, value of VCRH updated after every received Ack, which may sometime results in VCRH calculation overhead. One solution to this problem is to set threshold value for number of received Acks, when number of received Acks reaches to the threshold value then only update the VCRH value may reduce the calculation overhead.

• Also in above mechanism small problem occurs when the amount of segments is small. In this case, the time span between segments is large, and thus, some segments as part of the VCRH calculation may be outmoded to some extent.

One solution to this problem is to choose timestamp driven method to reduce this problem. Means every time a new segment arrives, the timestamp of the old segments is checked to determine whether we can remove some old segments before calculating the VCRH.

4 Performance evaluation

4.1 Scenario description

The simulation is carried out using Network Simulator (NS-2) and analysis is presented below. We evaluate the performance and validate the effectiveness of proposed FUZZY_QUEUE_CONG_BEE_ROUTING through this simulation. The simulation environment, performance metrics and simulation results are presented in this section. A comparative study on the metrics, with two protocols namely FUZZY_QUEUE_BEE_ROUTING, FUZZY_QUEUE_ROUTING are also presented in the graphs below. The simulation is performed for the network size varying from 50 nodes to 250 nodes.

Table 4.1 indicates the simulation parameters consider in our network

Property	**Values**
set val(chan)	Channel/WirelessChannel
set val(prop)	Propagation/TwoRayGround
set val(netif)	Phy/WirelessPhy
set val(mac)	Mac/802_11
set val(ifq)	Queue/DropTail/PriQueue
set val(ll)	LL
set val(ant)	Antenna/OmniAntenna
set val(ifqlen)	100
set val(nn)	200
set val(rp)	FUZZY_QUEUE_CONG_BEE_ROUTING,PADOV, FUZZY_QUEUE_ROUTING
set val(x)	1000
set val(y)	1000
set val(stop)	200s
Energy model	Energy Model
Initial energy	100 joules
Txpower	0.8 mw
Rxpower	0.6 mw

4.2 Network properties for simulation

The following parameters are analyzed in the simulation study:

- **Packet Delivery Ratio (PDR)** : The ratio of the mean number of data packets successfully received by the destination to the total number of packets transmitted by the source.

$$\text{PDR} = \frac{\text{Packet received}}{\text{Packet send}}$$

- **Routing Overhead:** The total number of control packets transmitted by all nodes in the network.

$$\text{Routing Overhead} = \frac{\text{Number of routing packets}}{\text{Number of received data packets}}$$

- **Average Delay:** It is the time interval once a data packet is generated by the source node and when it got delivered to the destination node.

$$\text{Average end-to-end Delay} = \frac{\text{Last packet transmission time}}{\text{Number of packets received}}$$

- **Packet loss ratio (PLR):** The PLR is defined as a ratio of the number of lost packets to the total number of transmitted packets.
- **Throughput:** It is the total amount of data packets delivered to destination nodes per unit of the simulation period time.

$$\text{Throughput} = \frac{\text{Number of bytes received} * 8}{(\text{end time} - \text{start time})}$$

- **Average Energy Consumption:** It is the energy consumed in transporting one kilo-byte of data to its destination.

$$\text{Energy} = \frac{(\text{Initial energy} - \text{final energy})}{\text{Total number of nodes}}$$

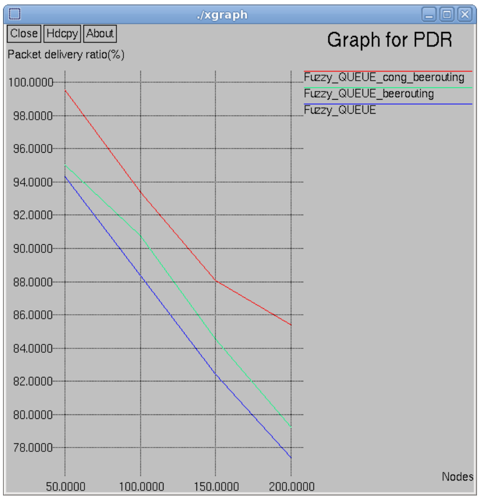

Fig 4.1 Packet delivery analysis on varying Network size

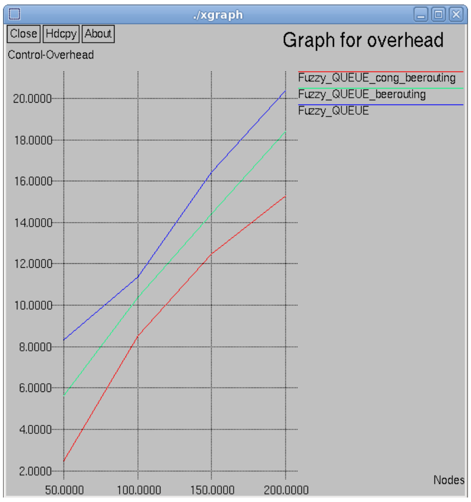

Fig 4.2 Routing Overhead analysis on varying Network size

The PDR decreases with increase in number of transmitting nodes. FUZZY_QUEUE_CONG_BEE_ROUTING is observed to be stable and the decrease in PDR is very marginal with a variation of less than 4%. FUZZY_QUEUE_BEE_ROUTING has nearly 10% reduction and FUZZY_QUEUE_ROUTING has just over 12%. This is significant improvement by the proposed FUZZY_QUEUE_CONG_BEE_ROUTING. Fig. 4.1 depicts packet delivery ratio (PDR) for given number of nodes involved in transmission.

Fig. 4.2 present the overhead with respect to the number of nodes. Overhead increases with increase in the number of nodes. As the number of nodes increase, the number of transmissions increases. FUZZY_QUEUE_CONG_BEE_ROUTING has less overhead compared to FUZZY_QUEUE_ROUTING and FUZZY_QUEUE_BEE_ROUTING. As claimed, FUZZY_QUEUE_ROUTING uses multipath for critical information to increase reliability still generates lots of control messages leading to huge overheads. FUZZY_QUEUE_CONG_BEE_ROUTING has the optimum balance of both reliability shown by the PDR and efficiency achieved by reduced Routing overhead.

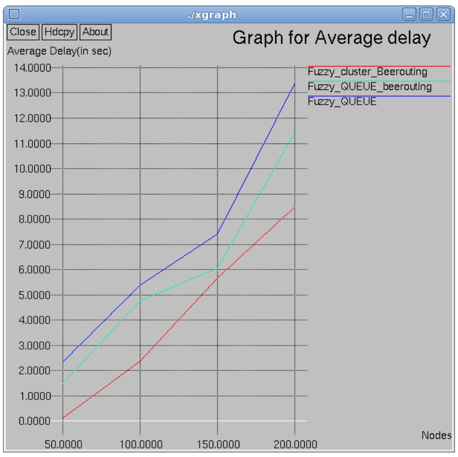

Fig4.3 Delay performances analysis on varying Network size

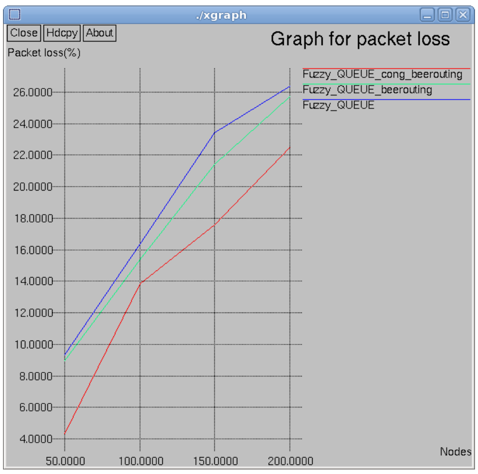

Fig 4.4 Packet loss ratio analysis on varying Network size

Fig. 4.3 shows that the average delay, defined as the time taken to transmit the packet from source to destination. The FUZZY_QUEUE_CONG_BEE_ROUTING suffers the least delay compared to the FUZZY_QUEUE_BEE_ROUTING and FUZZY_QUEUE_ROUTING. The delay in the case of FUZZY_QUEUE_ROUTING is found to be proportional to the number of nodes as the network size is scaled up. In this case also, the proposed FUZZY_QUEUE_CONG_BEE_ROUTING proves to be the best among the three.

Fig. 4.4 co11oborates the claim in Fig. 4.1. The packet loss ratio is much smaller than the other two protocols under consideration. The consequence is evident in Fig. 4.5 in which the average throughput is maintained consistently with a very marginal variation of around 1.5 kbps.

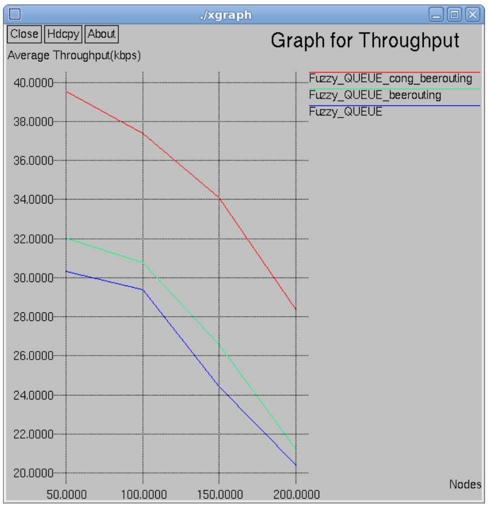

Fig. 4.5 Throughput analysis on varying Network size

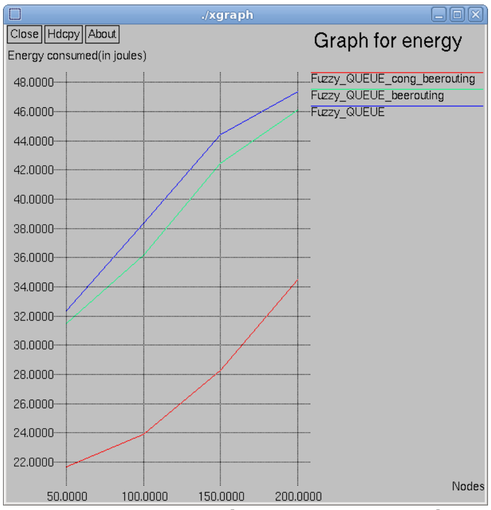

Fig. 4.6 Average Energy Consumption analysis on varying Network size

Fig. 4.6 shows the results for the energy consumption under node failures. FUZZY_QUEUE_CONG_BEE_ROUTING protocol outperforms the FUZZY_QUEUE_BEE_ROUTING protocol and FUZZY_QUEUE_ROUTING in this case.

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