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FUZZY QUEUE BASED BEE ROUTING ALGORITHM FOR MANET

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Abstract:

MANET plays an important role for wireless device communication with self organized way. The increasing popularity of using MANET, make it a logical support QoS over ad hoc networks. QoS support is very much related with allocation of resources to satisfy requirement of applications; these include end-to-end delay, packet loss ratio, and energy consumption etc., In order to overcome these drawbacks, in this paper, we propose a fuzzy based scheduling algorithm and finds an alternate path to destination by applying bee routing protocol which aims to select the shortest path based on energy consumption prediction. The simulation results show that the proposed work can enhance the route stability and network performance effectively.

Keywords: Fuzzy Logic, Ad hoc networks, QoS, scheduling algorithm

1. Introduction:

A Mobile ad hoc network (MANET) consists 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.

In addition, military operations, or any environment disaster it is important to provide speedy communication. Further it is highly important when the existing infrastructure is being destroyed, this kind of situation can be handled with ad hoc networks due to its quick deployment. Although there are few issues to be focused. Most important thing in data transmission is data dropping. Data dropping in delay sensitive application like tsunami monitoring, border surveillance, forest fire monitoring like disaster prone areas becomes more vulnerable in real time.

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. One of the survey based on QoS shows that most of the researchers consider one or two metrics for routing protocols. It is not sufficient for node mobility, link stability and battery power of the wireless devices in the network topology. All these factors are associated to each other. Hence only considering one or two factors of the QoS metrics is not adequate to determine an optimal path. No perfect mathematical model exists to describe the selection of routes. One of the probable tool to solve QoS metric problem is Fuzzy logic [23].

Fuzzy logic, a theory which does not support various inputs, also takes inaccurate information. These kind of problems in Ad hoc networks can be solved by Fuzzy logic. In this paper, we propose a simple and effective algorithm called Fuzzy scheduling algorithm which is based on its priority index.

In MANET, another important challenge is how to route data packets across the network. i.e., Routing is the process of selecting path in a network based on certain metrics. For instance AODV, DSR and DSDV choose hop count to find the shortest path. In order to reduce the energy consumption level, we use a routing protocol called Bee adhoc routing protocol. The idea of bee adhoc routing protocols inspired from bees. In this protocol, a peculiar observed phenomena is characterized by the movements performed by every individual bee under different conditions. Though each and every bee has simple rules to be followed, the collective behaviors of bees are very intelligent and hence the characteristics of a bee colony are used in ad hoc networks.

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[11] studied a mechanism on cross-layer scheduling. Due to excessive packet sharing, many challenges occur for QoS, it can be overcome by cross layer mechanism. By the use of cross layer approach, the order of the nodes is able to be determined and the packet can be scheduled in order to give a very high throughput .

Swarm intelligence is a approach of computational intelligence which is described by[12]. Bee colony optimization is studied widely among the order techniques of intelligence for networks. 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.

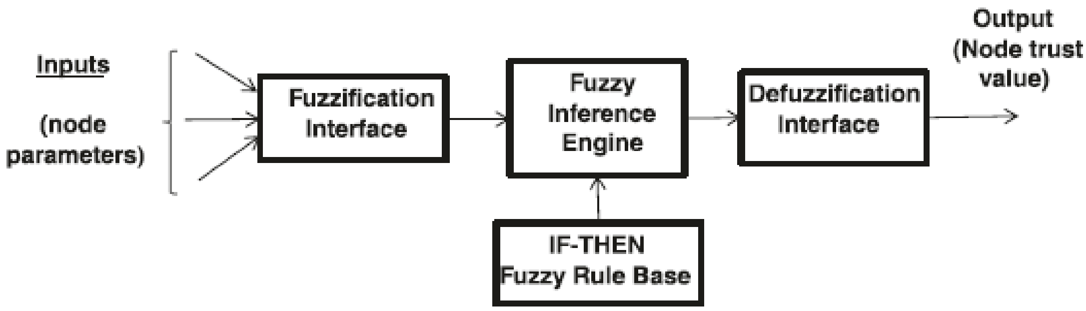

Fig.3.1 Fuzzy Logic System

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 and 3.3 are used for representing these variables.

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

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

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

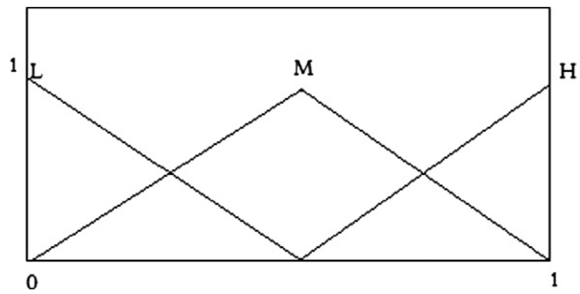

Fig. 3.2 Fuzzy memberships function for bandwidth, delay and hop count.

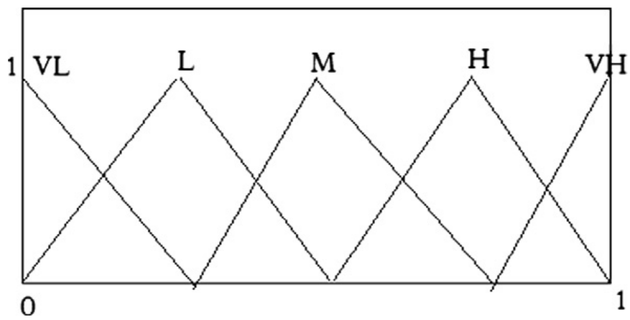

Fig. 3.3 Fuzzy membership function for cost.

3.2 Bee Ad hoc routing algorithm:

Bee Ad hoc routing algorithm is an reactive(on-demand) multipath routing algorithm, which is very simple and inspired from the foraging principles of bees. The honey bees are domestic live in a colony which is divided into a queen, drowns, workers and many broods. They communicate each other based on dances which are performed by the worker called “scout” which finds food. The main aims of dance is to recruit others by the distance transmission, direction and amount of food found with a visual, tactile and olfactory perception. Hence, some bees are recrited and they are called “foragers”.

Bee Ad hoc routing algorithm is shown in Fig.3.4 which works with the following types of agents: Packers, Scouts, Foragers and Swarms. The packers discover a forager and give the packets of datas to the found forager. scouts find new routes from the source node to the destination node. forager is the main worker.

1.Package floor:

The package floor is an interface to the upper layer (e.g tcp or udp).if the date packets arrive from upper layer i.e., transport layer ,send the data, similar forager for it is (saw) up on the dancing floor. if the forager is discovered then the packet is encapsulated is its payload. Else the packet is buffered waiting temporarily for a forager which is returning, if no forager came back, with in a prespecified time, a scout is launched for discovering new routes to the destination.

2.Entrance:

The entrance holds all incoming & outing data packets. Dance floor’s action is depended on the type of the data packets which entered the floor from the data link layer. If the packet is the forager and the current is its destination node, then the forager is forwarded to the package floor; else it is routed directly to the HAC interface of the next node. Suppose the packet is the scout ,it is broadcast to the neighbor node if its time to live(TTL)timer has not expired yet, if a replica of formerly received scout arrives at this floor, it is removed from the system.

3.Dance floor:

The dance floor recruits foragers newly by “dancing” based on the quality of the path it traversed. It sends matching foragers to the package floor w.r.t a request from a packer if the foragers life time has expired then they are not considered for matching. If multiple path is identified for matching then a forager is selected at a random manner. If enables to serve the data packet over multiple paths. That in turn serves two purposes: preventing congestion where high loads and consuming batteries of various nodes at comparable rate. When the last forager to a destination goes out a hive then the hive does not have any more routes to the destination. If a route to the destination Exists still then soon a forager will be returning to the hire if no forager comes back within expected quantity of time, then the node has considerably lost its connection to the destination node. Likewise, fewer control packets are transmitted in less energy expenditure.

[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 scouts: they find reactive(on-demand) new routes to the destinations and the foragers: they take data packets and meanwhile determine the quality of discovered routes.

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.

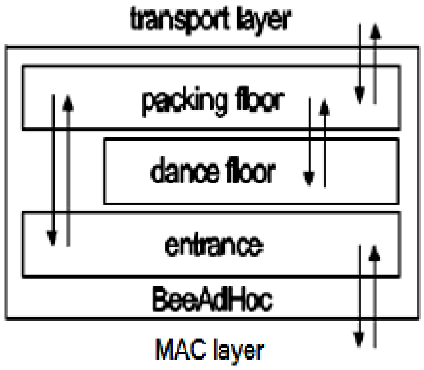

Fig 3.4. Bee Ad Hoc Algorithm Architecture

BeeIP achieves scale normalization of values by performing linear transformation. If a_1, b_1 and a_2, b_2 the minimum and maximum numbers of the first and second scale respectively, and χ is the number to be normalized to ϕ then, first place

$$\phi = \frac{a_2 + (\chi - a_1) * (b_1 - a_2)}{(b_1 - a_1)}$$

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

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

$w_{pow} \rightarrow$ rssi
$w_{speed} \rightarrow$ moving speed
$energy \rightarrow$ energy of node.
$w_{qd} \rightarrow$ queue size.
$w_{txd} \rightarrow$ delay

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

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

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

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_BEE_ROUTING through this simulation. The simulation environment, performance metrics and simulation results and also graphs are presented in this section. 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_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.

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

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

Routing

- **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.

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

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

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

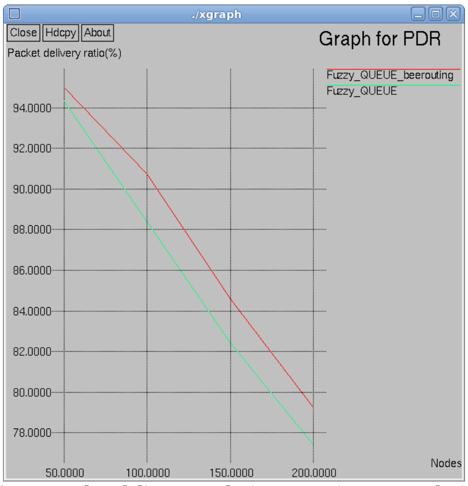

Fig 4.1 Packet delivery analysis on varying Network size

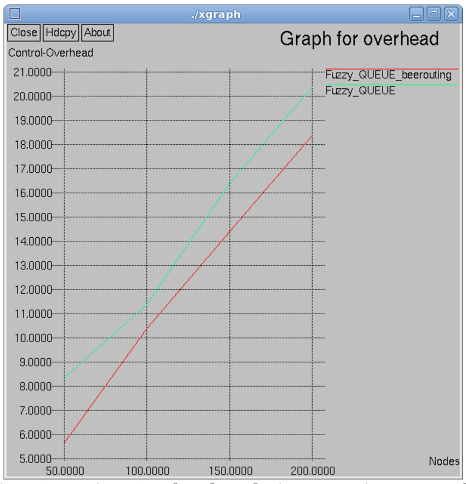

Fig 4.2 Routing Overhead analysis on varying Network size

The PDR decreases with increase in number of transmitting nodes. FUZZY_QUEUE_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%.

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_BEE_ROUTING has less overhead compared to FUZZY_QUEUE_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_BEE_ROUTING has the optimum balance of both reliability shown by the PDR and efficiency achieved by reduced Routing overhead.

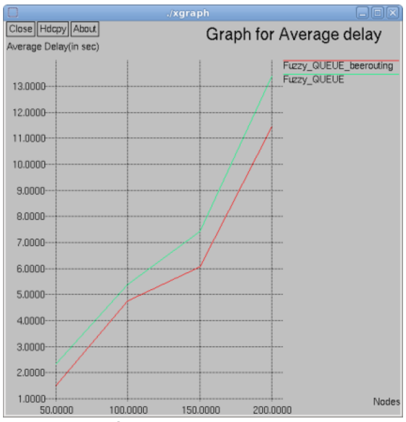

Fig4.3 Delay performances analysis on varying Network size

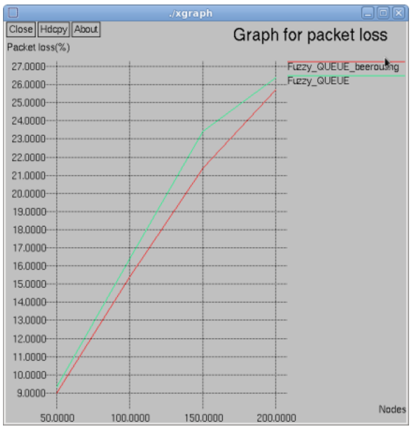

Fig 4.4 Packet loss ratio analysis on varying Network size

Fig. 4.3 shows that the average delay, defined as the time taken to transmit the packet from source to destination. The FUZZY_QUEUE_BEE_ROUTING suffers the least delay compared to the 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_BEE_ROUTING proves to be the best among the two.

Fig. 4.4 collaborates the claim in Fig. 4.1. The packet loss ratio is much smaller than the other protocol 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.

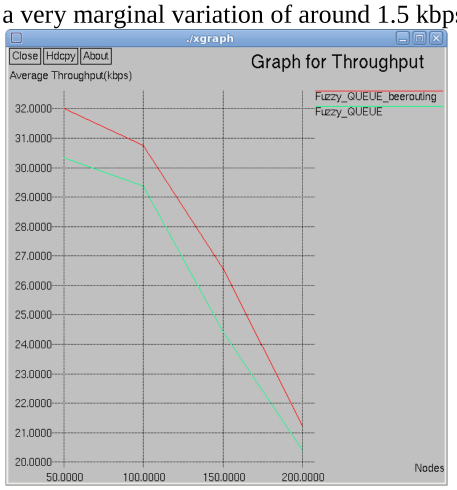

Fig. 4.5 Throughput analysis on varying Network size

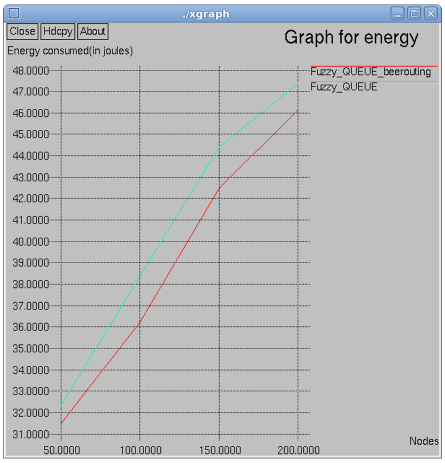

Fig. 4.6 Average Energy Consumption analysis on varying Network size

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

Conclusion:

In this paper, at first, fuzzy queue routing is investigated. This protocol is taken for the selection of optimal path. Later, Fuzzy bee routing protocol is proposed which is based on fuzzy set theory. Experimental results show that it overcomes link failures. In future work, we intend to extend Fuzzy bee routing to overcome high density reliability delivering for the routers.

References:

[1] R. Asokan, “A review of Quality of Service (QoS) routing protocols for mobile Ad hoc networks”, Proceedings of the International Conference on Wireless Communication and Sensor Computing, IEEE, Chennai, India, 2010,1-6.

[2] Aweya J., Ouellette M., and Montuno D. Y., “A Control Theoretic Approach to Active Queue Management,” Computer Networks, 36, no. 2-3, 2001, 203-35.

[3] N. Shah and Depei Qian, “Context-Aware Routing for Peer-to-Peer Network on MANETs,” in Networking, Architecture, and Storage, 2009. NAS 2009. IEEE International Conference on, 2009, 135–139.

[4] F. Gianfelici, “Measurement of quality of service (QoS) for peer-to-peer networks,” in Virtual Environments, Human-Computer Interfaces and Measurement Systems, 2005. VECIMS 2005. Proceedings of the 2005 IEEE International Conference on, 2005, p. 6 pp.

[5] D. L. Goldsmith, B. Liebowitz, K. Park, S. Wang, B. Doshi, and J. Kantonides, “Precedence and Quality of Service (QoS) Handling in IP Packet Networks,” in Military Communications Conference, 2006. MILCOM 2006. IEEE, 2006, pp. 1–6.

[6] Hannan Xiao, W. K. G. Seah, A. Lo, and K. C. Chua, “A flexible quality of service model for mobile ad-hoc networks,” in Vehicular Technology Conference Proceedings, 2000. VTC 2000-Spring Tokyo. 2000 IEEE 51st, 2000, vol. 1, pp. 445–449.

[7] K. Manoj, S. C. Sharma, and L. Arya, “Fuzzy Based QoS Analysis in Wireless Ad hoc Network for DSR Protocol,” Adv. Comput. Conf. 2009 IACC 2009 IEEE Int., pp. 1357–1361, 6.

[8] Nihad I. Abbas, Mustafa IIkan and Emre Ozen, “Fuzzy approach to improving route stability of the AODV routing protocol”, EURASIP Journal on Wireless Communications and Networking, Springer, 2015, 235, 1-11.

[9] Y.-F. Guo, G.-S. Kuo, “A packet scheduling framework for multipath routing in mobile ad hoc networks”, in Vehicular Technology Conference (IEEE, 2007), pp. 233–237

[10] R. Patil, A. Damodaram, R. Das, “Cross layer fair scheduling for MANET with 802.11 CDMA channels”, in First Asian Himalayas International Conference, IEEE (Kathmandu, 2009), pp. 1–5.

[11] Iyyapillai Ambika, Velayudhan Pillai Sadasivam and Perumal Eswaran, “An effective queuing architecture for elastic and inelastic traffic with different dropping precedence in MANET”, EURASIP Journal on Wireless Communications and Networking, Springer, 2014, 155, 1-9.

[12] Mayur Tokekar and Radhika D. Joshi, “Enhancement of Optimized Linked state routing protocol for energy conservation”, CS & IT-CSCP, 2011.

[13] D. Karaboga and Ozturk, “A novel clustering approach: Artificial Bee Colony (ABC) algorithm”, Elsevier, Applied Soft Computing 11 (2011) 652–657, 2011.

[14] D. Karaboga and B. Basturk, “On the performance of artificial bee colony (ABC) algorithm”, Elsevier, Applied Soft Computing 8 (2008) 687–697, 2008

[15] Imane M. A. Fahmy, Laila Nassef and Hesham A. Hefny, “PEEBR: Predictive Energy Efficient Bee Routing Algorithm for Ad-hoc Wireless Mobile Networks”, IEEE INFOrmatics and Systems (INFOS2012), 2012.

[16] Imane M. A. Fahmy, Laila Nassef and Hesham A. Hefny, “On the Performance of the Predicted Energy Efficient Bee-Inspired Routing (PEEBR)”, International Journal of Advanced Computer Science and Applications, Vol. 5, No. 4, 2014, 65-70.

[17] Shangchao Pi, Baolin Sun, "Fuzzy Controllers Based Multipath Routing Algorithm in MANET", Physics Procedia, Elsevier, 24, 2012, 1178 – 1185.

[18] Alexandros Giagkos , Myra S. Wilson, "BeeIP – A Swarm Intelligence based routing for wireless ad hoc networks", Information Sciences, Elsevier, 265, 2014, 23–35.

[19] H. F. Wedde, M. Farooq, T. Pannenbaecker, B. Vogel, C. Mueller, J. Meth, and R. Jeruschkat. "BeeAdHoc: an energy efficient routing algorithm for mobile ad-hoc networks inspired by bee behavior", Proceedings of ACM GECCO, 2005, 153–160.

[20] Jian Ni, Bo(Rambo) Tan, and R.Srikant, "Q-CSMA: Queue-Length-Based CSMA/CA Algorithms for Achieving Maximum Throughput and Low Delay in Wireless Network", IEEE/ACM TRANSACTIONS ON NETWORKING, 20, 3, 2012, 825-836.

[21] Zhigang Chen, Zhihui Ge, Ming Zha, "A Load-based Queue Scheduling Algorithm for MANET", Journal of Communication and Computer, USA, 3, No.8, 2006, 11- 16.

[22] Essam Natsheh, Adznan B. Jantan, Sabira Khatun, and Shamala Subramaniam, "Fuzzy Active Queue Management for Congestion Control in Wireless Ad-Hoc", The International Arab Journal of Information Technology, 4, No. 1, 2007, 50-59.

[23] S.Abinaya and G.Arulkumaran, "Detecting Black Hole Attack Using Fuzzy Trust Approach in MANET", International Journal of Innovations in Scientific and Engineering Research (IJISER), ISSN: 2347-971X (online), ISSN: 2347-9728(print), Vol.4, No.3, pp.102-108, 2017, http://www.ijiser.com/ .