Journal of Electronics and Communication Systems
Volume 1 Issue 2

Weighted Fair Queuing for AEERG Protocol in MANET

S. Rajeswari, Y. Venkataramani, S. A. Arunmozhi

Department of Electronics and Communication Engineering,

Saranathan College of Engineering, Panjapur, Trichy, India

E-mail: rajeswaris-ece@saranathan.ac.in, deanrd44@gmail.com,

arunmozhi-ece@saranathan.ac.in

Abstract

Quality of Service along with routing has been a subject of interest in Mobile Ad-hoc Network (MANET). This paper focused on the implementation of Weighted Fair Queuing (WFQ) in the Adaptive Energy Efficient Reliable Gossip (AEERG) protocol in MANET and comparison of the performance with other three existing queuing disciplines (FIFO, PQ and RED). Processing can be done by allowing packets in a scheduled manner. Traffic from different flows is subjected to pass through a specific node. When a particular path is selected as shortest path to reach destination for all traffic flows in the adaptive energy efficient algorithm, queue scheduling disciplines have been used to improve the quality of service. This paper gives the NS-2 simulation results to compare their relative performance based on average end to end delay, Actual packet delivery ratio in percentage and routing overhead for the above queuing techniques.

Keywords: *Ad hoc networks, QOS, queuing schedule, drop-tail, priority, RED, WFQ*

INTRODUCTION

A MANETs comprises set of mobile nodes communicating through the wireless links. The nodes are dynamic in nature. Due to the lack of infrastructure and dynamic nature, unpredictable movement of nodes and unpredictable topologies are expected. As the topology get changes, routing also get change. The nodes are linked by wireless channel. The routing facilities are not specified. Every node in MANET plays all the roles. It acts as a transmitter, receiver and a router which forwards data packets to other nodes in the network to establish the connectivity to reach the destination in the network. The supplementary services like directory services, diverting services and other functions are available so that it has the features like the traditional wired networks.

In mobile Ad Hoc Networks, Quality of Service policies cannot be applicable [1–8]. The existing routing protocols of MANETs are all suitable to a certain network environment as proposed by IETF. The QOS mechanism is not possible to any one routing protocol of MANETs. For a mobility environment, varying nature of queue is quite different compared to those in fixed conditions.

The QOS is discussed by means of scheduling mechanisms and packet discarding policies. The allocation of network resources is managed among different traffic flows by choosing the next packet to be processed is referred as queue scheduling discipline. Also, when packets speed of arrival is faster than that they can be processed, arrival packets are dropped. Thus, the congestion can be controlled in the network. But dropping rate in quality of service is changed [9–12]. By assigning various weights to different flows in the network, packet dropping can be reduced. That can be implemented by proper selection of the packet to be processed. This kind of logic is applicable to the applications which are having a mixture of real-time and non-real-time packets, so that it will reduce the impact upon unregulated flows. The performance analysis of current queuing disciplines in NS-2-First-In-First-Out (FIFO), Priority Queuing (PQ), and Random Early Detection (RED) are compared with Weighted Fair Queuing (WFQ) implemented in AEERG routing protocol.

RELATED WORK

Giang and Nakagawa [7] used RR buffer with three algorithms to control input/output packets. The proposed algorithms have achieved improved result in per-flow fairness. In Probabilistic Control on Round robin Buffer (PCRQ) scheduling, the MAC layer fairness was improved indirectly. This is due to scheduling in PCRQ helped flows of small loads to get more chance in using channel bandwidth by giving delay to the flow of heavy loads to send a packet. However, the total throughput performance was slightly degraded. In PCRQ scheduling, RR buffers were used with three algorithms: The first algorithm controlled the number of input packet to buffers, while the second algorithm controlled the turn of reading buffers, and the third controlled the number of output packets from buffers. Kui et al. described about the MANET QoS support and various challenges of QoS in MANETs which includes QoS models resource reservation signaling and QMAC (QoS Medium Access Control) [13].

Each router in the network must implement some queuing discipline that governs how packets are buffered while waiting to be transmitted. Queuing is one of the very vital mechanisms in traffic network services like VOIP, Videoconferencing and File Transfer and differing kinds of Traffic Management systems area unit employed in these services. Kawadia et al explained the design of a sequence of complex protocols, which address about the multidimensional ramifications of the power control problem in wireless networks [12].

Hesham N. Elmahdy *et al*. studied the result of the packet size and also the result of random early detection (RED) parameters on the two Rate three Color Marker(trTCM) and Single Rate three Color Marker (srTCM). Here, the packet drop probability will vary with variation in packet size [9]. Jianyong Chen *et al*. a new self-tuning RED is proposed to improve the performance of TCP-RED network [11]. But, exponential averaging weight parameter is adjusted based on linear stability condition to stabilize average queue size. So, there is a conditional relationship between weight parameter and queue size. Shensheng *et al*. discussed about an analytical traffic (Markov) model and three queue management schemes are developed for a heterogeneous multihop mobile ad hoc network [19]. But all the three queue managements are having limitations like slow convergence, not easy to implement and blocking probability. Babak Abbasov proposed a new active queue management algorithm based on RED, called AHRED has been designed and compared with different AQM schemes. Peter Marbach proposed a distributed scheduling and active queue management mechanism for wireless ad hoc networks which is based on a random access scheduler. Here, implementations are done by assuming collisions can be detected using a busy tone but exposed terminal problem is not been taken into account. B. Chun *et al.* discussed about the queuing dynamics change under different degrees of mobility, traffic loads, and routing protocols. The effects on performance of giving high priority to control traffic are based on the effects routing protocols used [2]. The effects on performance of setting priorities in data traffic and scheduling algorithms which improve network performance.

Jamal N. AI-Karaki *et al*. proposed Quality Virtual Routing (QVR) a QOS routing protocol for MANETs. QVR function based upon a static virtual rectilinear architecture which is built on top of the physical topology [10]. Periodically Cluster Heads (CHs) are elected and discover multiple QoS routes on the virtual grid using an extended version of the Open Shortest Path First (OSPF) routing protocol. An extended version of WFQ scheduling policy that takes into account of the wireless channel state is also implemented. But, this protocol is not suitable other than square geometrical structure. Wang *et al.* presented an algorithm concentrates on the provision of QoS and balanced energy-consumption over the whole network [21]. With the introduction of some metrics just like the minimum path energy and path hop count and by suggests that of advancing secretion path model of the pheromone tail model of ant colony system, the algorithmic program innovatively provides two heuristic ways that severally supported the length and therefore, the comfort of path to fulfill the various performance needs of real time and customary traffics. Xinyu Jin *et al*. conferred a brand new minimum energy routing theme [22]. This depends on the mobile node's energy consumption and therefore, the stratified node’s congestion levels. The algorithmic program is known as RED primarily based Minimum Energy Routing (REDMER) theme. Liu Ping *et al*. implemented a mathematical structure to estimate the queue delay for MANET [15]. However, totally different queue delay is obtained supported the chosen traffic kind. It has a stronger impact on raising the transmission stream that is delay sensitive. Rajeswari *et al*. proposed an Adaptive Energy Efficient and Reliable Gossip (AEERG) routing protocol for Mobile Ad hoc Networks to achieve energy efficiency with reliability. In this paper, the probability is varied adaptively for a sleep node. Probability is varied based on the parameter metric of Packet Delivery Ratio (PDR) [18]. In destination node, PDR is calculated and feedback to source node. If PDR is greater than the threshold value, other established paths are reduced by means of driving those nodes into sleep mode. So, energy consumption and reliability can be achieved.

EXISTING QUEUEING METHODS

More number of source nodes can establish path for routing to different destinations through the shortest path in MANET. When a particular node is selected as the shortest path for forwarding of all packets from different flows, congestion will occur. To ease the congestion and to increase the throughput, different scheduling mechanisms are implemented and the results are discussed. Queuing is the process of allocating network resources among different network traffic flows. It is a technique used in internetwork devices such as routers or switches during periods of congestion. Packets are held in the queues for subsequent processing. After being processed by the router, the packets are then sent to their destination based on priority. In a network, packets are accumulated and queued into memory buffers of routers and switches.

First-In-First-Out (FIFO)

Queuing is the most common queue scheduling discipline that has been mostly discussed in the references. It acts as standard measure for comparing the performance of various queue scheduling disciplines. In FIFO queuing, within a single queue all packets are received and then functioning will begin in the same order on which they arrived. So, another name is known as first come-first-serve (FCFS) queuing. Even though, it is simple to implement, it has predictable performance in behavior. It has got low computational load on the system. It has some important disadvantages while implementing the same for wireless network traffic. It is not capable of providing differentiated services. It is not used to isolate the effect of ill-behaved flow with other flows. A maximum flow of packets may occupy the entire buffer space and causes all other flows to be denied service until that burst is serviced. This results into increased delay, jitter and loss for the other well-behaved flows traversing in the queue. To reduce the serious effect of non well-behaved sources, other queue disciplines have been proposed. This leads to isolate traffic flows into separate queues. The following queues such as priority queuing, fair queuing and weighted fair queuing, weighted round robin or class-based queuing and deficit weighted round robin are some of the other queues. These queues are serviced according to their scheduling scheme.

Priority Queuing (PQ) is a simple queue to provide differentiated services to different packet flows. A different priority level is assigned to packets of different flows based on their QoS requirements. The packets are separated into different classifications, while packets reach at the link output. Accordingly various flows are en-queued formed based on their priorities. Once the queues are formed, they are served in order. The highest priority queue is served first before serving lower priority queues. Within the highest priority queue, packets are serviced in a FIFO manner. Packets from the lower priority class are served, as soon as highest-priority packets are served. While serving a lower-priority packet, if a higher-priority packet arrives, the server waits till to complete the service of the current packet then goes back to serve the higher priority queue (non-preemptive PQ). The demerit of PQ is that lower-priority flow packets may be given with small bandwidth and reduced time when a higher-priority class has successive stream of packets. This is referred as starvation problem [20]. The main drawback of this queue is not showing fairness to all queues.

Random Early Detection (RED)

RED is a recommended scheme of AQM by the Internet Engineering Task Force IETF (3). The main goal of RED is to obtain high throughput and low average delay. It is used as a congestion avoidance algorithm. This algorithm performs its functions by not admitting full queues for processing. So, packet delay and loss are reduced. It monitors the statistical probabilities like average queue size and average number of dropped packets. The other name for RED is a threshold based queuing discipline. RED queue algorithm starts to drop the packets from flows before it reaches its threshold value. So, it is considered a good queue for applications where the complexity of per-session state tracking needed by fairness queuing is not affordable.

For every packet arrival, the RED gateway calculates the weighted moving average queue size (avg). It then compares the results with minimum (min_{th}) and a following schema [17, 14].

• When $avg < min_{th}$ the packet is dropped with probability one.

• When $min_{th} \leq avg < max_{th}$ the packet is dropped with some probability.

• When $max_{th} \leq avg$ the packet is not dropped.

The value of the average queue size (avg) is computed as follows:

After each idle period the average queue size (avg) is additively decreased by a constant $\alpha > 0$ and after each busy period the average queue size (avg) is additively increased by a constant $\beta > 0$. Note that this rule follows the intuition that average queue size (avg) should be increased when the channel is busy, and be decreased when the channel is idle.

It is well known that by employing FIFO, throughput is not as good as priority Queue which is lesser than RED.

PROPOSED WFQ IMPLEMENTATION IN AEERG PROTOCOL

Weighted Fair Queuing (WFQ)

The main concept behind the Weighted Fair Queuing (WFQ) algorithm is to combine Priority Queuing (PQ) and Fair Queuing (FQ) algorithms. Advantage in FQ method is that all queues are served fairly so that there is no bandwidth starvation. But some queues have more weight so that they may receive more service. In other words, a weight is assigned to each queue to provide different priorities to the queues. Packets are entering into the appropriate queue according to their classification and they are serviced based on their weight.

WFQ supports flows with completely different information measure needs by giving every queue a weight that assigns. It a special share of output port information measure. WFQ additionally supports variable-length packets, so flows with larger packets are not allotted a lot of information measure than flows with smaller packets. Supporting the truthful allocation of information measure once forwarding variable-length packets, adds significance to the procedure complexness of the queue programming algorithmic program. This is the first reason that queue programming disciplines are a lot of easier to implement in fixed-length, cell-based ATM networks than in variable-length, packet-based informatics networks. WFQ is an approximation of the Generalized Processor Sharing (GPS) system. The rule is explained as follows. An end time is allotted to every packet taking into consideration the link information measure, the quantity of queues, the burden of queues and also the packets length. Afterwards, the hardware serves the queue wherever the packet with the minimum end time is keep. The end time is employed to create an order within which the packet are going to be transmitted through the link is explained with Figures as shown below.

Figure 1 shows a weighted bit-by-bit round-robin scheduler servicing three queues. Assume that queue 1 is assigned 50 percent of the output port bandwidth and that of queue 2 and queue 3 each assigned 25 percent of the bandwidth. The scheduler transmits two bits from queue 1, one bit from queue 2, one bit from queue 3, and then returns to queue 1. As a result of the weighted scheduling discipline, the last bit of the 600-byte packet is transmitted before the last bit of the 350-byte packet, and the last bit of the 350-byte packet is transmitted before the last bit of the 450-byte packet. This causes the 600-byte packet to finish (complete reassembly) before the 350-byte packet, and the 350-byte packet to finish before the 450-byte packet.

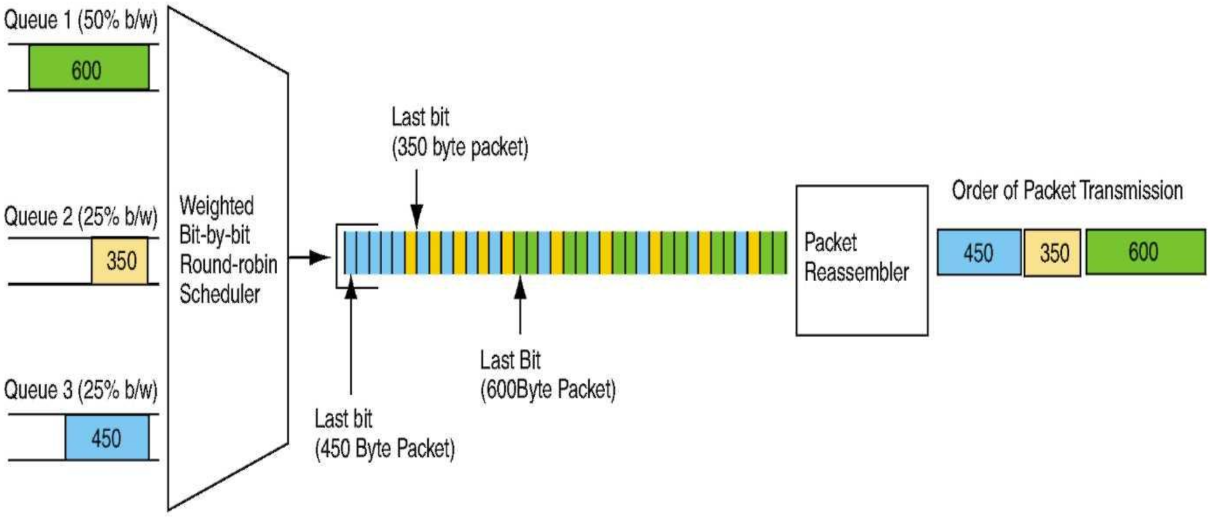

Fig. 1: *A Weighted Bit-by-Bit Round-Robin Scheduler with a Packet Re Assembler.*

WFQ approximates this theoretical programming discipline by conniving and distribution an end time t o every packet. Given the bit rate of the output port, the quantity of active queues, the relative weight allotted to every of the queues, and also the length every one in every of the packets in each queues, it is doable for the programming discipline to calculate and assign an end time to every incoming packet. The computer hardware then selects and forwards the packet that has the earliest (smallest) end time from among all of the queued packets. It is important to understand that the finish time is not the actual transmission time for each packet. Instead, the finish time is a number assigned to each packet that represents the order in which packets should be transmitted on the output port as shown in Figure 2.

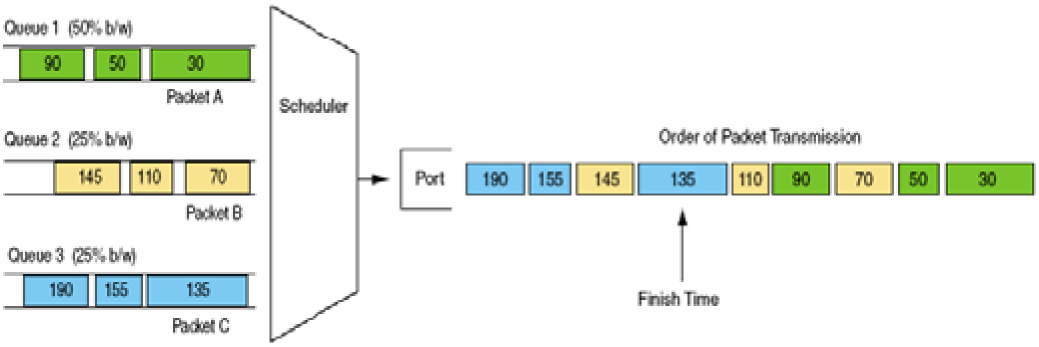

Fig. 2: *Example of the WFQ Algorithm.*

When each packet is classified and placed into its queue, the scheduler calculates and assigns a finish time for the packet. As the WFQ scheduler services its queues, it selects the packet with the earliest (smallest) finish time as the next packet for transmission on the output port. For example, if WFQ determines that packet A has a finish time of 30, packet B has a finish time of 70, and packet C has a finish time of 135, then packet A is transmitted before packet B or packet C. WFQ is a complex algorithm requiring per service class state and iterative checking of all states for each packet arrival and departure. Consequently, the WFQ presents scalability problems and cannot be used in environments with high volume of traffic requiring many classes of service. One possible application of WFQ is where the number of service classes is limited to a small number, so that the computational load is limited.

The problem to focus in the above working methodology is that when only one node becomes an intermediate node for many paths to reach the destination. When this happened, the intermediate node gets overloaded due to increased number of packets from different paths reaching the port of the intermediate node. Moreover, the possibility for congestion at node's port would occur. When traffic increases the congestion also gets increased, as a result, the Quality of service (QoS) gets affected. In AEERG protocol, to reduce energy consumption, the nodes in other than data transmission paths are driven to sleep mode.

So, in this protocol, the chances of occurrence to one or two neighbors are possible. In that case WFQ proves to be a fair method to avoid congestion and to improve QoS.

PERFORMANCE EVALUATION

Parameters are set for the simulation of queuing disciplines in NS-2. We have taken the queue size to be 500 packets as a maximum one. In all queues, three types of classes (except FIFO) are formed, whose queue buffer size decreases from lowest priority to highest one. For RED queue, we have set the minimum and maximum threshold as 100 and 200 respectively. The mark probability denominator is set as 10 which mark the position of packets dropped when the average queue size is reaching its maximum threshold. We have assigned exponential weight factor which is used to calculate average queue size based on the previous average and current queue size as 9. For WFQ, the various packets finish time is set such as 30, 75 and 135 and also varying bandwidths such as 1, 1.25, 1.5 and 2 Mbps are allocated for various flows.

SIMULATION PARAMETERS

Proposed algorithm is simulated in NS2. In our simulation, 2 Mbps has set as channel capacity. In order to indicate the link breakage, the distributed coordination function (DCF) of wireless LANs IEEE 802.11 is used in MAC layer. The MAC layer provides addressing and channel access control mechanisms. So it is possible to share a single medium for many terminals or network nodes to communicate within a multiple access network. In the simulation, space for mobile nodes is set as 600 meter x 400 meter region. It is set as 50 seconds for simulation time. The number of mobile nodes used is varied from 10-60. We have assigned the transmission range as 250 meters and each node moves with average speed in an independent manner. Parameter of the simulation speed is assigned as 20m/s. Constant Bit Rate (CBR) is set as simulated traffic parameter. Ns-2 parameter pause time of the mobile node is taken as 20-120 sec.

PERFORMANCE METRICS

The simulated values of Actual Packet delivery ratio, Routing Overhead and Average End-to-end delay with the increasing number of nodes are plotted as shown in the Figures below.

Actual Packet Delivery Ratio

Actual Packet delivery ratio is calculated by dividing the number of packets received by the destination to the number of packets originated by the application layer of different sources. It specifies the packet loss rate, which limits the maximum throughput of the network. The better the actual delivery ratio, the more complete and correct is the routing protocol. In case of FIFO and Priority, the generated packets are allowed to pass through the scheduler. But, in WFQ, due to the threshold parameter, the number of packets getting admitted into the scheduler is decreased. So, the loss is greater in RED. For different queuing disciplines, Actual Packet Delivery Ratio is computed with increasing number of nodes and the graph is plotted as shown in Figure 3. WFQ allows all the packets getting into scheduler and by means of Fair Queuing processing all are processed and reaching the destination. Obtained results shown below prove that WFQ performs better in delivering packets compared to other queuing techniques.

Table 1: *Packet Delivery Ratio with Varying Number of Nodes*

No. of Nodes	**Packet Delivery Ratio (%)**			
	Drop Tail	**Priority**	**RED**	**WFQ**
20	93.343	96.233	79.01	100
40	91.331	92.888	78.678	99.937
60	88	89.987	78.234	99.874
80	83.098	84.445	77.91	99.937
100	74.989	75.76	50.688	86.046

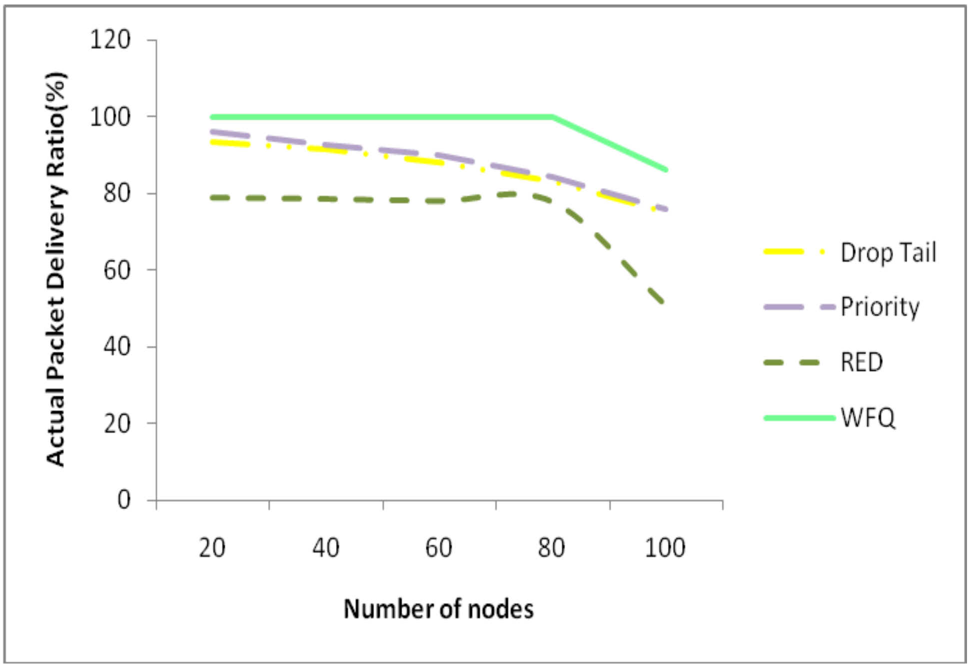

Fig. 3: *Actual Packet Delivery Ratio vs. Number of Nodes.*

Average End to End Delay

Average end-to-end delay is defined as the ratio of sum of the delays of each data packet received and number of data packets received. Here, the delay of the data packet refers to the difference between the times at which the packet reached the final destination minus the origination time of the packet. At the network layer, the end-to-end packet latency is the sum of processing delay, packetization delay, transmission delay, queuing delay, and propagation delay. The end-to-end delay of a path is the summation of the node delay at each node plus the link delay at each link on the path. Node delay includes the protocol processing time and the queuing delay at node i for link $i \rightarrow j$. Link delay is the propagation delay on link $i \rightarrow j$. In wireless link, the propagation delays are very small and almost equal for each hop on the path. The queuing delay and MAC delay are considered as two main factors that accumulated the node's delay. Figure 4 gives the Average End to End Delay of different queue scheduling mechanisms when the number of nodes is increased. This Figure helps us to study about the efficiency of the queue scheduling mechanisms. This result is obtained for non-real time communications. When the number of nodes is increased, number of flows will increase leads to generation of many number of packets. But in real-time communication, FIFO cannot give any promising results. The average end-to-end delay of RED is increased for increasing number of nodes whereas the delay of WFQ is decreased.

Table 2: *End-to-End Delay with Varying Number of Nodes.*

Number of Nodes	**Average End-to-End Delay (m.sec)**			
	Drop Tail	**Priority**	**RED**	**WFQ**
50	1.7	31.94	0.02925	7.1069
100	1.7932	10.25	2.8419	7.0294
150	3.915	41.12	52.2024	4.267
200	8.133	0.0065	60.374	3.053E-05

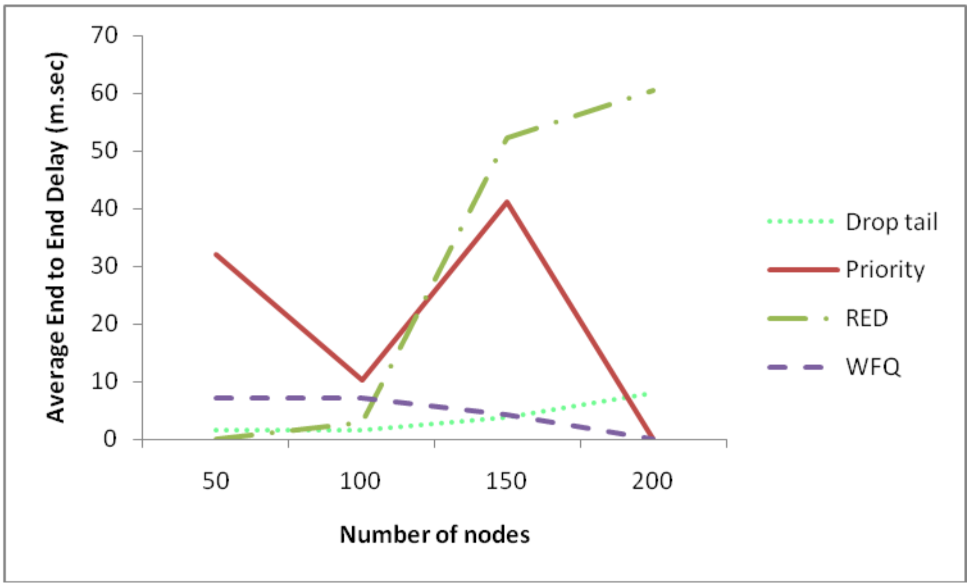

Fig. 4: *Average End-to-End Delay vs. Number of Nodes.*

Routing Overhead

The control overhead is defined as the total number of routing control packets normalized by the total number of received data packets. Figure 5 gives the Routing overhead of different queue scheduling mechanisms when the Number of nodes is increased. This Figure helps us to study about the adaptive queue buffer size change mechanisms. When the Number of nodes is increased, number of free space in the buffer is adaptively changed for RED. But WFQ requires less overhead than any other queue.

Table 3: *Routing Over Head with Varying Number of Nodes.*

Number of Nodes	Normalized Routing over Head (*512 Bytes)			
	Drop Tail	Priority	RED	WFQ
20	0.01332	0.01321	0.01257	0.00125
40	0.08441	0.08201	0.04106	0.007672
60	0.09342	0.091121	0.248	0.011831
80	0.2281	0.2198	0.62645	0.115283
100	0.49958	0.4922	2.04897	0.151424

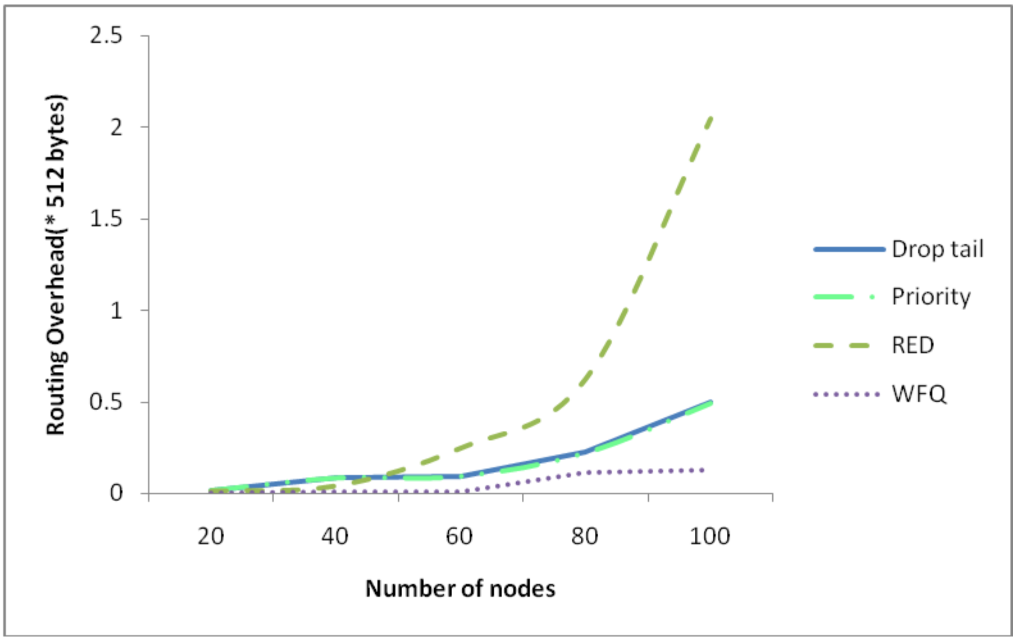

Fig. 5: *Routing Overhead vs. Number of Nodes.*

The results for all parameters obtained by simulation are summarized and tabulated as below. These results are showing that the WFQ is better in comparison with other queuing methods by means of the listed parameters. So, by implementing WFQ in AEERG protocol, congestion control can be achieved and in a guaranteed manner QOS can be enhanced.

Table 4: *Parameter Comparison Table.*

S. No.	Parameter	Drop Tail	Priority	RED	WFQ
1	Actual packet delivery ratio	75-93%	76-96%	50-79%	86-100%
2	Average End-to-End Delay(msec)	1.7-8.3	0.0065-41.2	0.029-60	7.1-3.15 E-05
3	Routing overhead (micro sec)	0.13-0.49	0.13-0.49	0.12-2.048	0.001-0.151
4	Processing Delay(sec)	1.89	0.67	1.89	0.25

Even though Drop tail's performance is better in some cases compared with PQ group, it is having large processing delay which is not suitable for real time communications. From the table, we can conclude that WFQ has good Actual

Packet Delivery Ratio, low average end-to-end delay with less amount of Routing overhead and Processing delay compared to other queuing methods. The other three queues results are also given. Those results are not as good as WFQ and so we can prove that WFQ is giving promising results.

CONCLUSION

In this paper, we have proposed the WFQ technique for providing better QOS in Mobile adhoc network (MANET). The WFQ can also be deployed at the edges of the network to provide a fair distribution of bandwidth among a number of different service classes based on the weight assigned to each service class. The design goals of WFQ is to allocate fair bandwidth to each flow without considering the packet size and thereby providing better Quality of service. After comparison of the results it is clear that WFQ shows better performance than other queuing techniques. But when compared with WFQ group in case of Average end-to-end, Normalized routing over head and Actual Packet delivery ratio the WFQ always shows the best performance among them. The main drawback of WFQ is its complexity and accuracy. But research works are can be carried out to provide many variations of WFQ with different trade-offs such as Class-based WFQ, Self-clocking Fair Queuing (SCFQ), Worst-case Fair Weighted Fair Queuing (WF^2Q) and Worst-case Fair Weighted Fair Queuing+ (WF^2Q+) and thereby attempting to balance complexity, accuracy, and performance.

REFERENCES

1. Babak Abbasov. AHRED: A robust AQM algorithm for wireless Adhoc networks. *International Conference on Application of Information and Communication Technologies.*1–4p.
2. Byung-Gon Chun, Mary Baker. Evaluation of packet scheduling algorithms in mobile ad hoc networks mobile computing and communications review. 2002; 1(2): 36–49p.
3. C. Toh. Ad hoc mobile wireless networks: protocols and systems, PTR Prentice Hall; 2002.
4. Chun. B, Baker. M. Evaluation of packet scheduling algorithms in mobile ad hoc networks. *Mobile Computing and Communications Review.* 2002; 36–49p.
5. Enzai, N.I.M, Rais, S.S., Darus, R. An overview of scheduling algorithms in mobile ad-hoc networks. *International Conference on Computer Applications and Industrial Electronics*. 2010.

6. Floyd.S and Jacobson. V. Random early detection gateways for congestion avoidance. *IEEE/ACM Transactions on Networking*. 1993; 1(4): 397–413p.
7. Giang P.T, Nakagawa. K. Achieving fairness over 802.11 multihop wireless ad hoc networks. *IEICE Transactions on Communication*. 2009; E92-B(8): 2628– 2637p.
8. Hafiz M. Asif, El-Sayed M. El-Alfy. Simulation-based performance comparison of queueing disciplines for differentiated services using OPNET. MMATCEE05 WSEAS Conference in Sofia, Bul-garia; 2005.
9. Hesham N. Elmahdy, Mohamed H. N. Taha. The impact of packet size and packet dropping probability on bit loss of VoIP networks. *ICGST-CNIR Journal*. 2009; 8(2): 25–29p.
10. Jamal N. AI-Karaki, Ahmed E. Kamal. Supporting quality of service in mobile ad hoc networks. *ACS/IEEE International Conference on Computer Systems Applications (AICCSA'05)*. 2005.
11. Jianyong Chen, Cunying Hu, Zhen Ji. Self-tuning random early detection algorithm to improve performance of network transmission mathematical problems in engineering journal. 22; 17p.
12. Kawadia V, Kumar P R. Principles and protocols for power control in ad hoc networks. *IEEE Journal Select. Areas Communications*. 2005; 23(1): 76–88p.
13. Kui Wu, Janelle Harms. Qos support in mobile ad hoc networks, crossing boundaries-the GSA. *Journal of University of Alberta*. 2001; 1(1): 92–106p.
14. Kulkarni P G, McClean S I, Parr G P, Black M. Proactive predictive queue management for improved QoS in ip networks proceedings of the international conference on networking. *International Conference on Systems and International Conference on Mobile Communications and Learning Technologies*.
15. Liu Ping, Yuan Peiyan. An Approach to calculate queue delay in mobile adhoc networks. *International Conference of Information Science and Management Engineering (ISME)*. 2010; 2.
16. Mohammad Mirza Golam Rashed, Mamun Kabir. A comparative study of different queuing techniques. In VOIP, video conferencing and file transfer. *Journal of Science and Technology*. 2010; 5(1): 37–47p.
17. Peter Marbach. Distributed scheduling and active queue management in

wireless networks. *INFOCOM*. 2321–2325p.

18. Rajeswari S, Venkataramani Y. An adaptive energy efficient and reliable gossip routing protocol for mobile adhoc networks. *IJCTE*. 2(5): 740–745p.
19. Shensheng Tang, Wei Li. QoS provisioning and queue management in mobile ad hoc. *Networks International Conference on Wireless Communications and Networking, WCNC*. 2006; 400–405p.
20. Shujie Wei, Guangwei Bai, Hang Shen. An adaptive queue management mechanism for video streaming over mobile ad hoc networks. *WiCOM'09 Proceedings of the 5th International Conference on Wireless Communications, Networking and Mobile Computing*.
21. Wang Jietai, Xu Jiadong, Xiang Mantian. EAQR: An energy-efficient aco based QoS routing algorithm in wireless sensor networks. *Chinese Journal of Electronics*. 18(1): 113–116p.
22. Wenyu Cai, Xinyu Jin, Yu Zhang, Kangsheng Chen, Rui Wang. ACO based QoS routing algorithm for wireless sensor networks. *Ubiquitous Intelligence and Computing, LNCS*. 419–428p.

