

# Buffer Management Schemes to avoid Packet Loss in Mobile Ad-hoc Networks: A Survey

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**Abstract** - Mobile Ad hoc Network is a self-configuring infrastructure less wireless network in which nodes are mobile in nature and they form a temporary network. Each mobile node is free to move anywhere independently in any direction. There is no centralized control in MANET due to the dynamic nature of the network. Hence, nodes communicate with each other through intermediate nodes. The intermediate nodes are normal nodes in the same network and assume the responsibility of forwarding packets on the route from source to destination. Wireless link transmission errors, mobility and buffer overflow (congestion) are major causes for packet loss in mobile ad hoc networks. Our work targets buffer overflow and it occurs at intermediate nodes i.e packet loss may occur in the buffer of a node, if the size of the buffer becomes less than the flow of packets into the buffer. If packet loss is not controlled then there will be a decrease in the performance of the MANETs. In order to reduce the packet loss, there are number of queue management techniques available like Drop Tail, RED and its variants. This paper provides a review of various buffer management schemes for packet queues and comparative analysis of existing techniques in wireless ad-hoc networks (MANETs).

**Keywords** — *Active queue management, MANETs, Packet Loss, Passive queue management, Packet Queue, Scheduling scheme.*

## I. INTRODUCTION

### A. Wireless Ad Hoc Networks

Wireless communication technologies are undergoing rapid advancements. The last few years have experienced a steep growth in teaching and research in the areas of wireless ad hoc networks. These networks have emerged to be attractive in many civilian and military applications and they hold great promises for our future. The attractiveness of ad hoc networks, in general, is attributed to their characteristics/features such as ability for infrastructure-less setup, minimal or no reliance on network planning and the ability of the nodes to self-organize and self-configure without the involvement of a centralized network manager, router, access point, or a switch. These features help to setup a network fast in situations where there is no existing network setup or in times when setting up a fixed infrastructure network is considered infeasible, for example, in times of emergency or during relief operations.

Wireless Ad Hoc Networks can broadly be classified into three categories:

- Mobile ad-hoc networks (MANETs)
- Wireless Sensor Networks
- Wireless Mesh Networks

Each one of these has significance for different application areas; each of these differs in the capacity and capabilities of nodes that participate in the network, the purpose of the network and the communication protocols employed. The focus of this paper is MANETs; from this point onwards, the words MANETs and Wireless Ad Hoc Networks will be used interchangeably.

### B. Mobile Ad-Hoc Networks

A Mobile Ad hoc Network (MANET) is a type of ad hoc network [1]. Ad hoc means set or occurrence whenever important and not having plan in advance. Ad hoc is a LAN which permits new network devices to be inserted quickly. Mobile ad hoc network contains a collection of autonomous nodes which forms a short-term network without any fixed environment or central controller. For introducing network wireless connections (Wi-Fi) are used or any other average such as satellite or cellular transmission. Each device in a MANET is free to move self dependently in any direction. In MANET, each node (Mobile Device) acts as a router, which helps in sending forward packets from a source to destination. MANET nodes can be own devices such as laptop, mobile phones and PDA. MANET can change place of location and configure itself on the fly. Fig.1 shows that source and destination nodes are not in range so packets are routed through intermediate nodes.

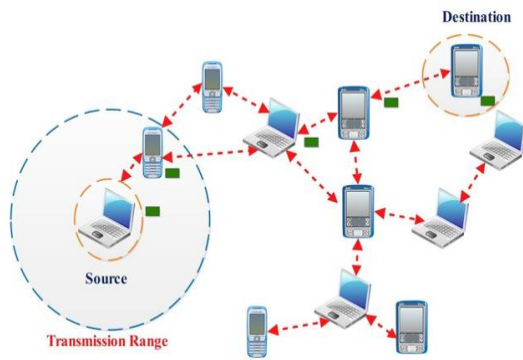


Fig.1. Mobile Ad Hoc Network

There are three types of MANET. It includes Vehicular Ad hoc Networks (VANETs), Intelligent Vehicular Ad hoc Networks (In VANETs) and Internet Based Mobile Ad hoc Networks (iMANET).

InVANETs – Intelligent vehicular ad hoc networks make use of artificial intelligence to tackle unexpected situations like vehicle collision and accidents.

Vehicular ad hoc networks (VANETs) – Enables effective communication with another vehicle or helps to communicate with roadside equipment's.

Internet Based Mobile Ad hoc Networks (iMANET) – helps to link fixed as well as mobile nodes.

We are having many protocols for routing in multipath. The multipath routing protocols to enhance the quality of service in MANET through providing reliable communication. Mobile nodes communicate with each other in a multi-hop fashion in MANETs. That means a mobile node transfer a packet to a sink via middle nodes. The availability of each node very important. Otherwise, overall performance of the network may be precious by single middle node.

### C. Characteristics of MANETs

Mobile ad hoc network nodes are furnished with wireless transmitters and receivers using antennas, which may be highly directional (point-to-point), omni directional (broadcast), probably steer able, or some combination [2]. At a given point in time, depending on positions of nodes, their transmitter and receiver coverage patterns, communication power levels and co-channel interference levels, a wireless connectivity in the form of a random, multihop graph or "ad hoc" network exists among the nodes. This ad hoc topology may modify with time as the nodes move or adjust their transmission and reception parameters.

The characteristics of these networks are summarized as follows:

- In MANET, each node acts as both host and router.
- Multi-hop radio relaying- When a source node and destination node for a message is out of the radio

range, the MANETs are capable of multi-hop routing.

- Distributed nature of operation for security, routing and host configuration. A centralized firewall is absent here.
- The nodes can join or leave the network anytime, making the network topology dynamic in nature.
- Mobile nodes are characterized with less memory, power and light weight features.
- The reliability, efficiency, stability and capacity of wireless links are often inferior when compared with wired links. This shows the fluctuating link bandwidth of wireless links.
- Mobile and spontaneous behavior which demands minimum human intervention to configure the network.
- All nodes have identical features with similar responsibilities and capabilities and hence it forms a completely symmetric environment.
- High user density and large level of user mobility.
- Nodal connectivity is intermittent.

### D. Challenges of MANETs

A MANET environment has to overcome certain issues of limitation and inefficiency. It includes:

- The wireless link characteristics are time-varying in nature: There are transmission impediments like fading, path loss, blockage and interference that adds to the susceptible behavior of wireless channels. The reliability of wireless transmission is resisted by different factors.
- Limited range of wireless transmission – The limited radio band results in reduced data rates compared to the wireless networks. Hence optimal usage of bandwidth is necessary by keeping low overhead as possible.
- Packet losses due to errors in transmission – MANETs experience higher packet loss due to factors such as hidden terminals that results in collisions, wireless channel issues (high bit error rate (BER)), interference, frequent breakage in paths caused by mobility of nodes, increased collisions due to the presence of hidden terminals and uni-directional links.
- Route changes due to mobility- The dynamic nature of network topology results in frequent path breaks.

- Frequent network partitions- The random movement of nodes often leads to partition of the network. This mostly affects the intermediate nodes.

## E. Applications of MANET

Some distinctive MANET applications include:

- Military field
- Cooperative work
- Disaster relief operations.
- PAN and Bluetooth
- Business Sector
- Sensor Networks
- Backup Services
- Educational Sector

## II. QUEUE MANAGEMENT SCHEMES FOR MANET

Any communication network consists of a network of queues. Efficient management of these queues is mandatory in order to enable Quality of Service (QoS). This task is generally accomplished by congestion avoidance and control mechanisms. This process is called **queue management**. From the point of dropping packets, queue management can be classified into three categories as in the figure 2.

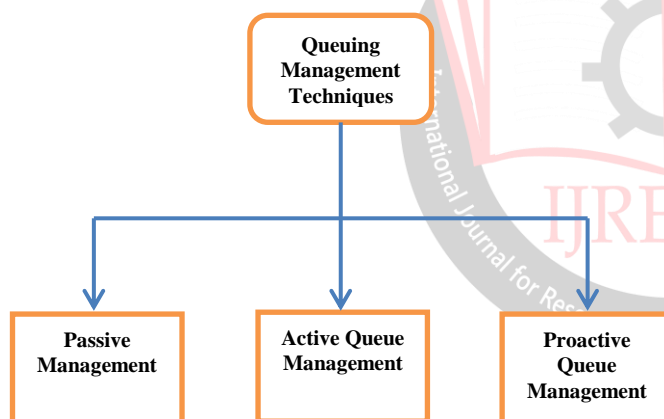


Fig.2. Classification of Queue Management Techniques

Queue management is defined as the algorithms that manage the length of packet queues by dropping packets when necessary or appropriate. Passive queue management (PQM) which does not employ preventive packet drop before the router buffer gets full or reached a specified value. Packets are simply dropped when buffer gets full. Even though it is less effective and have several drawbacks, the main advantage of using PQM is that it is easy to implement in network with less computational overheads.

**Drop Tail** is most commonly used algorithm in PQM. The main principle of Drop Tail approach is shown in fig. 3. As the name indicates Tail of enqueued packets is dropped once the buffer gets full and keeps on dropping them until the enough space gets created for new packets. The length of buffer is therefore the main parameter that controls the

packet drop in this scheme [3]. The only two dropping probabilities in Drop Tail are 0 and 1. When the number of packets arrived to the queue larger than the buffer size, the probability of packet dropping is 1. Otherwise the dropping probability is 0 [8]. It is very simple to implement but does not provide fair distribution of buffer space. If multiple TCP connections exist in the system and a buffer overflow will cause TCP global synchronization, which reduce the network throughput [5].

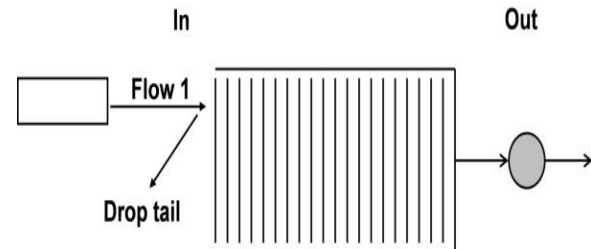


Fig.3. Main principle of Drop Tail

Active Queue Management employs preventive packet drop before the router buffer gets full. In this scheme, the sending node is notified before the queue is near to be completely filled so that the sender can stop sending data or lower the rate of data transmission [3]. There are many AQM Techniques used in MANETs which are as under

- RED (Random Early Detection)
- REM (Random Exponential Marking)
- SFQ (Stochastic Fair Queuing)
- FRED (Flow Random Early Drop)
- RED-PD: Random Early Detection with Preferential Dropping
- SRED: Stabilized Random Early Detection
- BLUE
- AVQ: Adaptive Virtual Queue

In this paper we are going to discuss the most popular and common AQM techniques SFQ, RED, REM etc., in detail. RED (random early detection) is the most commonly used algorithm. It monitors the average queue size and take actions on packet (either drop or mark) based on statistical probabilities.

**Red:** Random Early Detection (RED) Lin and Morris [13], is a congestion avoidance queuing mechanism (as opposed to a congestion administration mechanism) that is potentially useful, particularly in high-speed transit networks. Sally Floyd and Van Jacobson projected it in various papers in the early 1990s. It is active queue management mechanism. It operates on the average queue size and drop packets on the basis of statistics information. If the buffer is empty all incoming packets are acknowledged. As the queue size increase the probability for discarding a packet also increase. When buffer is full probability becomes equal to 1 and all incoming packets are dropped.

The advantage of RED is that it is capable to evade global synchronization of TCP flows, preserve high throughput as well as a low delay and attains fairness over multiple TCP connections, etc. It is the most common mechanism to stop congestive collapses. The main limitation of RED is that when the queue in the router starts to fill then a small percentage of packets are discarded. This is deliberate to start TCP sources to decrease their window sizes and hence suffocate back the data rate. This can cause low rates of packet loss in Voice over IP streams. There have been reported incidences in which a series of routers apply RED at the same time, resulting in bursts of packet loss.

**Rem:** REM is an active queue management scheme that measures congestion not by performance measure such as loss or delay, but by quantity. REM can achieve high utilization, small queue length, and low buffer overflow probability. Many works have used control theory to provide the stable condition of REM without considering the feedback delay. In case of (Random Exponential Marking) REM, the key idea is to decouple congestion measure from performance measure (loss, queue length or delay). In REM, the user rates are matched by clearing buffers irrespective of number of users. The sum of link prices, summed over all the routers in the path of the user to the end-to-end marking. Kwon and Fahmy [14], Victor et al. [15].

**Stochastic Fair Queuing:** Fair Queuing is a queuing mechanism that is used to allow multiple packets flow to comparatively share the link capacity. Routers have multiple queues for each output line for every user. When a line is available as idle routers scans the queues through round robin and takes first packet to next queue. FQ also ensure about the maximum throughput of the network. For more efficiency weighted queue mechanism is also used. This queuing mechanism is based on fair queuing algorithm and proposed by John Nagle in 1987. Because it is impractical to have one queue for each conversation SFQ uses a hashing algorithm which divides the traffic over a limited number of queues. It is not so efficient than other queues mechanisms but it also requires less calculation while being almost perfectly fair. It is called "Stochastic" due to the reason that it does not actually assign a queue for every session; it has an algorithm which divides traffic over a restricted number of queues using a hashing algorithm. SFQ assigns a pretty large number of FIFO queues queuing Paul E. McKenney [16].

**Flow Random Early Drop:** Flow Random Early Drop (FRED) is a modified version of RED, which uses per-active-flow accounting to make different dropping decisions for connections with different bandwidth usages. The implementation of flow and traffic control has resulted in a greater control over bandwidth allocation and flow control over individual channels. The main goal of FRED is to

provide different dropping strategies to different kind of flows. Two parameters are introduced into FRED: minq and maxq, which are minimum and maximum numbers of packets that each flow is allow to buffer. An advantage of FRED is that it makes the dropping decisions based on the flow control and allocation of the connection on the channel, D. Lin and R. Morris [17].

#### **Random Early Detection With Preferential Dropping:**

Another probabilistic approach towards queuing derived from RED is RED-PD. It uses several lists containing the drop history of consecutive intervals of time. RED-PD is only active if there is not enough bandwidth to provide sufficient service to all flows. In the case of congestion flows that use more of the bandwidth than their fair share should be cut back in service to a target bandwidth by packet dropping, Ratul Mahajan and Sally Floyd [18].

**Stabilized Random Early Detection:** In contrast to normal RED which focus on estimating the average queue size, in SRED, introduced by Ott et al. in [OLW99], the most important value is the estimation of the number of active flows. The drop probability of a new arriving packet is stated by the following two formula. In the formula B is the total queue size, Pmax is the maximum dropping/marketing probability, QC is the current queue length, Pest(t) is a factor estimating the number of active flows, and Hit(t) is either 1 or 0, depending on whether the current packet had a match in the zombie list or not. SRED focuses mainly on the active flows in the queue instead of average queue size, which is why it is more suitable for dynamic topological changes which are more frequent to the nature of MANETs.

**Blue:** BLUE is an active queue management algorithm to manage congestion control by packet loss and link utilization history instead of queue occupancy. BLUE maintains a single probability, Pm, to mark (or drop) packets. This effectively allows BLUE to "learn" the correct rate it needs to send back congestion notification or dropping packets, Debanjan Saha Wu-chang Feng, Dilip D. Kandlur and Kang G. Shin [19].

**Adaptive Virtual Queue:** An Adaptive Virtual Queue Algorithm (AVQ) was proposed by Kunniyur and Srikant to achieve the stability of the queue length. The maximum size of the virtual queue is adapted as follows:  $V_{max} = (\lambda_{current} - \lambda_{desired}) / \mu$  where  $\lambda_{current}$  is the arrival rate at the link,  $\lambda_{desired}$  is the smoothing parameter and the desired utilization of the link. The delay and packet loss small while the utilization of the link is high AVQ tries to maximize the sum of utility functions of single users.

Pro-active queue management algorithms are novel attempts to prevent congestion from ever happening in the first place. We present a proactive queue-management (PQM) algorithm called GREEN that applies knowledge of the steady state behavior of TCP connections to intelligently and



proactively drop packets, thus preventing congestion from ever occurring and ensuring a higher degree of fairness between flows. This congestion-prevention approach is in contrast to the congestion avoidance approach of traditional active queue-management schemes where congestion is actively detected early and then reacted to.

The following TABLE I [20] show advantages and disadvantages of various queue management techniques in Mobile Adhoc Networks.

**TABLE I: Advantages and Disadvantages of Various Queue Management Techniques**

S.No	Algorithm	Strengths	Weaknesses
1.	DT	Simple; There is no State information	Lacks in QoS; no fairness; global synchronization problems; biased for bursty traffic
2.	RED & its Variants	Simple; fair; QoS; EWMA; AQM; unbiased for bursty traffic	Very sensitive to parameters settings
3.	BLUE & SFB	Low packet loss rate and Less buffer needed	Do not scalable
4.	REM	Low packet loss; high link utilization; scalable; and low delay	It is Based on global parameter; Lacks QoS
5.	SFQ	Reduced look up cost.	Complicated; incomplete fairness; more queues
6.	AVQ	Adaptive to traffic changes	DT used in VQ

### III. LITERATURE REVIEW

**P. G. Kulkarni, M. Nazeeruddin, et al.** [7] presented a predictive queue management strategy named PAQMAN that proactively manages the queue, is simple to implement and requires negligible computational overhead (and hence uses the limited resources efficiently). The performance of PAQMAN (coupled with explicit congestion notification - ECN) has been compared with Drop tail through ns2 simulations. Results from this study show that PAQMAN reduces packet loss ratio (and hence the fraction of retransmissions) while at the same time increasing transmission efficiency. Moreover, as its computational overhead is negligible, it is ideally suited for deployment in MANETs.

**P.G.Kulkarni, S.I.McClean,** [6] presents a proactive prediction based queue management scheme called PAQMAN that captures variations in the underlying traffic accurately and regulates the queue size around the desirable operating point. PAQMAN harnesses the predictability in the underlying traffic by applying the Recursive Least Squares (RLS) algorithm to estimate the average queue length for the next prediction interval given the average

queue length information of the past intervals. This predicted average queue length then drives the computation of the packet drop probability. The performance of PAQMAN has been evaluated and compared against the RED scheme through ns-2 simulations that encompass a wide variety of network conditions.

**Muhammad Aamir et al.** [4], introduces a new scheme of buffer management to handle packet queues in Mobile Ad hoc Networks (MANETs) for fixed and mobile nodes is introduced. In this scheme, we try to achieve efficient queuing in the buffer of a centrally communicating MANET node through an active queue management strategy. Firstly we assign dynamic buffer space to each node then we assign a dynamic buffer space to all neighbouring nodes in proportion to the number of packets received from neighbours and hence control packet drop probabilities. Through analysis and simulation study we reveals that the proposed scheme is a way to improve the buffer management for packet queues in MANET nodes in terms of packet loss ratio, transmission efficiency, and some other important system parameters.

**Lutz et al.** [9] focused on the assignment of transmission frames with same number of transmission slots per frame to a wireless node on a channel shared with other nodes. They proposed a variation in such a way that number of transmission slots ("weights") can be varied in different transmission frames. In this way, throughput may be increased without compromising "fairness" and packet losses due to collision may also be mitigated.

**Chen and Bensaou** [10] presented a study for high speed networks about their survivability in terms of fairness and packet loss problems with Drop Tail queue management scheme. The authors mentioned when TCP flows come across multiple congested links in high speed networks working on Drop Tail scheme, they face packet drop probability unfairness and round trip time unfairness. On the other hand, AQM schemes reduce the severity of above mentioned unfairness.

**Abbasov and Korukoglu** [11] improved the existing RED algorithm on networks and the improvement is called Effective RED (ERED). It has a few variations as compared to RED in the packet drop function which produce better throughput and less packet loss rate as compared to RED and some other well known AQM schemes. It is shown by authors through simulation study in NS-2.

**Dimitriou and Tsaoussidis** [12] proposed an active queue management scheme called Size-oriented Queue Management (SQM) in which the criterion is packet size. Hence, it differentiates time-sensitive traffic and applies different policies of scheduling and packet drop on separate flows to increase the level of application satisfaction.

**Mr. A. Chandra** [13] this paper made an effort to present a queue management approach. However the approach has outperformed existing queue management techniques RED and REM. Here choke packet mechanism is used to send the feedback to sender. It involves additional overhead to the traffic. Maintenance of virtual queue consumes additional buffer space. Decreasing of the size of virtual queue can be carried in future.

**P.T.Mahinda** [21] have done the analysis of queue management techniques using NS-2 simulator. Allocating resources to user in the network effectively is the main issue. Queue management enhances the efficiency of transferring the packet in the network by using Transmission control protocol (TCP). Too many packets in the queue are queued for transmission and as the queue overflow packets are dropped which results in congestion. So to overcome this queue management algorithms are applied to router to provide quality of service. Comparison of various queue management scheme is done on the basis of simulation and the results indicates that active queue management schemes (RED, REM) performed better in terms of packet drop rate and end to end delay.

**Shubhangi Rastogi** [22] done the comparison of different queuing mechanism in Dumb-bell Technology. Congestion is the main problem in the networks so for managing traffic and keep network stable congestion control algorithms are required. Queuing is also important in traffic management system so various queuing mechanisms are analyzed on the basis of performance parameters. The simulation results show that Non Linear Random Early Detection has superior quality than others.

#### IV. SIMULATION RESULTS AND ANALYSIS

The experiments were conducting using the ns-2 network simulator. The comparison in Table 2 indicates that, packet loss ratio of Drop Tail, PAQMAN and QMN schemes for tested flow arrival rates in 50 node scenario. On the flow arrival rate of 25 Mbps, we observe that Drop Tail is slightly better than PAQMAN which indicates that PAQMAN may be beaten by Drop Tail in low congestion cases. We can mention that as flow arrival rate increases, there are more incidents of congestion due to more packet transmissions. Therefore, the packet loss ratio in all schemes generally increases with the rise in flow arrival rate.

Table 2: Packet loss ratio in 50 – node scenario.

Flow arrival rate (Mbps)	Packet loss ratio		
	Drop Tail	PAQMAN	QMN
10	0.06	0.05	0.03
25	0.23	0.24	0.11
35	0.36	0.29	0.19
45	0.41	0.33	0.26
54	0.56	0.45	0.31

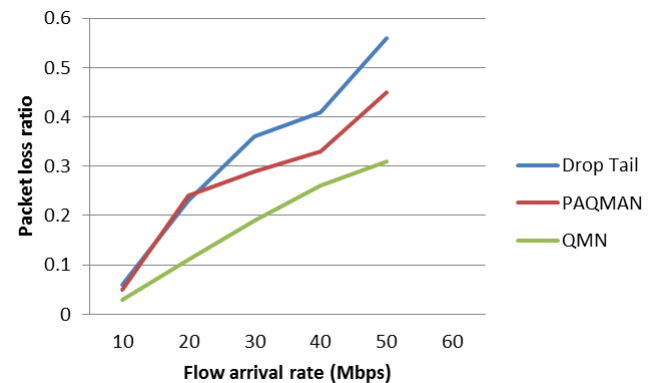


Fig. 4. Flow arrival rate Vs. Packet loss ratio in 50 node scenario.

Figure 4 show that, the performance of three active queue management techniques of Drop Tail, PAQMAN and QMN in terms of Flow arrival rate and Packet loss ratio.

#### V. CONCLUSION

In this paper, we tried to understand various queue management techniques behavior in the traffic loaded network. Our literature review identifies that considerable work has been done on the matter of packet queue management in both wired and wireless forms of networks. Majority studies have taken measures for strengthening packet queue management system to avoid packet loss and few studies also expressed their limitations on congestion control mechanisms. We compared the simulation results for few techniques in terms of flow arrival rate and packet loss ratio of Drop Tail, PAQMAN and QMN. We find that, an effective solution is required to address the packet loss issue of queue management in the buffers of MANET nodes.

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