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Analysing Mobile Random Early Detection for Congestion Control in Mobile Ad-hoc Network

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ABSTRACT

This research paper suggests and analyse a technique for congestion control in mobile ad hoc networks. The technique is based on a new hybrid approach that uses clustering and queuing techniques. In clustering, in general cluster head transfers the data, following a queuing method based on a RED (Random Early Detection), the mobile environment makes it Mobile RED (or MRED), It majorly depends upon mobility of nodes and mobile environments leads to unpredictable queue size. To simulate this technique, the Network Simulator 2 (or NS2) is used for various scenarios. The simulated results are compared with NRED (Neighbourhood Random Early Detection) queuing technique of congestion control. It has been observed that the results are improved using MRED comparatively.

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1. INTRODUCTION

An ad hoc network is a collection of wireless devices(referred to as nodes) which communicate with each other using shared wireless medium without intermediate infrastructure. When nodes move and change their locations in these specialized networks then this category is called Mobile Ad hoc Network or MANET. In general, mobile nodes organize themselves to form a network over radio links while communicating with each other. One of the advantages of this network is that it can be easily deployed anywhere as it is defined in [1], [2], but a large amount of real-time traffic requires high bandwidth. The reason is that these nodes share a priori protocol information along with up-gradation of information in terms of parameters which takes part in communication, for example the evolving & scaling or expanding parameter list causes congestion [3]. Congestion not only affects the integrity of data but also decreases overall bandwidth and throughput of the links & ultimately reduces QoS of network. To avoid congestion, a lots of work has been done earlier, such as Cluster Based QoS (Quality of Service) Routing [4], Cross Layer congestion control [5] & Queuing Technique e.g., Neighborhood Random Early Detection (NRED) [6] as shown in Table 1. The main objective of all these efforts is to limit the delay and buffer overflow caused by congestion, and improve the communication performance , the enhanced form of Queing technique will be used in this research paper in which nodes are in the mobile trajectory and NRED changed in to MRED, Diffrence in the approach of droping packet when it goes up from the threshold value. It not only reduces congestion but also improves QoS. A description on Background, Problem and the proposed solution.

1.1. Background

A number of researches have been done to give a solution for congestion control. In Table-1 there is a list of congestion control techniques, different columns represents author, publication year, research topic, methodology used and problems noted in applying the methodology. In Table-1, problems related with TCP fast start, RED, ARED revised ARED, improved ARED, weighted RED, Cross layer design approach, NRED, and CBQR (cluster based QoS routing protocol) are tabulated. In TCP fast start approach [7], a sender temporarily stores congestion information to start the new connection from a larger initial window size. The advantage is that, it avoids the slow start penalty for each page download. However, with this methodology, there is a risk of performance degradation when the cached information is stale (or old). And, the new route is used for next transaction. The Active Queue Management (AQM) technique, named RED in [8], reduces packet loss, attains high throughput and prevents global synchronization as discussed in Table 1. The RED gateway drops the packets when the average queue size is greater than maximum threshold value Feng et al. [9] presents the original ARED. A revised version of ARED (Adaptive RED) is presented by Floyd et al. [10], which is also named as Adaptive RED. An improved ARED technique described in [6] optimizes the bounds on the maximum drop probability and adjusts the lower threshold of the exponential averaging weight on linear stability conditions. The techniques, mentioned above, have been applied successfully in wired networks, to improve the TCP performance in ad hoc networks. Several techniques have been proposed emphasizing on addressing link breakages, routing algorithm failures and mobility [11].

1.2. The problem

The congestion control problem in ad-hoc wireless networks, described in Antonopoulo et al [12] identifies that the main cause for performance degradation in wireless network is excessive congestion. For such networks the utilization of the cross-layer design approach is advocated. They also argued that the layered approach of the OSI/ISO model is not sufficient enough to provide substantial performance enhancement in wireless networks with dynamic nature. To provide a promising solution Xu K. et al [11] proposed NRED (Neighborhood RED) technique, which is an extension of original RED [8] developed for wired networks. An NRED brings the concept of distributed neighborhood queue. It is given in the table given herewith degree algorithm , WCA (Weighted Clustering Algorithm) [13], [14] etc.Thus, Congestion control is the main problem area and addingly queuing too, which has not been worked together for MANETS earlier, which raises a requirement of a technique for MANETS .

1.3. The proposed solution

To overcome the problem a hybrid technique is introduced in this research. We refer to this technique as Mobile RED (Mobile Random Early Detection) and abbreviated as MRED. In this technique the original ARED (Adaptive RED), [10] is applied instead of RED [8] at the cluster head nodes in a clustered network. The difference in, RED, ARED, NRED & MRED, is the way their drop probabilities. The RED gateway starts dropping the packets when the average queue size reaches the maximum threshold value while in ARED (Adaptive RED), which dynamically changes the range of maximum drop probability P_{max} according to different network scenarios and adjusts P_{max} to limit average queue size Q_{ave} in a steady range, thus, it is more suitable for ad hoc networks (dynamic topology) in the proposed method. The scenario is supposed to be simulated on MANET type of networks in which not only cluster nodes but also cluster head regularly change their location. MRED also works same as ARED [15], [16]. But, the ever changing position of Cluster head changes the values which is the main challenge, its delt in this research. As far as current research in concerned. In Abinasha Mohan et. al. [17] a noval work on queue management was done using basic RED technique. They have given a joined early congestion based solution on cross layer designed to optimize congestion control. S. Subharmanam in [18] has suggested predictive congestion control using a predictive congestion index of a node as ratio of current queue occupancy over the available total queue size & that node. It completed using AODV protocol and proactively defined & finds congestion. Several research works are going on , in the currecnt scenario keeping power and energy as main parameters .Work done in [19] is done using integration in optical & wireless networks which also proposes a power consumption model for such type of networks [20].

The paper is consisting of 6 sections in which Section 1 contains introduction about the problem Section 2 gives the Research method which gives more clarity about the relevance of the problem with several schemes, modules and techniques which are evolved earlier to remove congestion to give better QoS (Quality of Service). Section 2 also gives clear idea about the protocols discovered in current scenario for the congestion control by giving simultaneous explanation of RED, ARED, NRED & MRED. Section 3 gives the result analysis for efficient clustering technique and the proposed clustering and queuing combination, making it as a hybrid technique MRED. All experiments, scenario simulation and its analysis done explained in Section 3 and 4 simultaneously. Section 5 gives conclusion followed by the references.

2. RESEARCH METHOD

2.1. Mobile random early detection (OR MRED)

The congestion in an ad hoc network can be traced to the entire space around the node because in ad hoc network node has to compete for the channel requirements with the nodes that lie in the same. "Neighbourhood" is the name given for this "space" in [11] to name it as NRED. NRED is compared with MRED in this research, in which MRED technique is applied on the cluster head in the clustered network. Cluster-head contains the information of its member node as well as of other cluster-heads, is the reason why we apply MRED on cluster-head. It will also reduce the load from the member nodes in a cluster by calculating the average queue size or we can say channel utilization. The queue size on the cluster-head nodes determines the degree of congestion in network. For this first we have to choose the cluster-head first, as shown in Figure 1 [2].

The objects in one cluster are similar in terms of synchronisation than the objects that lies in other cluster. Every cluster selects a cluster head and all the other nodes which lie in the transmission range of that cluster-head are called the member nodes of that cluster, as shown in Figure 1 [1]. Several algorithms are proposed for the selection of cluster-head, but we are using the highest degree algorithm to find the cluster-head.

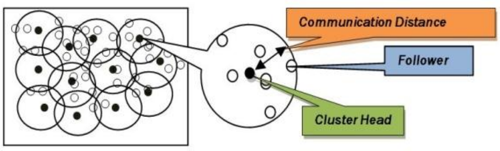

Figure 1. Selecting cluster head

2.2. Cluster-head congestion detection

After the cluster-head selection these cluster-heads have to detect the congestion in the network. It is similar to the congestion detection in NRED except that the congestion is detected at the cluster gateway or cluster head nodes. A brief overview is provided here for congestion detection in ad hoc network. As it is difficult to get the actual queue size of node in ad hoc network due to change in traffic pattern and network topology, so, channel utilisation is used to measure the queue size in ad hoc network and there is also a direct relationship between channel utilization and input- output queue size and there are 5 different radio states that are monitored by the nodes. These radio states are: a) Transmit, b) Receive, c) Carrier sensing busy, d) Virtual carrier sensing busy (e.g. deferral to RTS, CTS etc.), and e) Idle. Figure 2 show the flow diagram for Cluster head selection.

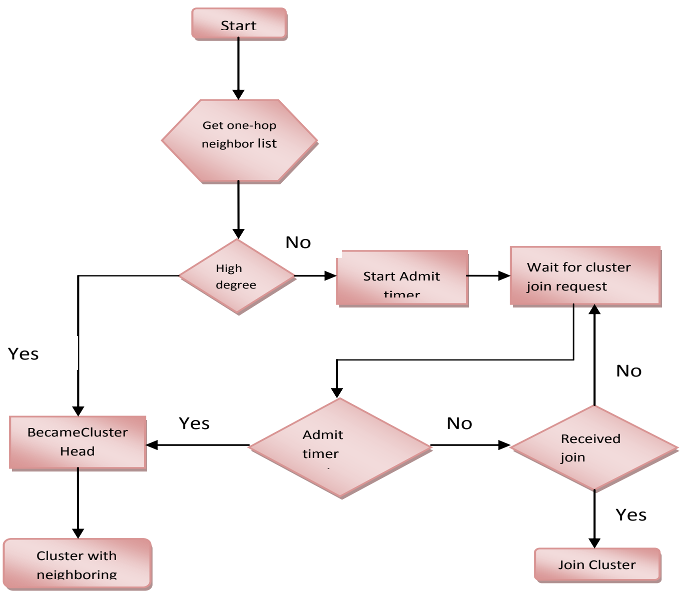

Figure 2. Flow diagram for cluster head selection

These radio states are divided into 3 categories in, where states 1) and 2) contribute of node to the total channel utilization by the nodes. States 3) and 4) are the contribution of the node's neighbors to the channel utilization, and state 5) is assumed as empty queue. In original NRED, a node estimates 3 channel utilization ratios, i.e. total channel utilization ratio (U_{busy}), transmitting ratio (U_{tx}) and receiving ratio (U_{rx}) and maintains the logs for time period in each 5 radio states as. T_{tx}, T_{rx}, T_{cs}, T_{vcs} and T_{idle}. Let T_{int} represents the total time period spent at each state. Then utilization ratios become:

$$U_{busy} = \frac{T_{int} - T_{idle}}{T_{int}} \quad (1)$$

$$U_{tx} = \frac{T_{tx}}{T_{int}} \quad (2)$$

$$U_{rx} = \frac{T_{rx}}{T_{int}} \quad (3)$$

Where,

$T_{int} = T_{tx} + T_{rx} + T_{cs} + T_{vcs} + T_{idle}$.
U_{busy} = cluster-head queue size.
U_{tx} = outgoing queue channel bandwidth usage, and
U_{rx} =incoming queue channel bandwidth usage

The network is said to be in early congestion state if U_{busy} exceeds its threshold value. Now this channel utilization is translated into an index of the queue size by using

$$q = \frac{U_{busy} * W}{C}$$

Where,

W is channel bandwidth in bps
C is average packet size in bits (Constant)

The variable q is not dimensionally correct, and it is expressed in pkts/sec rather than packets. It is only a scaling factor that affects the choice of the values for minimum and maximum threshold (Th_{min} and Th_{max}).
Similarly, q_{tx} and q_{rx} can be calculated using U_{tx} and U_{rx}.Now, the average queue size is

$$avg = (1 - wq) * avg + wq * q$$

Initially avg is 0 and w_q is weight parameter. Similarly, we can also get avg_{tx} and avg_{rx} using q_{tx} and q_{rx}. avg_{tx} and avg_{rx} are the average queue size of the incoming and outgoing queue.

2.3. Cluster-head congestion notification

Under MRED, the cluster gateway or Cluster head node checks the estimated average queue size avg periodically and compares it with a minimum threshold Th_{min}. If queue is larger than threshold, early congestion is detected. Then the node calculates a drop probability p_b based on the average queue size and broadcasts it to other cluster-head. This paper also replaces the specified target range of average queue size as

$$q_{target} = [Th_{min} + 0.4(Th_{max} - Th_{min}), Th_{min} + 0.6(Th_{max} - Th_{min})]$$

The bound on q_{target} and p_{max} is based on ARED [10]. Here, we present the algorithm for calculating p_b using pseudocode.

Algorithm 1: Calculating Drop Probability p_b
Saved Variables:
avg: average queue size
Fixed Parameters:

Th_{min}: *minimum threshold for queue*
Th_{max}: *maximum threshold for queue*
up_{max}: *upper threshold of* p_{max}
lp_{max}: *lower threshold of* p_{max}
T_{NCN}: *time interval for performing this action*
Variable Parameter:
p_{max} : *drop probability when avg is equal to* Th_{max}*, initially* p_{max} *is set with lower threshold of* p_{max}.
for each T_{NCN}
$avg \leftarrow estimatedQueueSize()$
for each interval seconds:
if (avg > q_{target} && p_{max} < up_{max})
$p_{max} = p_{max}+\alpha$;
else
if(avg <q_{target} && p_{max} >lp_{max})
$p_{max} = p_{max} * \beta$;

if $Th_{min} \leq avg < Th_{max}$
$p_b \leftarrow p_{max} * (avg - Th_{min})/(Th_{max} - Th_{min})$
$P_{norm} \leftarrow p_b / avg$
else if $Th_{max} \leq avg$
$p_b \leftarrow 1$
P_{norm}

Where, P_{norm} *is normalized probability* and the value used by estimated Queue Size() is calculated from channel utilization as index queue size.Three fields, packet Type, P_{norm}, and lifetime, are used by the NCN packets as in [11]. The field "packet Type" represents a NCN packet. Cluster-heads calculate their local drop probability by using Normalized Probability i.e. P_{norm} and packet dropping is stopped after lifetime period. In case of multiple NCN packets are received largest P_{norm} is stored at P_{norm} field.

2.4. Cluster gateway/head packet drop

Since congestion is detected and notified to other cluster-heads, now, we explain how these cluster-head nodes cooperatively drop packets to realized the expected drop probability p_b over the distributed queue. Overall drop probability local share of cluster-heads is calculated and is proportional to its queue size. In our clustered model, there are two queues that are associated at each cluster-head node, i.e. the outgoing queue and incoming queue. Both the queues calculate and implement packet drop probability separately. For this we are using the same pseudocode as used in [8].

Algorithm 2: RandomDrop() action at outgoing queue
Saved Variables:
cnt_{tx}: *outgoing packet arrived since last drop*
avg_{tx}: *average outgoing queue size*
Other Parameters:
p_c: *accumulative drop probability.*
for each *packet arrival*
$cnt_{tx} \leftarrow cnt_{tx} + 1$
if $normalizedP_b < 1$
$p_b \leftarrow normalizedP_b * avg_{tx}$
$p_c \leftarrow p_b/(1 - count_{tx} * p_b)$
else $p_c \leftarrow 1$
if $p_c > 0$
$aRandomNumber \leftarrow ran([0, 1])$
if $aRandomNumber \leq p_c$
drop the arriving packet
$cnt_{tx} \leftarrow 0$
else $cnt_{tx} \leftarrow -1$

Random number between 0 and 1 are generated by using the function ran ([0, 1]) in the above pseudocode. Same action is performed on incoming queue by using avg_{rx} and cnt_{rx} in place of avg_{tx} and cnt_{tx}. So, the parameters of mobility is also checked and used as the parameters to check droping of packets.

The reason why we apply MRED on cluster- head nodes are:

a. Cluster-head contains the information of its member node as well as of other cluster-heads.
b. It will reduce the bourdon from the member nodes, in a cluster, of calculating the average queue size or we can say channel utilization. The queue size on the cluster-head nodes determines the degree of congestion in network

3. EXPERIMENTAL SET UP AND RESULTS ANALYSIS

3.1. Scenario

The scenario of this model consists of very small experimental setup of 17 mobile nodes, 2 gateways are tested here on the Network Simulator-2(NS2). The topology is a rectangular area with 1000 m length and 1000 m width. The two gateways are placed on each side of the area; their x, y-coordinates in grid are (150,280), (800,250). All simulations are run for 150 seconds of simulated time. Four of the 17 mobile nodes are constant bit rate traffic sources as shown in the table in Figure 3. They are distributed randomly within the mobile ad hoc network. After this time the sources continue sending data until one second before the end of the simulation.

PARAMETER	VALUES
Simulation time	150 sec
Topology size	1000 X 1000
No. of nodes	17
No. of clusters	2
Node mobility	0 to 20m/sec
Routing Protocol	DSDV
Frequency	11 MHz
Traffic type	CBR
MAC	IEEE 802.11
Mobility model	Random Waypoint
Max. no. of packets	10000
Pause time	10sec

Figure 3. Parameters used

3.2. Cluster formation & cluster changes

The nodes in the cluster are mobile in nature thus the cluster nodes as well as the heads changes their positions unknowingly. The cluster change variation and cluster head change variation with respect to node mobility are shown in fig 4. We can observe that the network is more stable in lower mobility scenarios. The simulations for these results were carried with No. of node = 17 and Topology size = 1000 x 1000. As the node mobility increase the cluster change increase pause time for mobile nodes the changes also decrease, thus, cluster head changes and cluster head changes also decreases if node mobility decreases and pause time increases from 1 to 100 secs which can be easily seen in the data set kept in Table 2 [2], graph shown in Figure 4 a drop in pause time as per dereased mobility.

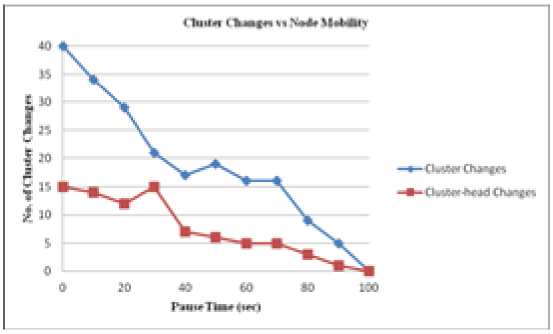

Figure 4. Cluster changes vs node mobility

Table 2. Cluster Changes Vs Node Mobility

S. No	Cluster Head Changes		Cluster changes	
	No of times cluster Head changes	Pause time (sec)	No of times cluster changes	Pause time (sec)
1	15 times	0	40 times	0
2	15 times	20	30 times	20
3	7 times	40	17 times	40
4	5 times	60	16 times	60
5	3 times	80	10times	80
6	0 times	100	0 times	100

3.3. Queuing among clusters

In the proposed MRED scheme, there are several parameters which will affect the performance. The queuing is done in between the gateway nodes of different clusters which will get updated by the cluster head as shown in previous section. In this section, we will try to determine their optimal values. Moreover, our scheme for estimating the average queue size of the neighborhood queue is realized by estimating the channel utilization. Major parameters are TIME INTERVAL and QUEUE SIZE as shown in Figure 5. As the main goal of this scheme is to achieve low average delay and high throughput, in order to which MRED gateways measures s_{ag}, and drops/marks the arriving

Packets with the probability p to notify TCP end of the initial congestion when $s_{ag} > m_{an}$.

We have to calculate the q_{avg} to find out the number of packet (in queue) transferred per unit time.

$$q_{avg}=(1-w)q`_{avg}+w_q$$

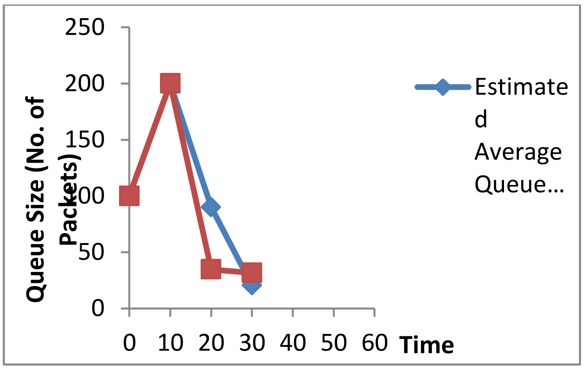

Figure 5. Queue size vs time

Table 3. Queue size Vs Time

Time	0	10	20	30
Estimated Average Queue Size	100	200	90	20
Real Average Queue Size	100	200	35	32

In graph of Figure 4 of data represented in Table 3 increased mobility low size in clusters is seen and node changes accordingly, Queu size decseases as per pause time decrease. Thus, from Fig. 5 it’s clear that initially the mobility is there packet size increase with time passes and increases Queue size decreases drop probability also increases.

4. RESULTS ANDTHROUGHPUT ANALYSIS

After MRED is applied, we observe that the fairness indices under the both scenarios are improved quickly along with the increase of p_{max}. For the hidden terminal scenario, the fairness index is close to 1 (the highest value) after p_{max} is larger than 0.1. For the exposed terminal scenario, fairness index is also above 0.95 when p_{max} is larger than 0.14. The throughput loss comes from two reasons. First, before a packet is dropped by NRED, it may have used the channel. Dropping such packets certainly wastes some bandwidth. Second, the NRED scheme tends to keep the wireless channel slightly underutilized. Thus, a small fraction of bandwidth is also sacrificed. (MRED) and (with NRED) show the dynamics of the two connections by plotting the instantaneous throughput of each flow as it has been shown in [21]. From Figure 6, we observe that when node 5 moves down, the two connections are out of interference with each other.

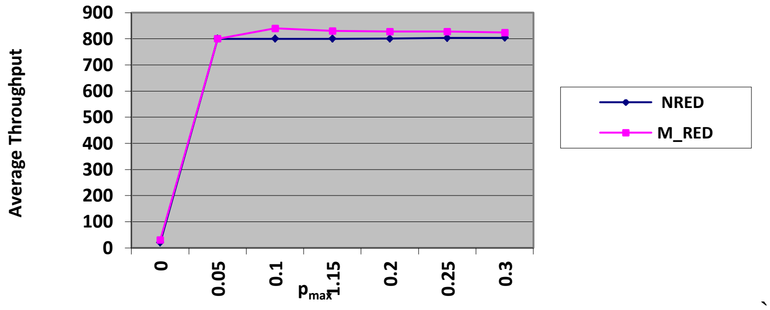

Figure 6. Average throughput vs p_{max}

Table 4. Average Throughput Vs p_{max}

Pmax	0	0.05	0.1	1.15	0.2	0.25	0.3
NRED	20.4	800	800	800	801	803	804
MRED	30.6	800	840	830	828	828	824

The throughput of the proposed MRED is checked in comparision to NRED and it has been found that the performance of the MRED is improved 3%. As in case, of MRED the clustering and queuing make the results so improved. In certain topology several bottleneck neighbourhoods may be present at the same time. The overall throughput of each flow is given in following Figure 7.

5. CONCLUSION

This analysis concludes that the overall results of the average throughput is increased using MRED and the results are compared with the previously evolved NRED. The performance of the network in terms of Queue size decreased as compared to previous results. This shows that the mobility and ad hoc nature helps in strengthening the congestion but, the clustering and queuing when applied simultaneously diminishes the effect of mobility as well as ad hoc nature as shown by the results. etc. Especially, this work may be extended for the clustered environment solution. Furthermore, the effect of multiple Gateways is also need to be considered as an important aspect to be considered. As there can be multiple gateways available with Internet access in a MANET, Handover is necessary and its effect must be considered also. Thus, it may be said that the congestion may be somehow affected or controlled in the proposed approach.

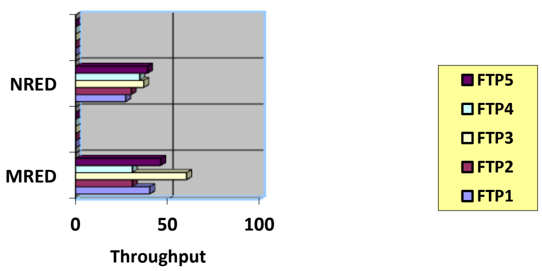

Figure 7. Performance measurement using MRED and NRED

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Appendix

Table 1. Related Literature Review

S. No	Author & Year	Research Topic	Methodology	Limitations
1	Venkata N. Padamanabhan, , Randy H. Katz,1998	TCP Fast Start: A Technique for Speeding Up Web Transfers	TCP fast start	risk of performance degradation
2	S. Floyd and V. Jacobson, 1993	Random Early Detection Gateways for Congestion Avoidance	RED Queuing	No bound of threshold value
3	W. Feng, D. Kandlur, D. Saha, and K. G. Shin, 1999	A self-configuring RED gateway	ARED Queuing	For wired network
4	S. Floyd, R. Gummadi, and S. Schenker, 2001	Adaptive RED: an algorithm for increasing the robustness of RED’s active queue management	Revised ARED using AIMD mechanism	For wired network
5	J. Chen, C. Hu, and Z. Ji, 2010	An improved ARED algorithm for congestion control of network transmission	Improved ARED Queuing	For wired network
6	Liang Guo and Ibrahim Matta, 2001	The War Between Mice and Elephants	Weighted RED Queuing	For wired network
7	Christos Antonopoulo and Stavros Koubias, 2010	Congestion Control Framework for Ad-Hoc Wireless Networks	Cross layer Design approach	Only Static nodes are covered
8	K. Xu, M. Gerla, L. Qi, and Y. Shu, 2003	Enhancing TCP fairness in ad hoc wireless networks using neighborhood RED	NRED Queuing	static nodes
9	Prof. P.K. Suri, Dr. M. K.Soni, and Parul Tomar, 2010	Cluster Based QoS Routing Protocol for MANET	CBQR	QoS is tested