Congestion Control Using a Tri-level Marking Algorithm in Multi-Hop Wireless Environment

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***Abstract*—With the growth of multi-hop wireless network, an excessive demand for the limited network resources results in more congestion. Gateway congestion control under existing standard active queue management (AQM) experiences performance degradations due to multiple packet losses, high queuing delay and low link utilization, in addition to that AQM's require tuning of more parameters. In this paper, a new proactive queue management algorithm is proposed that supports end-to-end transmission control protocol (TCP) congestion control through triple packet marking. From the simulation results we have proved that MLM has zero packet loss due to queue overflow and improves the queuing delay by 0.1% with that of existing standard AQM's such as RED, DT, REM, and BLUE.**

***Keywords*— Drop Tail (DT), Gateway Congestion Marking (GCM), Multi-Level Marking (MLM), Proactive Queue Management (PAQM), Random Early Drop (RED), Random Early Marking (REM).**

I. INTRODUCTION

Today's internet mostly depends on TCP robust congestion avoidance mechanism. In single-hop wireless networks the wireless communication occurs only on the last mile between a base station and the wireless nodes as shown in fig.1. The congestion in these networks will be taken care by the backbone routers which has an efficient inbuilt congestion avoidance mechanism called an Active Queue Management (AQM) algorithm [9].

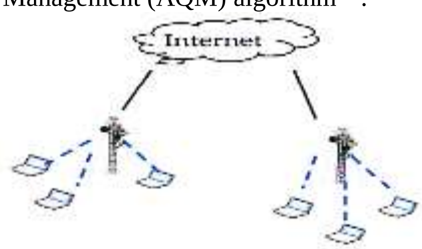

fig.1: Single-Hop Wireless Networks

But multi-hop wireless network requires a gateway congestion avoidance mechanism, because data from the source travels through a sequence of intermediate nodes (gateways) to reach their destination as shown in fig.2.
The congestion occurs when the processing rate at the intermediate nodes is less than the arrival rate of the destination node [1].

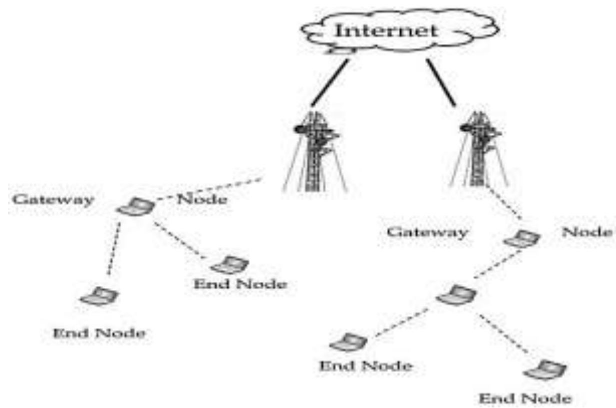

fig.2: Multi-Hop Wireless Networks

Most of the existing intermediate gateways play a passive role in congestion control, and are known as FIFO (First in First Out) gateways. In-order to indicate the congestion at an earlier stage before the buffer overflows, an active queue management algorithm such as RED and its following variants were implemented and analyzed at a mobile gateway in multi-hop environment. The simulation result shows that the traditional RED [1and 9] and its variants such GRED [3], AGRED [3], NL-RED [4], REM [5], RIO [6], etc. has more parameters to be tuned each time for the arrival of the packet. The tuning of more parameters leads to computation load, so it is unsuitable for low memory less devices such as laptops, handset, etc. [2].

To address these problems, it is necessary for an AQM algorithm to have a more efficient congestion indicator and control function. To avoid or control congestion proactively before it becomes a problem, the congestion should indicate the level of congestion to the sender through gateway congestion marking (GCM). This leads us to propose an ultra-light weight proactive queue management algorithm in a multi-hop wireless network.

II. PROACTIVE QUEUE MANAGEMENT

Implementation of existing AQM in mobile gateways has 2 drawbacks as follows,

I. No preference for control packets, which carries vital information [7].
II. The Congestion level indication was not possible [10].

To address the above problem total queue volume was virtually separated into control queue and data queue. It was expressed as

$$Q_T = Q_C + Q_D \quad (1)$$

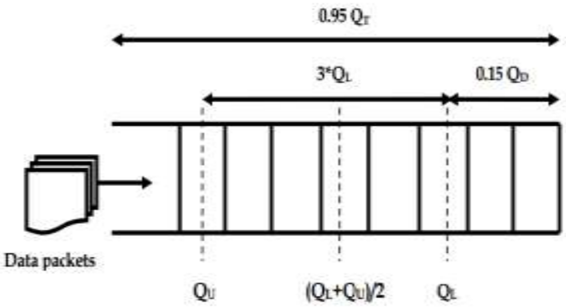

Fig.3: Data Queue model

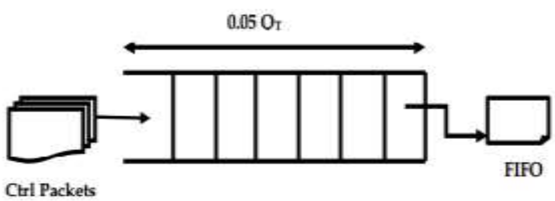

Fig.4: Control Queue model

The size of a single data packet is 512bytes, which is 12times that of a control packet. Hence the 95% of total queue was allocated for data queue and the remaining 5% is for control queue as shown in fig.3and 4.

Initial parameters

Q_T - Total Queue
Q_D - Data Queue
Q_C - Control Queue
pkt_size - Mean Packet Size
Pkts - Packets
Q_{Avg} – Average Queue Length
Q_L – Lower Threshold of Queue
Q_U - Upper Threshold of Queue
GCM – Gateway Congestion Marking

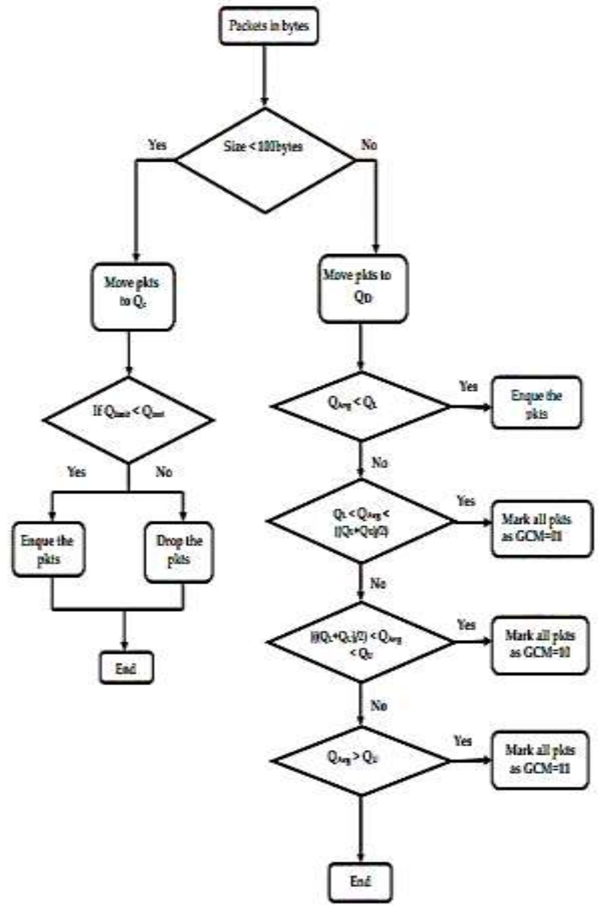

Fig.5: Flow Chart of MLM algorithm

```
If (pkt_size ≤ 120 bytes)
        Move pkts to QC;
Else
        Move pkts to QD;
end
```

Fig.6: Separation of Control and Data Packets

```
If (QLIMIT <QINST)
        Enque the pkts;
Else
        Drop the packet;
end
```

Fig.7: Control Packets Processing Mechanism

The gateway separates the incoming packets as control and data packet based upon their size in bytes as shown in fig.5 and 6. If the size of the packet is less than 120bytes it will be moved to control queue, otherwise to the data queue.

The control packets are processed based on the traditional droptail mechanism as shown in fig.7. Droptail is the current technique for managing gateway queue lengths. It accepts the packets until the maximum length is reached, then drop the subsequent incoming packets until a packet from the queue has been transmitted. Here enough memory is allocated for control queue, so the possibilities for dropping are very minimum. The data packets are processed using the proposed MLM algorithm as shown in fig.8.

The average queue length was calculated as [11],

$$Aql = (1-w_q) * Aql + w_q * q\_instantaneous \qquad (2)$$

W_q – queue weight

When an average queue length is less than minimum threshold, all the incoming packets will be enqueued. If an average queue length is between minimum and middle threshold, all the incoming packets will be marked as GCM=01 or Yellow marking. If an average queue length is between middle and maximum threshold, all the incoming packets will be marked as GCM=10 or Purple marking. If an average queue length is greater than maximum threshold, all the incoming packets will be marked as GCM=11 or Red marking as shown in fig.8.

```
If (aql < QL)
        Enque the pkts;                  //GREEN MRKING
end
else if (QL <aql< (QL +QU )/2)
        Mark the packet as GCM1;         //YELLOW MARKING
end
Else if ((QL +QU)/2 < aql < QU)
        Mark the packet as GCM2;         //PURPLE MARKING
end
Else if (aql > QU)
        Mark the packet as GCM3;         //RED MARKING
end
```

Fig.8: Data Packets Processing Mechanism

III. SIMULATION AND DISCUSSION

In this section the simulation result of proposed MLM algorithm was compared with above mentioned standard queuing mechanisms such as RED, REM, RIO ,BLUE and Drop Tail under multi-hop wireless environment for mobile nodes and their performance were analyzed using the network simulator [12 and 13]. The simulation environment considered being an outdoor with area of 150*150 meter and the TCP used is Newreno with the packet size of 512 bytes. The performance of the standard AQM's was validated against the following metrics such as throughput, delay due to buffer overflow, end-to-end delay and queuing delay for a different traffic and buffer size.

A. Throughput

Average throughput is a measure of receiving data packets per second at the network receiver end. To measure the throughput performance of the network two different sets of experiments were conducted one with a varying queue length of the order 500 , 1000 and 1500 packets with constant 4 flows, another set of experiments are carried out with fixed queue size of 1000 packets by varying the flows from 2 to 10 flows.

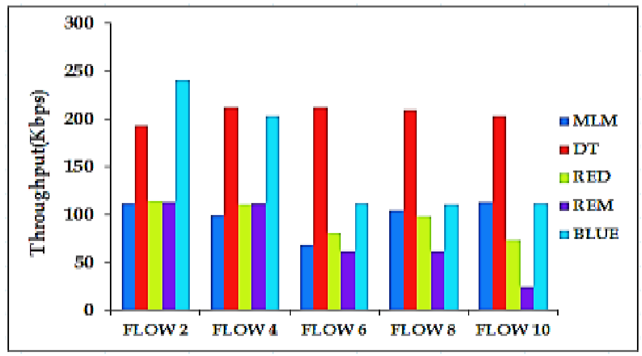

Fig.9. Number of Flow vs. Throughput

From fig.9 BLUE has the maximum throughput than all other standard AQM’s. Fig.10 shows the analysis of throughput with respect to different queue length, from the analysis it is evident that Drop Tail has poor throughput than all other queuing standards because it has no active queue mechanisms to indicate the filling up of buffer. In Drop Tail, each packet has the same priority. MLM provides better throughput than Drop Tail. But it provides only moderate performance than BLUE.

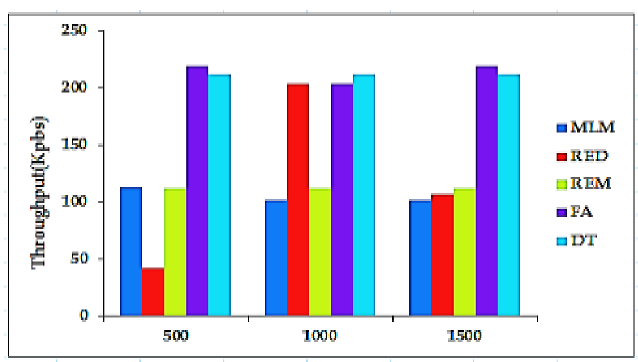

Fig.10. Queue Length vs. Throughput

B. Drop due to buffer over flow

The total number of packets dropped due to buffer overflow during the simulation. The lesser value of the packet lost gives the superior performance. The fig.11 shows that drop is compared between standard AQM's with varying flow. From the fig.11 the proposed MLM has zero packets drops due to queue overflow at the mobile gateway because when the incoming packet crosses the lower threshold Q_l the sender will reduce its sending rate by half in response to the GCM notification. Blue and RED has the maximum packet drop of 1499 and 505 respectively.

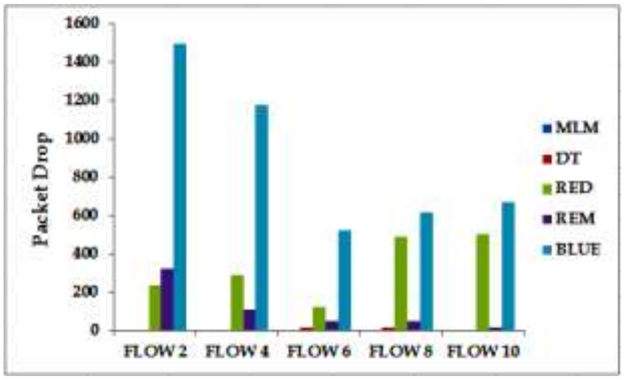

Fig.11. Flow vs. Drop

All standard queues have fewer drops for fewer traffic flows. When the traffic is increased burst of packets will arrive at the gateway which leads to buffer overflow. Then all standard AQM's will drop the packet until the queue transmits some its packets.

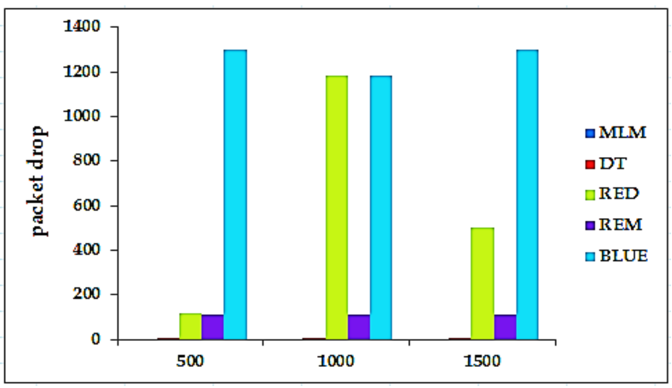

Fig.12. Queue Length vs. Drop

From fig.12 we have analyzed the queue length against the packet drop, if the queue length is minimized the number of packets dropped in the queue is maximum and minimum for larger queue size. The node with small buffer size cannot accommodate burst traffic. The proposed MLM has zero packet drops irrespective of queue size. Here DT has fewer drops than RED, GRED, and BLUE.REM has minimum drops than RED.

C. End To End Delay (ms)

End-to-end delay refers to the total time taken for a data packet to be transmitted across the network from the sender process to the receiving process.

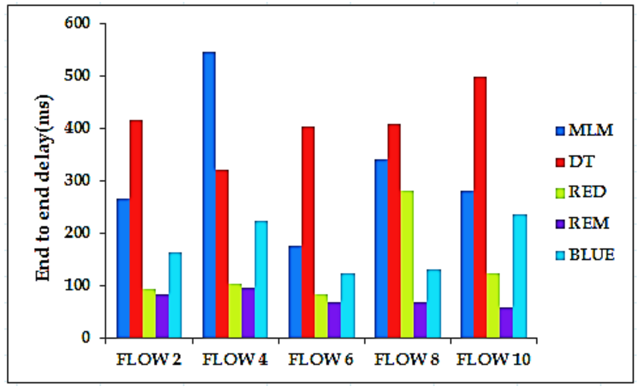

Fig.13. Number of Flow vs. End to End Delay

From the fig. 13 and fig. 14, it is observed that the overall end to end delay increases for higher flow and higher queue length. From fig. 9 it is apparent that the end to end delay is minimum for 2 flows because the resource is shared by a few users, as the flow increases the delay associated with the accessing the resource also increases. We have analyzed that end to end delay is maximum for Drop tail and minimum for REM. The proposed MLM has minimum end to end delay than existing DT, but maximum than other standard AQM's. In Droptail the maximum queue or buffer size was used to avoid packet drop. When the queue size increases the end to end delay also increases.

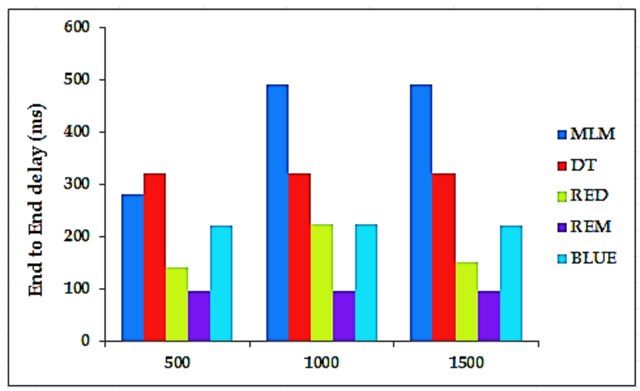

Fig.14. Queue Length vs. End to End Delay

From fig.14 the end to end delay is directly proportional to buffer size. Hence the end to end delay increases with increase in queue size. The end to end delay is small for buffer size 500.end to end delay is maximum for DT and MLM.it is minimum for REM and RED.

D. Queuing Delay

The term queuing delay is most often referred as the occurrence of a delay at the intermediate nodes / gateways. In multi-hop wireless environment the intermediate node encounters queuing delay in two cases, when there is no route to forward and in case if the packets arrive at the node faster than its processing capability, then the gateway puts them in a queue.

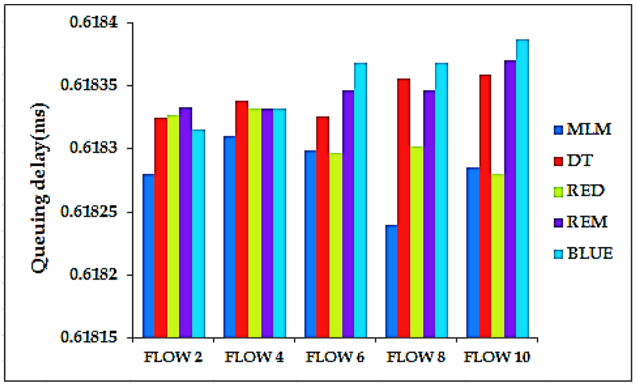

Fig.15. Flow vs. Queuing Delay

From fig.15 it is evident that the queuing delay is least for a single flow and it builds up when the flow is increased. Here the proposed MLM has the minimum queuing delay because the mice traffic enters into the control queue and the elephant traffic enters into the data queue.The minimum queuing delay indicates that the congestion in the network is reduced to an extent.BLUE and REM has the maximum queuing delay.

The next set of experiment is to measure the queuing delay with respect to its length; the fig.16 shows that the drop tail mechanism has the maximum queuing delay because of its larger buffer size. Since the wireless node / gateway has a finite amount of buffer memory, a gateway which receives packets at too high a rate may experience a higher delay. In this case, the gateway has no other option than to simply discard excess packets, MLM has the minimum queuing delay. DT has the maximum queuing delay.

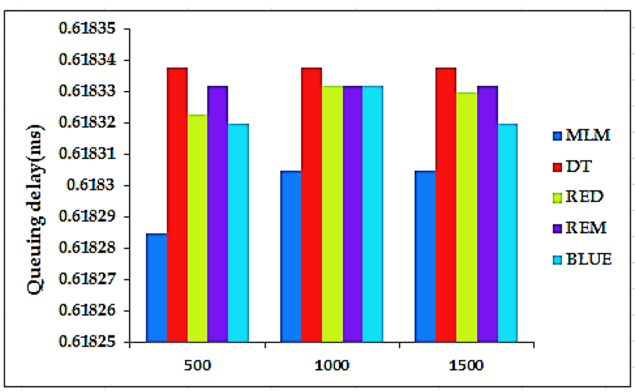

Fig.16. Queue Length vs. Queuing Delay

IV CONCLUSIONS

The graphs clearly indicate that the proposed MLM queuing mechanism in multi-hop wireless network performs well in terms of congestion avoidance at intermediate gateway nodes. The new queue was designed to regulate the packet loss and to give separate treatment for control packet as it carries vital information. In the existing standard AQM's, whether the congestion is experienced or not (CE) is the only information delivered to the sender to reduce the congestion window size. Whereas MLM gives three levels of congestion notification to the sender in order to reduce the network congestion. MLM achieved zero packet drops due to buffer overflow and recorded minimum queuing delay of 0.61828ms. End to end delay is less than the existing DT mechanism of about by 63%. Hence the proposed MLM queuing mechanism plays a vital role in achieving the stability of multi-hop wireless network.

REFERENCES

[1] Sally Floyd and Van Jacobson, "Random Early Detection Gateways for Congestion Avoidance", IEEE/ACM transactions on networking. VOL I. NO. 4, pp.397-413, August 1993.
[2] N. Monisha, M. Joseph Auxilius Jude and G. Murugesan," Micro Level Analysis of AQM's in Multi-Hop Wireless Environment", IEEE International Conference On Electrical, Computer And Communication Technologies,pp.1493-1498,March 2015.
[3] Omid Seifaddini, Azizol Abdullah and Hamid Vosough," RED, GRED, AGRED congestion control algorithms in heterogeneous traffic types", proc. of 4th ICOCI 2013, pp. 123-140, Aug. 2013.
[4] Kaiyu Zhou, L.Kwan Yeung and O.K. Victor Li," Nonlinear RED: A simple yet efficient active queue management scheme", vol. 50, no.18, pp. 3784 – 3794, Dec 2006.
[5] Sanjeewa Athuraliya, Steven H. Low, Victor H. Li and Qinghe Yin," REM: Active Queue Management", IEEE Network, vol. 15, no. 3, pp.48-53, May 2001.
[6] Rodolfo Cartas, Julio Orozco, Jose Incera and David Ros," A Fairness Study of the Adaptive RIO Active Queue Management Algorithm", Proceedings of the Fifth Mexican International Conference in Computer Science, pp.57 - 63, Sept. 2004.
[7] Shreeshankar Bodas, Sanjay Shakkottai, Lei Ying, and R. Srikant, "Scheduling in Multi-Channel Wireless Networks:Rate Function Optimality in the Small-Buffer Regime", IEEE Transactions On Information Theory, vol. 60, no. 2, pp.1101-1125,Feb 2014.
[8] Richelle Adam," Active Queue Management: A Survey", IEEE Communications Surveys & Tutorials, vol.15.no. 3, pp.1425-1476, March 2013.
[9] Braden, et. al. " RFC 2309: Recommendations on Queue Management and Congestion Avoidance in the Internet" April 1998.
[10] Babek Abbasov and Serdar Korukoglu,"Effective RED: An algorithm to improve RED's performance by reducing packet loss rate", Journal of Network and Computer Applications 32 (2009), pp. 703–709.
[11] Kamal Preet Kaur, Navdeep Kaur, Gurjeevan Singh," Assessment of Active Queue Management algorithms by using NS2 simulator", Int. Journal of Engineering Research and Applications .ISSN: 2248-9622, Vol. 4, No. 3(Version 1), pp.798-802, March 2014.
[12] NS-2, the network simulator ns-2, available from: <http: //www.isis.edu/nsnam/ns>.
[13] BonnMotion: A mobility scenario generation and analysis tool available from :< http://sys.cs.uos.de/bonnmotion/>.

