Effect of Load and Threshold Variation on Performance of RED: Random Early Detection

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Abstract: ***To support end to end control mechanisms in Internet Active Queue Management (AQM) is proposed. Random Early Detection (RED) is one such prominent congestion avoidance mechanism in Internet architecture. Since it is proposed in 1993 several modification and enhancements have been made so as to make it more responsive for congestion avoidance. RED parameter setting has a great impact on its performance In this paper we are investigating the effect of varying threshold parameter and additionally updating average queue size value depending on current queue value. We are analyzing the impact of these changes using network simulator ns-2 and got improved results in terms of packet loss, throughput, and better link utilization. Using extensive simulation our strategy evolution demonstrates superiority over original RED.***

Keywords: Active queue Management (AQM), Average queue size, Network Simulator (ns-2, Random Early Detection (RED) and Threshold

1. Introduction

Due to exponential growth of Internet in the past few years at router, congestion avoidance and control has become a hot spot in researching. Internet Engineering Task Force (IETF) [1] recommended RED as AQM scheme to avoid network congestion. In 1993 Flyod [2] introduced Random Early Detection (RED) and more enhancements to it [7]. RED calculates the average queue length by exponential weighted moving average algorithm and uses this average length to adjust packet dropping probability in order to inform the transmitting ends to reduce transmit bit rate at the very beginning of network congestion, finally achieve the goal of congestion avoidance.

In RED in order to anticipate congestion average buffer queue size is calculated given by the following equation

$$avg_{i+1}\ (1 \leftarrow w_q) avg_i + w_q q_i \quad (1)$$

where
avg_{i+1}: average queue size at (i + 1)th time
avg_i: average queue size at ith time
w_q: moving weighted average constant
q_i: current queue size

Here average of current queue size is calculated in order to find actual congestion not transient congestion. Two thresholds TH_{min} Minimum threshold and TH_{max} maximum threshold are used. After calculation of average queue size it is compared with threshold to find drop probability for the packet. Probability is calculated in following way.

$$P_b\ P_{max} \longleftarrow (avg - TH_{min}) / (TH_{max} - TH_{min}) \quad (2)$$

$$P_a\ P_b \longleftarrow / (1 - count \times Pb) \quad (3)$$

Where
TH_{min}: Minimum threshold for queue
TH_{max}: Maximum threshold for queue
P_{max}: Maximum value for P_b
P_a: current packet marking probability
P_b: temporary probability used in calculation
count: packets since last discarded packet

In general the RED algorithm performs the following steps for each packet arrival.

If avg < TH_{min}
queue the packet
else if TH_{min} <= avg <= TH_{max}
calculate the probability Pa
with probability Pa
discard packet
else with probability 1-Pa
queue the packet
else if avg >= TH_{max}
discard the packet.

Figure 1: RED algorithm

Being simple in its approach RED achieves the goal of congestion avoidance and also removes global synchronization, being fair to its sources. There are still some limitations with it as given in [3],[5]. The parameter setting is hard in case of RED, congestion depend on parameters and there is no matching between average queue length and current queue length and also RED is insensitive to input traffic. Although RED can prevent global synchronization, reduce packet loss, and achieve high throughput, its performance of both QoS and security is suspected by many researcher [11–16]. In particular, it is difficult to parameterize RED to achieve good performance in various networks.

This paper has been organized in the following manner section 2 gives the proposed work and explained about approach used, section 3 gives simulation results and section 4 deals with conclusions and final section gives all the references made in completing the present work.

2. Proposed Work

In order to capture the actual congestion not the transient congestion RED average queue size is calculated using EWMA which is a low pass filter. The changes in average queue length are very slow due to low value of EWMA constant w_q. Due to this there is lot of variation between actual queue size and average queue size and also this is the reason for which input changes are not reflected by average queue size and there are many oscillations in queue size.

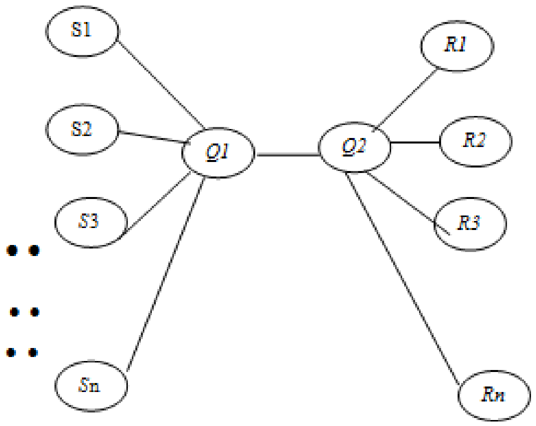
The parameters that RED uses are average queue size avq, upper threshold value TH_{max}, lower threshold value TH_{min}, exponential average constant w_q, The thumb rule [3] to set theshold value are: set TH_{max}, value to half of queue size and TH_{min}, value to one third of TH_{max},value.

Steps

1) Keeping the RED algorithm intact to see the impact of increased input, when the input rate is high which is calculated by comparing current queue value with warn value. Warn value is set 50% of buffer value when the high value of traffic is sensed then average value is increased by 5% of current queue value otherwise normal processing of RED continues. This approach is given the name LRED. This is first approach.
2) In second approach we have done slight modification in threshold parameters. THmax, is set 70% of queue size and THmin, is set 40% of queue size. Along with this, changes in average value by LRED approach is also included in this method which is given name LMRED.

3. Simulation Results

To evaluate the improvements network topology is shown in the figure 2. We implemented the proposed schemes using network simulator ns-2[4].



S1, S2, R1and R2 have bandwidth of 2Mb and delay of 10 ms
S3 to Sn and R3 to Rn have bandwidth of 10Mb
S3 to Sn and R3 to Rn have delay from 14 to 15 ms
Figure 2: Simulation Network Topology

Two FTP sessions randomly start in between 0 to 0.01 seconds and last to end that is 30 seconds. In middle of simulation another m FTP session would randomly start in between 10.0 to 10.1 seconds and last to the end which is to simulate change of network conditions. TCP Reno is used for all networks (RED, LRED and LMRED),

Parameters used for RED and LRED are TH_{max} = 15, TH_{min}, = 5, queue size q=30, Maxp=0.1, w_q= 0.002. In case of LMRED rest parameters are same except TH_{min},=12 and TH_{max} =21.

We have observed results for source varying m from 30 to 60 sources to show the improvement of proposed method. We have drawn different graphs for three approaches used. We have observed performance in case of packet loss, packet arrival ratio, average queue size and current queue size.

The figure 3 shows the graph between number of packets lost as time progresses. Following points can be observed from this

1. Initially when two sources are there number of packets lost is less and increases up to 18 packets only depicted by point A.
2. Up to point B for all the three methods packet losses are same and onwards three curves pertaining to three methods are shown in the graph.
3. The curve which includes the points C and D shows packet losses for RED method
4. The curve which includes the points E and F shows packet losses for LRED method.

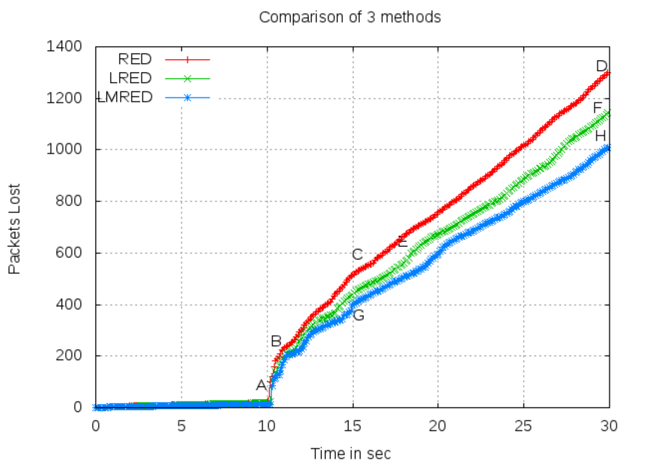


Figure 3: Packets Lost Ratio

5. The curve which includes the points G and H shows packet losses for LMRED method. Looking at graph it is clear that packets losses are maximum in case of RED and lowest in case of LMRED. In case of LRED it is in between the two.

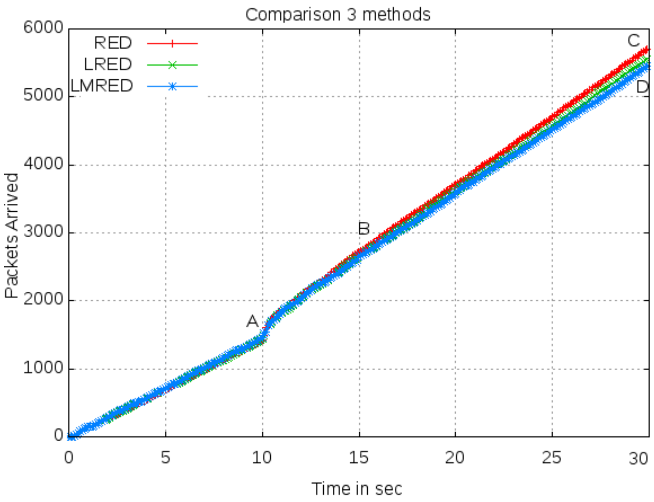


Figure 4: Packets Arrival Ratio

The graph in figure 4 shows number of packets arrived in all he three cases. Following points can be observed from it,

1. From the starting till point A at 10 seconds packets are arrived in a linear way and same in all the three cases.
2. From point A onwards up to point B there is slight difference in all the three cases but in case of RED the number of packets arrived are more compare to LRED and LMRED.
3. From point B onwards there is clear distinction among all the three cases.
4. Points B and C are on the RED method curve which shows the number of packets arrived are more.
5. Point D on the curve of LMRED shows the number of packets for it and curve between RED and LMRED shows the curve for LRED.

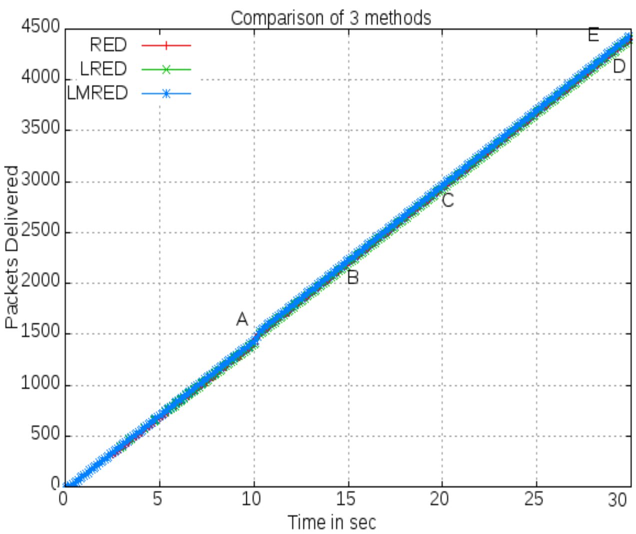


Figure 5: Packets Delivered Ratio

For the graph in figure 5 it shows the graph of Packets delivered per unit of time.

Observations:

1. From the above graph it is clear that up to point A there is linear increment in packets delivered and it is same in all the three cases.
2. From point A onwards graph shows points B, C,E and D which shows that packet delivered in case of LMRED are maximum compare to other two cases and curve for it has covered the curves for RED and LRED.

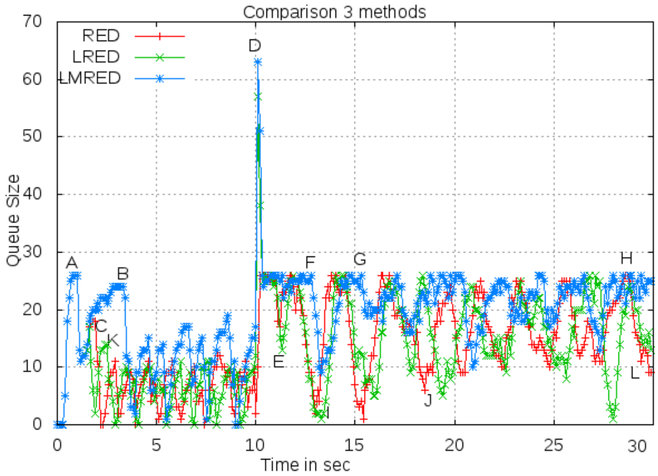


Figure 6: Current Queue Size Variation

The figure 6 graph shows status of current queue size that is buffer for all the three cases. The queue size reflects here value that is current status after deduction of packet drop and packet departure that is current occupied buffer value.

Observation:

1. Initially for all the three methods queue is filled near to its maximum capacity near to value 26 and 27 which becomes reason for packet dropping in all the cases. This is depicted by point A.
2. From point C there is clear separation of curves of all the three cases. Point C is a point on curve of RED.
3. Point K is a point on curve of LRED.
4. Points A and B which are points on LMRED shows higher values of current queue and onwards it fluctuates between 0 to 20 during 0 to 10 seconds period.
5. When simulation reaches at 10 seconds, there is sudden increase in traffic due to which value of queue size jumps to 65 shown by point D in case of LMRED.
6. From this point onward queue varies between 10 to 26 in case of LMRED shown by points F, G and H.
7. In case of LRED after reaching value to high at 10 second it drops down to E and varies between 0 to 26 as shown by points E, I and H.
8. In case of RED, point C is there in region of 0 to 10 seconds and it varies between 0 to 12.
9. At 10 seconds it reaches to high value and drops to 22 above point E curve and it also varies from 0 to 26. Points J and L are points on its curve.

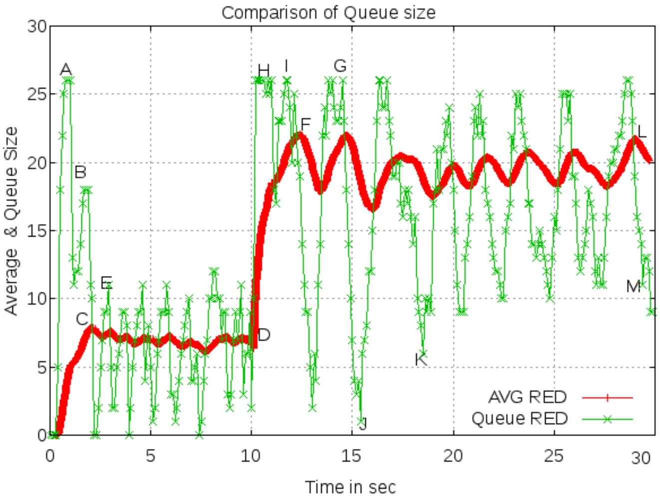


Figure 7: Average Queue size Variation

Figure 7 graph shows comparison of average queue size for all the three cases.

Observations:

1. Up to point A increment in average queue size for all the three cases is same.
2. From point A onwards B and D which shows points on curve of average queue size for LMRED depicts that here average queue size varies from 13 to 15,
3. In case of RED and LRED average queue size varies in between 6 to 7 shown by curve from A to C.
4. At 10 seconds due to increase in traffic of incoming packets in case of LMRED it reaches to 18 and onwards it reaches to 25 and fluctuates between 22 to 26.
5. In case of RED from 10 seconds onwards it fluctuates between 17 to 22 indicated by points I and J.
6. In case of LRED it fluctuates between 16 to 22 indicated by points F and H.

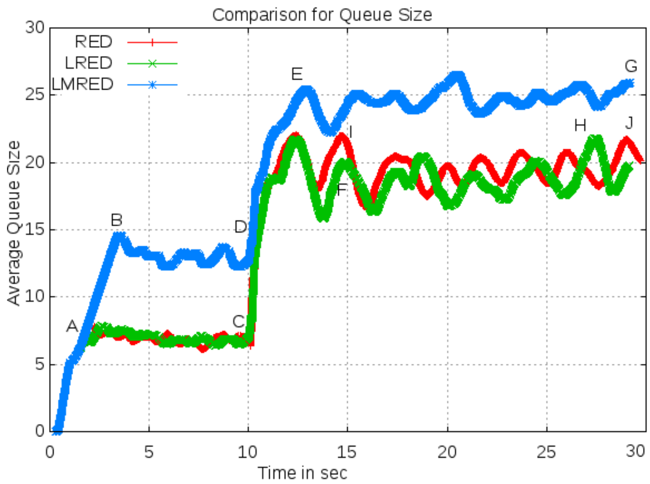


Figure 8: RED Average Size Variation

Figure 8 shows comparison for average queue size and current queue size in case of RED.
Observations:

1. During starting of simulation point A and B shows high value for current queue it grows rapidly and then fluctuates between 0 to 12 in the region 0 to 10 seconds.
2. Here average size also grows up to point C and then nearly becomes constant up to point D in the region 0 to 10 seconds.
3. From 10 seconds onwards when the traffic increases a lot and suddenly the value of current size increases which corresponds to increased traffic reaches to nearly maximum values during this whole period value of current size fluctuates between 0 to 26 points H,I,G,J,K and M shows points at various positions on the curve.
4. In case of average size during the increment of many sources from 10 seconds onwards average size shoots up to 22 and in this region of heavy traffic it varies between 18 to 22 depicted by points F and L.

Figure 9 shows comparison of Average queue size and current queue size in case of LRED.

Observation:

1. Point A shows that current queue reaches near to maximum level at that time average queue size starts rising shown by point J.
2. Point B and C shows that value of current queue size decreases and fluctuates between 0 to 10 during this time average queue size remains nearly constant.
3. Point D shows arrival of lot of packets as number of sources increases at this point and at this point this is also indicated by lot of increment in average size which is shown by point E.

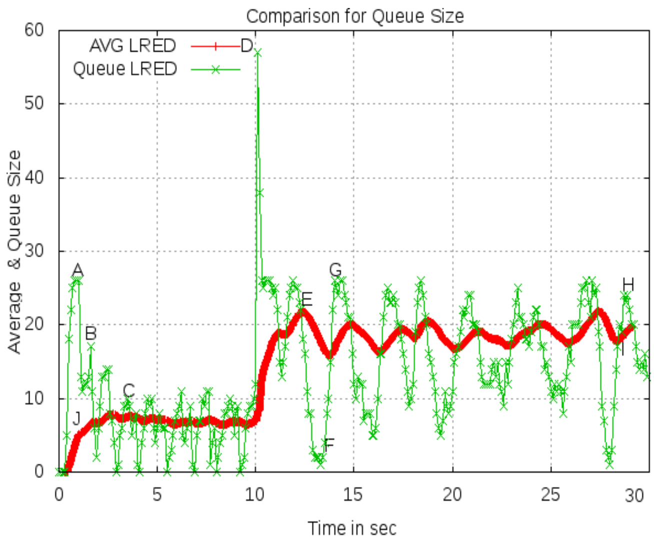


Figure 9: LRED Average Size Variation

4. Variation of current queue size in 10 to 30 seconds area is shown by curve having the points F, G and H.
5. Variation of average queue size in region 10 to 30 seconds is given by curve enclosing points E and I.

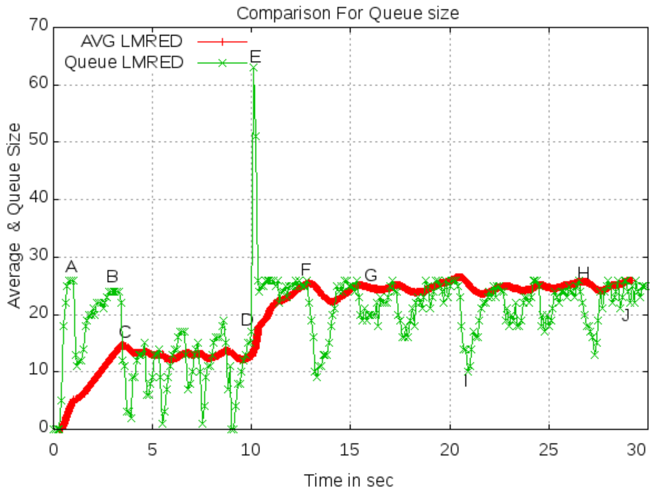


Figure 10: LMRED Average Queue Size Variation

The Figure 10 graph shows comparison of average queue size and current queue size in case of LMRED.

Observation

1. Here in this case point A and B at the starting of simulation shows raise in current queue size which is near to maximum and then drops near to zero and varies between 0 to 20 in value in the region of 0 to 10 second period,
2. Average queue size also increases shown by point C and remains nearly constant.
3. At 10 second when the traffic increases a lot, current size value shoots up to 65 shown by the point E and then drops down near to 26 indicated by point F in region of in the heavy traffic that is during 10 to 30 seconds current queue size varies between 10 to 26.
4. For the average queue size from point C onwards it is nearly constant at the starting phase of increasing traffic it also increases it reaches to 24 and in the region of heavy traffic it varies between 21 to 24 indicated by points F,G and H.

4. Conclusion

Following points can be inferred from the above work.

1. Packet loss ratio is lowest in case of LMRED shown by figure 3.
2. In case of LRED and LMRED sources are informed earlier about impeding congestion due to which packet arrival is low in case of LRED and LMRED shown by figure 4.
3. As the sources increases their sending rate, packet loss indicates to them that congestion is about to occur their transmission rate have to be decreased in order to prevent more packet losses in future time. This is achieved as shown by packet loss ratio and packet arrival graphs.
4. LRED and LMRED are more sensitive toward input load variation as compare to RED.
5. Throughput is calculated in terms of packets delivered which is highest in case of LMRED shown by figure 5.
6. In case of RED during heavy traffic there are many oscillations in current queue size which decreases in case of LRED and found very less in case of LMRED.
7. In case of RED mismatch between average queue size and current queue size is large but it is reduced from LRED to LMRED a lot as shown by the individual graph of each..
8. Congestion indication is done effectively which is indicated by decrease in arrival of packets.
9. Due to increment of threshold value the utilization of buffer size is more in case of LMRED as compared to RED and LRED.
10. In case of heavy traffic when value of current size increases by 50% of buffer value impact of input is also incorporated in average value which improves the performance of RED.
11. In case of LMRED mismatch behavior of current queue and average queue size is reduced a lot.

In the future work, comparison with other well known AQM techniques such as AVQ[9] and REM[10] can be observed.

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