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Priority based Adaptive Random Early Detection Algorithm for Congestion Control in LTE

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Abstract

Long Term Evolution is being widely used now a days for data as well as voice communication. As dependability on communication systems is increasing day by day, Quality of Service is becoming an important factor in any communication technology. There are various issues like congestion, flow control and delay which plays important role in quality of communication. In Long Term Evolution technology there are many techniques available by which congestion can be controlled. Adaptive random early detection is one of them. In this paper an analysis of priority based Adaptive Random Early Detection and Active Queue Management scheme is done for various parameters such as throughput, delay, packet delivery ratio etc. To improve performance of this algorithm a priority based Adaptive random early detection algorithm is proposed which discards packets on the basis of some specific priority when a congestion situation is encountered in the network. It is seen that performance in terms of congestion improves significantly when priority based Adaptive Random Early Detection scheme is used.

Keywords: *LTE; 4G; ARED; Congestion control; Throughput.*

1. Introduction

Wireless network has seen exponential development in past decade and distinctive advances in wireless technology have taken place. Late patterns demonstrate that future system foundations will comprise of heterogeneous wired and wireless networks. In a fourth era (4G) environment, a mobile node is furnished with numerous interfaces and it will have the capacity to handover flawlessly between heterogeneous systems to ensure the congruity of a progressing application session. The 4G network is giving very high transmission rates along with good Quality of Service (QoS) features. The objective of 4G is to supply the whole cellular system which is totally based on IP for video, multimedia services and packet information

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using Voice over IP (VoIP). The newly designed network is providing fast data, voice and video services to the User Equipment based entirely on IP. 4G frameworks will be sent with programming characterized radios, permitting the hardware to be moved up to new conventions and administrations by means of programming updates. It is not a framework composed from scratch neither it provides totally new specialized solutions, rather it is a technology which is based on convergence and integration process. Two main technologies Long Term Evolution and WiMAX have been offering 4G services. Long Term Evolution has gained much better acceptability as it offers better services to the ever demanding user. There are many quality parameters in Long Term Evolution technology which contribute to quality of Service and are becoming an important factor in any communication technology. There are various issues like congestion, flow control and delay which plays important role in quality of communication. In Long Term Evolution technology there are many techniques available by which congestion can be controlled. During congestion performance degrades because of the immersion of system resources. Thus, a system will encounter long delay and resource wastage or network breakdown. Congestion control is process of preventing and recovering from bursty traffic condition. Congestion exists in every type of network even LTE networks are also not an exception. There are two basic ways to deal with congestion, which is avoidance/prevention and detection/recovery. Then again, flow control and other traffic management systems are utilized as a part of congestion framework. Various techniques have been developed over the years to combat congestion in a network out of which some are described in the next section.

2. Literature Review

Many techniques have been proposed in literature for modeling the performance of network. In 1993, Floyd and Jacobson [1] introduced a new congestion control algorithm called Random Early Detection (RED) which avoids congestion and also detects the upcoming congestion by estimating the queue. It inform nodes about congestion either by dropping packets or by changing a specific bit in header of the packet. At the point when queue size surpasses a threshold, the gateways drop or assign a certain probability to each arriving packet. RED gateway keeps the average queue measure low while permitting infrequent blasts of packets in the queue. RED packets are intended to go with a transport level congestion control mechanism. The RED gateway has no inclination against bursty traffic and evades the worldwide synchronization of numerous connections diminishing their window in the meantime. In 2001, Floyd, *et al.* [2] introduced an enhancement of ARED algorithm to increase the robustness of the ARED algorithm. This algorithm works by adjusting the RED parameter and consequently setting the RED parameters, keeps up an predicted queue length and lessens RED's parameter dependability.

In 2003, Ryu, *et al.* [3] presented a paper on advancement in the internet congestion control

techniques by proposing algorithms to battle congestion and enhance execution its variations. The authors examined three issues: parameter setting, traffic load variation, and conduct of queue length progression. In 2005, Byun and Lim [4] proposed a congestion control algorithm for fair sharing of the accessible data transfer capacity. The proposed algorithm removes the network status from progressive binary congestion data.

In 2007, M. Lestas, *et al.* [5] presented a new protocol which implements a controller which uses evaluations of the compelling number of users using the connection along with multi-bit feedback strategy without requiring flow states. Further in 2010 Chaba et al. [6] modeled the performance of MANET when congestion is occurring due to multiple mode Wormhole attacks by disabling the broadcasting mechanism on detection of congestion. In 2012, Youssef Bassil [7] proposed another TCP congestion control plan proper for remote which is fit for recognizing losses. The proposed plan depends on utilizing header to demonstrate whether connection is wired or remote which influences the SNR proportion to distinguish the dependability of the connection and choose whether to decrease packet burst or retransmit a time-out packet. In year 2012, Ahmad, *et al.* [8] proposed a model to take care of the network congestion issue through iterative server. In this model, when a client send a solicitation to server then server will produce an individual iterative server for asking for client. In the wake of finishing the solicitation, the iterative server will be naturally gets destroyed. In 2015 Zaki, *et al.* [9] presented Verus, an adaptive exploration congestion control convention that is custom-made for unpredictable cell networks. Through nonstop exploration utilizing delay estimations and a delay profile, Verus adjusts to both quickly changing cell conditions and to contending traffic. In 2020 Rathee *et al.* [10] proposed a method for allocation of resources in device to device communication when there is a state of congestion.

As the literature review presents various congestion control techniques, research can be done to enhance the performance of the Adaptive Random Early Detection and further work can be done to implement priority based ARED. Further work can be done in this direction to remove other disadvantages of ARED such as throughput sensitivity to the network load.

3. Proposed Technique

Adaptive Random Early Detection (ARED) algorithm based on Active Queue Management scheme is used for congestion control at the router level. There are few limitations of this technique which we have proposed to overcome using a priority based ARED algorithm in which packets are discarded on the basis of specific priority when a congestion situation is encountered in the network. Firstly it tries to avoid

congestion by forecasting a congestion situation before hand and it tries to remove congestion by discarding packets on the basis of priority, once congestion has occurred. The packet drop priority, p is computed by Priority as equal to qsize divided by 25. The algorithm for proposed technique using Priority method is as given:

At every packet arrival:
Priority schedule
averageQueueSize+=qSize;
CheckTimes++;
if (Mi < target)
{
*Mx = 2 * Mi ; else*
Mx = Mx + I;
}
Variables:
Mi = Minimum queue size threshold
P=qsize/25;
Mx = Dynamic queue-->GetSize
$I = (1\text{-}w)^{nk} \times a_0 + (1\text{-}(1\text{-}w)^{nk}) \times q_0$
w = 0.002, n= no. of nodes, k= buffer size
till end of simulation time

Mi indicates Minimum threshold, Mx indicates maximum threshold, I indicates increase value, qsize is size of queue and Priority is P. Above algorithm has been implemented in ns-3 Simulator and performance is evaluated for various parameters such as throughput, delay, received packets and dropped packets etc.

4. Performance Evaluation of Proposed Technique

The performance of Priority based Adaptive Random Early Detection Algorithm is evaluated in this paper. To analyze the algorithm and to evaluate the results, a twenty five node simulation environment is considered in ns-3. The topology of the system consists of 10 to 50 in an area of 450 x 450 mt, one node is the entrance point (Access point) and rest are stationary node. The packet transmission is totally in light of the queue size and required plan. Following is the summary of simulation parameters which are used in this experimental setup :

Simulation Parameters

Parameters	***Values***
No. of nodes	10, 20, 30, 40, 50
Area	450m x450m
Range	70m

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Data Speed	5 mbps, 10 mbps and 20 mbps
TCP window Size	25
Simulation time	10 sec
Transmission rate	100 bits/sec.
Bandwidth	5000 bits/sec.

The priority based ARED algorithm has been analyzed on the bases of utilizing numerous execution parameters as given below:-

- Throughput : It is characterized as the quantity of packets effectively received at the destination in kbps unit.
- Delay : It is time to transmit information starting with one switch or endpoint then onto the next.
- Total Received Packets : This is characterized as the quantity of packets effectively received at the receiver toward the end point.
- Total Transmitted Packets : This parameter demonstrates that what number of packets is sent amongst sender and receiver amid transmission time.
- Ratio of total received packets to total transmitted packets is Packet Delivery Ratio

The simulation results are analyzed on the basis of traffic. Readings are taken for 10, 20, 30, 40 and 50 number of Active nodes and graphs are plotted for each parameter of the priority based ARED algorithm and ARED algorithm such as throughput, delay and PDR. The two algorithms are then compared on the basis of three parameters to show that the priority based ARED algorithm gives better results than the ARED algorithm.

4.1 Throughput

Table 1 and corresponding graph in Figure 1 gives the comparison graph of priority based ARED algorithm and ARED algorithm based on throughput. Comparison graph shows that the throughput of the priority based ARED algorithm is much higher than that of the ARED algorithm. It is further observed that Priority based Algorithm has more impact when traffic is high in terms of Active nodes.

Table 1 Throughput in Priority based ARED Congestion Control Technique

Throughput in kbps

No. of Active Nodes	ARED	**Priority based ARED**
10	980	**1010**
20	1605	**1690**
30	2350	**2632**
40	2900	**3305**
50	3550	**4005**

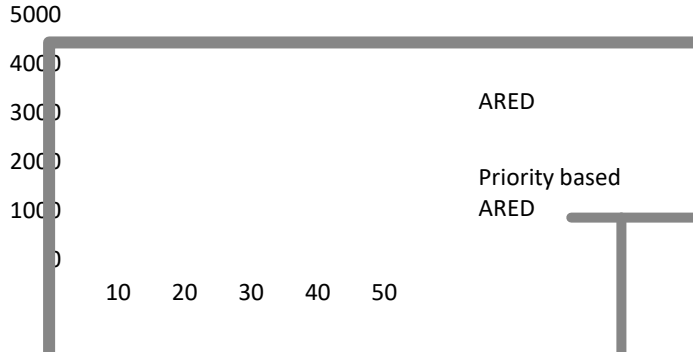

Figure 1 Graph for Throughput in Priority based ARED Congestion Control Technique

4.2 Packet Delivery Ratio :

Table 2 and corresponding graph in Figure 2 gives the comparison graph of priority based ARED algorithm and ARED algorithm based on Packet Delivery Ratio. Comparison graph shows that the PDR of the priority based ARED algorithm is better than that of the ARED algorithm. It is further observed that Priority based Algorithm has more impact when traffic is high in terms of Active nodes.

Table 2 Packet Delivery Ratio in Priority based ARED Congestion Control technique

PDR in %age		
No. of Active Nodes	ARED	**Priority based ARED**
10	0.90	**0.90**
20	0.87	**0.88**
30	0.84	**0.86**
40	0.80	**0.83**
50	0.75	**0.80**

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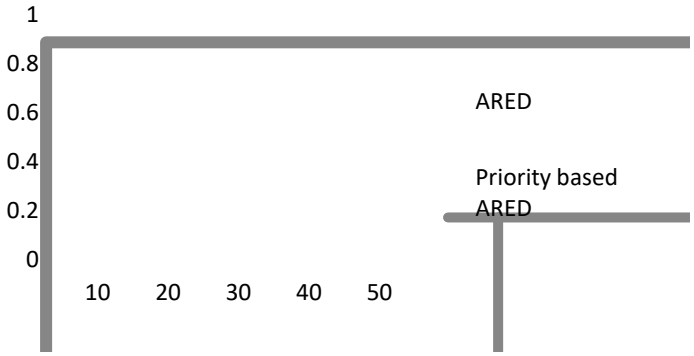

Figure 2 Graph for PDR in Priority based ARED Congestion Control Technique

4.3 Delay :

Table 3 and corresponding graph in Figure 3 gives the comparison graph of priority based ARED algorithm and ARED algorithm based on delay. Comparison graph shows that the delay of the priority based ARED algorithm is lower than that of the ARED algorithm. It is further observed that Priority based Algorithm has more impact when traffic is high in terms of Active nodes.

Table 3 Delay in Priority based ARED Congestion Control technique

Delay in Sec		
No. of Active Nodes	ARED	**Priority based ARED**
10	0.90	**0.85**
20	1.57	**1.50**
30	1.98	**1.75**
40	2.6	**2.40**
50	2.9	**2.55**

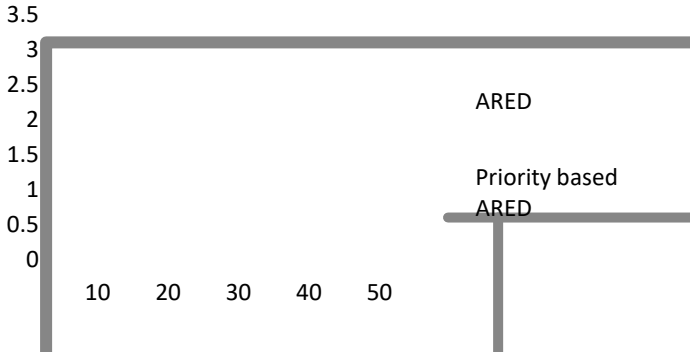

Figure 3 Graph for Delay in Priority based ARED Congestion Control Technique

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In our experiments, performance of ARED algorithm has been compared with proposed priority based ARED in terms of Packet Delivery Ratio, Delay and Throughput. The performance gain (in %) is listed below in the table 4.

Table 4: Performance gain of priority based ARED as compared to ARED.

Performance Parameter	Performance Gain (in %)
Throughput	11.00
PDR	2.9
Delay	10

Taking into account the above parameters we can say that the algorithm priority based ARED performs much better than the ARED algorithm. Performance is more significant in Priority based ARED when traffic is high. The algorithm is connected on a switch and the switch disposes of the packets on the priority basis when a congestion circumstance is experienced. The outcomes demonstrate that the algorithm performs fair in a congested system.

5. Conclusion

In this paper performance of existing Adaptive Random Early Detection (ARED) congestion control algorithm is analyzed and further improved by implementing Priorities factor in it. In proposed technique, packets are discarded on the basis of specific priority when a congestion situation is encountered in the network. Firstly it tries to avoid congestion by forecasting a congestion situation before hand and then it tries to remove congestion by discarding packets on the basis of priority, once congestion has occurred. Network Simulator NS-3 is used to implement the algorithm. Priority based ARED algorithm is analyzed by us in order to control congestion in a network segment. Priority based ARED algorithm is applied on a congested router. The algorithm is evaluated for three performance parameters which are throughput, delay and Packet Delivery Ratio and further compared with normal ARED algorithm without priority. Results show that the algorithm priority based ARED performs quite better in a congested networks node for all the three performance parameters as compared to basic ARED algorithm.

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