Packet-loss Probability versus Queue Nodes Capacities in Dynamic Random Early Drop Algorithm

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Summary
This paper comprises an exploration of the significance of alterations to queue node packet capacity in terms of congestion algorithm functioning. In respect of both the management and forecasting of congestion and the selection of the ideal packet number, the dynamic random early drop (DRED) algorithm plays a critical role. In order to perform an evaluation of the impact of diverse packet capacities, a packet-loss probability ($P_{loss,j}$) performance measurement was conducted. In addition, the tractability and efficacy of different queue node capacities were also investigated. Subsequently, a comparative analysis was made of these diverse capacities in order to appraise performance levels. This analysis revealed that the performance of the third queue node surpassed the second in terms of its effectiveness, whereas the second queue outclassed the first node when an equivalent metric was applied.
Key words:
Packet-loss probability, congestion control, DRED, network management and control, packet capacities, queuing network.

1. Introduction

In contemporary society, the transferal of vast quantities of data via Wi-Fi networks, Bluetooth, and the Internet of Things (IoT) is critical to a plethora of mission systems and commonplace devices. The speed with which data can be transmitted has advanced at an exponential rate, as have developments in the character and content of such networks. These advances are entirely dependent upon technological innovations. However, the increasingly impressive transmission speeds have demonstrated a discernible connection with a widespread decline in performance. This occurrence is known as congestion. To avoid the congestion issue, algorithms can be urbanized, RED [1], dynamic random early drop (DRED) [2], and random exponential marking (REM) [3]. Also an active area of importance among the research community has been to expand and optimize many of the formerly projected algorithms. Such as , urbanized stabilized RED (S-RED) [4], [5] proposed gentle RED (G-RED) and adaptive RED (A-RED), correspondingly[5,6,7,8]. also Ababneh et al.'s [9,10], Ababneh et al.'s [11], 3-DRED and Ababneh et al.'s [12], mQDRED, Al-Bahadili, et al.'s [13,14]. Thus, Moreover, the development of previously proposed algorithms has been the focus of considerable research endeavours. Specifically, studies have stressed the importance of investigating the self-tuning RED algorithm Jamali et al., [15], Bakizi investigated the performance FLRED AND AGRED also the fuzzy logic gentle random early detection algorithm formulated by Baklizi et al. [16,17,18], also abdeljaber, et al. [19] and [20] examined techniques to enhanced active Queue Management and adaptive gentle random early detection method for twice conditions noncongestion and congestion. Hence, Baklizi et al. [21], Briscoe [22], Zhao et al. [23], Patel [24], Patel [25], Abualhaj et al. [26] and Ababneh [27] they have investigated the Markov G-RED, curvy RED, nonlinear RED, adaptive threshold RED, fuzzy logic RED algorithms and buffer size and congestion algorithms respectively.

A review of the literature pertaining to the last few decades reveals a consistent scholarly emphasis on the evaluation of network performance using metrics such as throughput, delay, and packet dropping. However, there is a gap in this literature is respect of the correlation between packet size and performance. Consequently, this paper seeks to gauge the impact of increases in the packet capacities (K) of queue nodes on packet loss (PJ) in the DRED algorithm. To this end, a comparative analysis of three nodes was performed in the paradigm to locate the identity of the queue node related to the most significant augmentation in performance.

The remainder of this paper comprises four principal sections, commencing with a literature review pertaining to all pertinent literature. This is followed by a discussion of the DRED algorithm, after which the research findings are discussed. The paper concludes with recommendations for future research.

2. Literature Review

Amongst the published research into the correlation between varying parameters and performance metrics for DRED in respect of AQM algorithms is the work of Ababneh [27], Abu-Shareha [28] and Sharma et al. [29]. Specifically, Abu-Shareha addressed shortcomings in the original algorithm and the second suggested P-RED though an augmentation of the functioning of the RED algorithm. Hence, this comprised a probabilistic random early detection algorithm for queue management in MANET.

In addition, the FL-RED and AG-RED algorithms, which are associated with queue management, were both evaluated by Baklizi et al. [30] and Baklizi et al. [31]. Research by, while Yu-Hong et al.'s [32] study concerned an augmented version of the RED algorithm and Tsavlidis et al.'s [33] research has offered a new router mechanism for networks with selfish flows. Two years earlier, Baklizi et al. [21] hypothesized that fuzzy logic could be employed to regulate the G-RED algorithm under multiple congestion conditions, which is in accordance with Ababneh et al.'s [9] 3-DRED formulation. Baklizi et al.'s [16] later study offered an effective model for the dynamic G-RED algorithm. Moreover, Baklizi and Ababneh's [17] collaborative study into the enhanced adaptive G-RED algorithm explored performance in a range of congestion contexts, BabekAbbasov and Serdar Korukoğlu,[34] get better algorithm to plummeting packet loss rate, whilst Ahmad Adel, [35] customized delay for router buffer using RED, .Amigó, et al.,[36]. Wide-ranging model for scheming TCP-RED for Internet congestion, but Bohloulzadeh, and Rajaei, [37], Wrote about WSN protocols for managing Congestion.

While this paper has identified related studies between 2001 and 2006, these investigations will not be substantively considered in the current context.

The mechanisms, models, methods, and algorithms which have thus far been developed for use with routers and switches have all made significant contributions to the advancement of the regulation of optimization performance metrics in network service quality.

There have been multiple investigations into areas of performance measurement, such as packet-loss rates, queuing delays, and throughput. However, with the exception of Ababneh's recent study[27], there has been scant research into the implications for performance metrics of the correlation between router size and service quality. Ababneh's research examines variations in the packet capacities of queue nodes to explore performance measurements, with reference to the potential of changing capacities to impact congestion algorithm performance, as manifest in throughput and average queuing delays [27]. The research results revealed that the throughput performance of the first queue node surpassed that of the second node, while the second node outperformed the third node in both categories.

3. DRED Algorithm

The current research examines the impact on packet size in respect of performance where packet loss is on the DRED algorithm, as per Aweya et al.'s proposition that it can be employed to address issues associated with the network congestion algorithm [2]. Eq.(1) Illustrates the capacity of the DRED router buffer (*K*), as follows:

for j = 1, 2, 3 $$H_j = [0.9K/2] \qquad (1)$$

Equation (2) and Eq.(3) both present calculations for packet loss probability (P_{lossj}). This can be regarded as the proportion of all the original packets which were lost to the service at the router buffer.

$$P_{j\,loss} = \sum_{i=th}^{K_j} \Pi_i \qquad (2)$$

Where

$$\Pi_i = \Pi_0 \left[\lambda_j^{\,i} \left(1-\beta_j\right)^{i-1} \Big/ \beta_j^{\,i} \left(1-\lambda_j\right)^{i} \right] \qquad (3)$$

j=1, 2, 3 are queue node 1, queue node 2 and queue node

i=1, 2, 3, 4,…,Hj-1

Π_0 :balance equations of the queue nodes

λj :the packet arrival probabilities for queue node 1, queue node 2 and queue node 3 .

βj : is the probabilities of packet departure in a slot from nodes j, Where parameters are used in the congestion measurement, the DRED algorithm can be expressed in the following way:

Units of time (*t*): The time required to dispatch either ten packets or an appropriated substitute value.

Target level for the queue (Q_{avgt}) = *0.5 k*

Buffer capacity = K

Queue weight (Q_w)= 0.2%

System control (ε) = 0.005%

The identical Bernoulli process is dispersed in a self-regulating manner and can be expressed as a_n {0,1}, n= 1, 2, 3, …. . This is applied in the current study. Moreover, λ_j (j = 1, 2, 3) comprises the probability that a packet will reach the router buffer of the three queue nodes. Hence, $\beta_j$signifies the probability that the packet will depart via a node slot. In addition, there is an underlying presumption of queuing network equilibrium.

4. Results and Discussion

Not only were the range of parameters appropriately applied, but the prioritizing of principles was also suitably considered in light of the first node demonstrating priority over the second, and second having priority over the third. Thus, the third node inevitably had less priority than the first in respect of the serving of packets which were routed externally to the network. By varying the packet capacities (buffer size) of the queue node in respect of a single performance metric, in the shape of packet loss probability, it was possible to identify which correlated with the highest service quality.

Fig. 1 illustrates the consequences of the varying of queue capacities (buffer size) and the performance metric. These findings are also presented in Table 1, Table 2, and

Table 3. The first node's parameters can be represented as r_{01} = 0.50, thereby indicating the likelihood of the external routing of packages. The parameter values can be expressed as λ_1=0.75, β=0.9, and K= [12,20,40,80,160,320,640].

Furthermore, the second node's routing probabilities comprise r_{10}=0.4, r_{11}=0.3, r_{12}=0.2, and r_{13}=0.1, whereas the likelihood of packets being routed externally in respect of the third node can be expressed as r_{03} = 0.50. The remaining parameter values comprise λ_3=0.75, β=0.9, and K= [12, 20, 40, 80, 160, 320, 640], also r_{30}=0.4, r_{31}=0.3, r_{32}=0.2, and r_{33}=0.1.

Table 1: performance measure (Ploss1, K) results of first node with different queue sizes (K)

K	Ploss1
12	8.4276E-02
20	2.4341E-02
40	2.2861E-03
80	2.4525E-05
160	2.8864E-09
320	3.9990E-17

Table 2: Performance measure (Ploss2, K) results of second node with different queue sizes (K)

K	Ploss2
12	5.6377E-04
20	2.2557E-07
40	5.1017E-15
80	2.6097E-30
160	6.8285E-61
320	4.6753E-122

Table 3: Performance measure (P_{loss3}, K) results of third node with different queue sizes (K)

K	P*loss3*
12	9.3019E-06
20	6.3409E-11
40	1.5050E-22
80	8.4790E-46
160	2.6911E-92
320	2.7109E-185

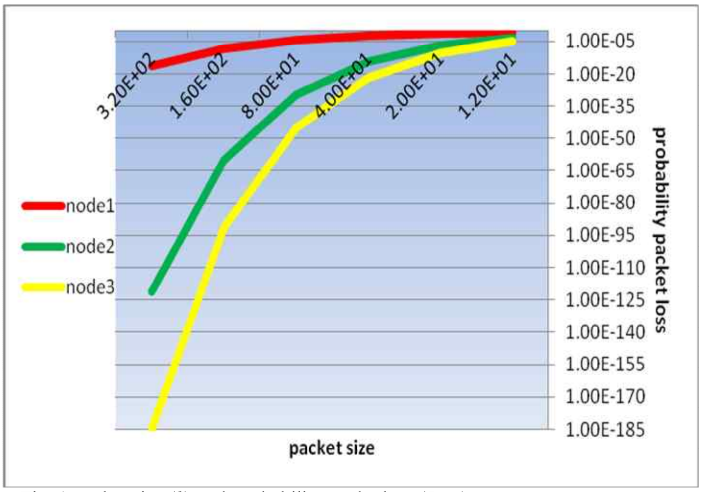

Fig. 1 packet size (k) and paobability paclet loss (P_{lossj})

Fig. 1, 2, and 3 illustrate the results in respect of varying the size of packets. Furthermore, Table 4 and Figure 1 both indicate the correlations between packet size variations and packet loss probability. Hence, it is reasonable to conclude that, in regard to the first node, the decrease in packet loss equated to x 3.5 within the range 8.4276E-02 to 2.4341E-02 when the size of the packet was increased x 1.67 from 12 to 20. However, when the packet size was augmented from 20 to 40, there was a x 10 decrease in the probability of packet loss. By increasing the packet size from 40 to 80, the probability of packet loss was reduced by x 93.22. In addition, when the packet size was modified from 80 to 120, there was a x 8496 decrease in the probability of packet loss. Finally, by increasing the packet size from 160 to 320, the packet loss probability fell by x 721 million.

Fig. 2 and Table 4 both present the findings in respect of the second node, wherein packet loss decreased at a rate of x 2.4993E03 when the packet size was increased from 12 to 20. However, when the packet size was increased from 20 to 40, the probability of loss fell by x 4.4421E07. Increasing the packet size from 40 to 80 served to decrease the loss probability by x 1.9549E15 times, while increasing the size of packets from 80 to 160 led to a x 3.8218E30 reduction in loss probability. Finally, when the packet size was doubled from 160 to 320, the loss probability fell by x 1.4605E61.

The figures pertaining to the third bode are presented in both Fig. 3 and Table 4, such that the packet loss was seen to fall by x 1.4670E05 when the size of the packet was doubled from 12 to 20. The loss probability decreased by x 04.2132E11 when the packet size was increase from 20 to 40, by x 01.7750E23 when is rose from 40 to 80, by 01.7750E23 when it doubled from 80 to 160, and by x 09.9270E92 when packet size was increased in from 160 to 320.

The data contained in Table 4 are also illustrated in Figure 2, wherein the correlation is shown between increased packet size (*k*) and the decreased probability of packet loss (P_{lossj}).

Table 4 comparing decreasing packet size loss probability for nods with themselves (1,2,3) / times

Increasing packet size(k)		**Comparing decreasing packet loss probability for nods with themselves (1,2,3) / times**		
From	**To**	**Node1**	**Node2**	**Node3**
12	12	1	1	1
12	20	1.6700E00	2.4993E03	1.4670E05
20	40	1.0647E01	4.4421E07	4.2132E11
40	80	9.3215E01	1.9549E15	1.7750E23
80	160	8.4967E03	3.8218E30	3.1508E46
160	320	7.2178E08	1.4605E61	9.9270E92

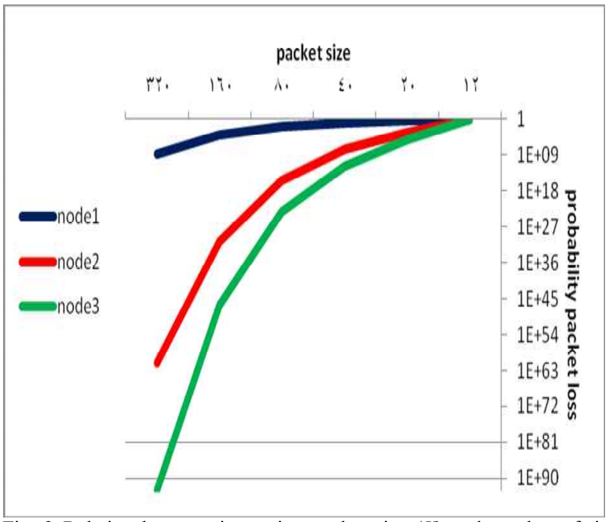

Fig. 2 Relation between increasing packet size (*K*) and number of times decreasing packet loss probability (P_{lossj})

Table 5 and figure 3 illustrate the relation between increasing packet size(*k*) and no. of times decreasing packet loss probability (P_{lossj}) respect to node 1.

It is deemed acceptable to establish a buffer below 20 in light of the combination of performance metrics, fixed packet arrival rates, and routing probability. This threshold fluctuated because of the linear relationship existing between buffer size and threshold, as indicated in Equation 3, which is connected to the moderate probability of packet arrival.

Table 5 Relation between increasing packet size(k) and no. of times decreasing packet loss probability (Plossj) respect to node 1.

Increasing packet size(k)	Comparing decreasing packet loss probability for nods (1,2,3) / times, with respect to node 1		
	Node1	Node2	Node3
12	1	1.4950E2	9.0601E3
20	1	1.0791E5	3.8389E8
40	1	4.4811E11	1.5190E18
80	1	9.3976E24	2.8920E40
160	1	4.2270E51	1.0726E83
320	1	8.5535E104	2.4752E168

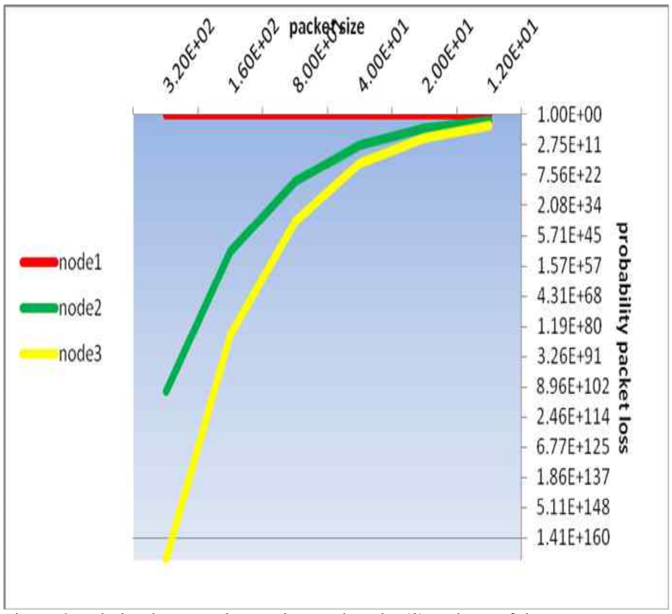

Figure 3 Relation between increasing packet size(*k*) and no. of times decreasing packet loss probability (P_{lossj}) respect to node 1.

5. Conclusion

This paper seeks to explore the implications of varying the packet capacities (buffer size) of queue nodes in respect of the probability of packet loss. The study has been conducted in the context of three nodes, which were compared to ascertain which offered more positive outcomes. Multiple parameters were established to gauge node performance. The correlations between varying packet size and the probability of packet loss have been evaluated, which reveals that the packet loss probability associated with each node significantly diminished, not least for the second and third nodes. The decrease rate for node one was x 2, then x 10, then x 100, and finally x 100,000 for varying packets 12 to 20, 20 to 40, 40 to 80, 80 to 160, and 160 to 320. The node two decrease times were x 2,500, followed by x 44 million, x 1.95E+15, x 3.82E+30, and ultimately x 1.46E+61 in respect of varying packets (12 to 20, 20 to 40, 40 to 80, 80 to 160, 160 to 320). The increases for node three are staggering.

To conclude, this paper recommends that future research focuses on the correlations between packet size variations and the probability of packets arriving at their destinations. In order to achieve this, multiple algorithms should be explored in order to generate a comparative analysis.

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