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Achieving Relative Loss Differentiation using D-VQSDDP with Differential Drop Probability

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차별적인 드랍-확률을 갖는 동적-VQSDDP 를 이용한 상대적 손실차별화의 달성

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Abstract

In order to various service types of real time and non-real time traffic with varying requirements are transmitted over the IEEE 802.16 standard is expected to provide quality of service(QoS) researchers have explored to provide a queue management scheme with differentiated loss guarantees for the future Internet. The sides of a packet drop rate, an each class to differential drop probability on achieving a low delay and high traffic intensity. Improved a queue management scheme to be enhanced to offer a drop probability is desired necessarily. This paper considers multiple random early detection with differential drop probability which is a slightly modified version of the Multiple-RED(Random Early Detection) model, to get the performance of the best suited, we analyzes its main control parameters (max_{th}, min_{th}, max_p) for achieving the proportional loss differentiation (PLD) model, and gives their setting guidance from the analytic approach. we propose Dynamic-multiple queue management scheme based on differential drop probability, called Dynamic-VQSDDP(Variable Queue State Differential Drop Probability)T, is proposed to overcome M-RED's shortcoming as well as supports static max_p parameter setting values for relative and each class proportional loss differentiation. M-RED is static according to the situation of the network traffic, Network environment is very dynamic situation. Therefore max_p parameter values needs to modify too to the constantly and dynamic. The verification of the guidance is shown with figuring out loss probability using a proposed algorithm under dynamic offered load and is also selection problem of optimal values of parameters for high traffic intensity and show that Dynamic-VQSDDP has the better performance in terms of packet drop rate. We also demonstrated using an ns-2 network simulation.

1. Introduction

The goals of differentiated services in IP networks are to manage and provide different types and levels of quality of service (QoS) to satisfy the varying requirements of a diverse set of applications. Many efforts for service differentiation, however, have been relatively limited, because of the additional complexity and the scalability requirements of the continuously growing Internet. As a result, there have been a number of previous works for providing some form of service differentiation. The best known such effort is the proportional differentiated services (PDS) model [3], which attempts to provide a controllable, consistent, and scalable QoS and enables network service providers to have a control knob for the convenient management of services and resources in the next generation network.

In general, the PDS model has two mechanisms: 1) the proportional delay differentiation (PDD) and 2) the proportional loss differentiation (PLD). PDD and PLD can be quantitatively adjusted to be proportional to queuing delay and packet loss in routers, respectively. In this paper, we limit our discussion to PLD for quantifying loss differentiation between different classes of traffic, and forcing the ratios of loss rates of adjacent classes to be proportional. More recently, Even though VQSDDP scheme has several benefits such as low complexities and good functionalities, Koo et al. [7] identify that it has some shortcomings such as low throughput, long queuing delays, and selection problem of optimal values of parameters. In this paper, we consider multiple RED with differential drop probability which is capable of easily tuning the original RED, analyze its main control parameters for achieving the PLD, and give their setting guidance from the analytic approach. The optimal setting of RED parameters for the PLD upon their requests helps increase the goals of differentiated services in IP networks.

The rest of this paper is organized as follows. We analyze D-MRED(Dynamic-Multiple RED) queues by deriving drop probability equations, Adjusting drop probabilities for PLD model in section 2, examine the accuracy of the analytic results obtained so far by comparing them with simulation results in section 3, respectively. Finally the paper concludes in Section 4. Dynamic-VQSDDP with differential drop probability We analyze Dynamic-VQSDDP (Dynamic-Variable Channel Schedule differential Drop Probability) queues by deriving drop probability equations using a queuing model [1]

2 Dynamic-MRED with differential drop probability

We analyze D-MRED(D-Multiple RED) queues by deriving drop probability equations using a queuing model [1].

2.1 Deriving drop probability algorithm and equation

We first derive the drop probability equation from a FIFO tail drop queue, and then we extend it to a single RED queue [2]. Since Dynamic-VQSDDP queues are independent and inherit common properties from a single RED queue, the derived equations of single RED queue are immediately applicable to Dynamic-VQSDDP queues. For a FIFO tail drop queue with a buffer of size K and a system utilization factor of $\rho = \lambda / \mu$, the probability k packets in the system is $\pi(k) = \left((1-\rho)\rho^{k} / \left(1-\rho^{k+1}\right)\right)$. As newly arriving packets will be refused to the system and will depart immediately without service in case when K packets are occupied in the system, so a packet drop probability of $P^{TD} = \pi(K) = \left((1-\rho)\rho^{k} / \left(1-\rho^{k+1}\right)\right)$. With a each class queue *i*'s buffer size of K having TD queue, the steady-state probability of finding k packets in the queue is given by

$$\pi_i(K) = \frac{\prod_{l=0}^{k-1} \rho_i}{\sum_{k=0}^{k} \prod_{l=0}^{k-1} \rho_i} \qquad \textbf{(1)}$$

For a single RED queue, however, incoming packets are dropped with a probability that is an increasing function $d(k)$ of the average queue size k. Dynamic-VQSDDP queue, like the original RED, offers three control parameters: maximum drop probability *max_p*, minimum threshold *min_{th}*, and maximum threshold *max_{th}*. It depends on the averaged queue length k with weighted factor w_q to tune RED's dynamics [9]. The average queue size is estimated using an exponential weighted moving average formula, $k = (1-w_q)\cdot k + w_q \cdot \hat{k}$, algorithm for RED scheme are shown in Table 1.

<Table 1> Average queue size algorithm for RED

Avg$_q$ = (1-Weight Avg$_q$)+ Weight * Current queue size;

$$0 \le w_q \le 1$$

Weight : Weighted parameter of queue, (W$_q$);

Avg$_q$: Averaged of queue length, (k);

Current queue size : each time a packet arrivals,($\hat{k}$);

The dropping function of Class *i*, $d_i(k)$, in Dynamic-VQSDDP is defined using three parameters min_{th}, max_{th} and max_p as follows:

$$d_i(k) = \begin{cases} 0, & k < \min_{th} \\ \dfrac{\max_{p,i}(k-\min_{th})}{\max_{th}-\min_{th}} \equiv \max_{p,i}\cdot f(k), & \\ 1, & k \ge \max_{th} \end{cases} \qquad \textbf{(2)}$$

The dropping algorithm Class *i*, $d_i(k)$, in Dynamic-VQSDDP is shown in Table 2.

<Table 2> The dropping algorithm of Class *i*, in Dynamic-VQSDDP

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Every time t;
if $Avg_q \le \min_{th}$ then
    enqueue the packet $k$
if $\min_{th} < Avg_q \le \max_{th}$ then
    Calculate probability $p^{TD}$;
    Drop arriving packet $k$ with probability $p^{TD}$;
If $\max_{th} \le Avg_q$ then;
    Drop arriving packet $k$;
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where $max_{p,i}$ is maximum drop probability of Class *i*. Therefore, the drop probability of a packet depending on the dropping function related to each state K is defined as follows:

$$\begin{aligned} p_i^{DMR} &= \pi_i^{DMR}(1)d_i(1) + \cdots + \pi_i^{DMR}(k)d_i(K) \\ &= \sum_{k=\min_{th}}^{k} \pi_i^{DMR}(k)\, d_i(k), \ \min_{th} \le k < K \end{aligned} \qquad \textbf{(3)}$$

Let max$_{th}$ = K and $\{\lambda_k = \lambda, \mu_k = \mu, \forall k\}$, then the number of packets in the RED queue is actually a birth-death process with the birth rate in state k equal to $\lambda_i(1-d_i(k))$ and death rate equal to μ_i. For more details, the formulas for π_i can be referenced in [8]. Accordingly, the steady-state probability of finding k packets in the system, $\pi_i^{DMR}(k)$, is derived by modifying Eq.(1) as follows:

$$\pi_i^{DMR}(k) = \frac{\rho_i^k \prod_{l=0}^{k-1} (1-d_i(l))}{\sum_{k=0}^{k} \rho_i^k \prod_{l=0}^{k-1} (1-d_i(l))} \qquad \textbf{(4)}$$

2.2 Adjusting drop probabilities for PLD model

For PLD, δ_L, which is given as network service provider's request, is described as

$$\frac{l_{i+1}}{l_i} \qquad \delta_L, \qquad 1 \le i \le M \qquad (5)$$

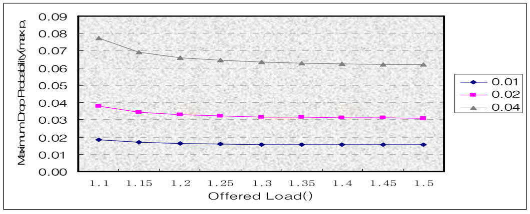
where *M* is service class, l_i is the desired loss probability of class *i*, δ_L is the differentiation factor between adjacent classes, and loss-priorities are decreasing order with class *i*.

Then we want to deduce how to set $max_{p,i}$ for given δ_L. From the estimated packet drop probabilities for class *i*, p_i^{DMR}, in Eq.(3), a suitable $max_{p,i}$ can be retrieved from the following equation by assuming the same ρ_i.

$$\delta_L = \frac{p_{i+1}^{DMR}}{p_i^{DMR}} = \frac{\sum_{k=\min_{th}}^{k} \pi_{i+1}^{DMR}(k)\, d_{i+1}(k)}{\sum_{k=\min_{th}}^{k} \pi_{i}^{DMR}(k)\, d_{i}(k)}$$

$$= \frac{\max_{p,i+1} \cdot \sum_{k=\min_{th}}^{k} f(k) \prod_{l=0}^{k-1} (1 - \max_{p,i+1} f(l))}{\max_{p,i} \cdot \sum_{k=\min_{th}}^{k} f(k) \prod_{l=0}^{k-1} (1 - \max_{p,i} f(l))} \qquad (6)$$

$f(l)$ is an increasing function with queue length l, approaching either one with a heavy queue length (i.e., max_{th}) or a negligible value with a smaller queue length (i.e., min_{th}). Eq. (6) can be approximated by considering only several higher l, terms, as the following:.



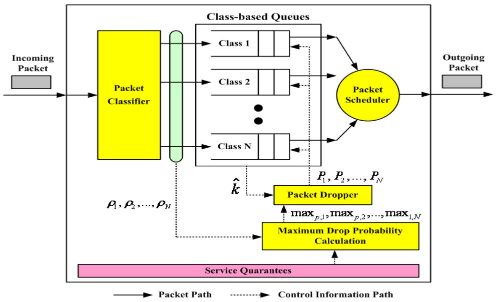
(Figure 1) $max_{p,i}$ versus offered load for loss probability of 0. 01, 0.0 2, 0.04, 0.08, and 0.16.

From Eq.(7), the value of $max_{p,i}$ for a control knob when δ_L is given as a service request, can be determined. Numerical analysis of Eq.(7) can be evaluated by selecting $max_{p,i}$ for PLD across dynamic offered load patterns presented in Fig. 1. First, we calculate the maximum packet drop probabilities for Dynamic-MRED queue *i*, $max_{p,i}$ (t) in Fig. 1, which is used during time interval $[t, t+\Delta\tau]$, from the accurate formulation in Eq.(3) when the drop probability in a service class is provided under the known offered load, ρ_i. Then we can perform initial setting of $max_{p,i}$ for the loss probability of referenced class *i*. Secondly, we determine next value of $max_{p,i+1}$ of adjacent class, i.e. $(i+1)_{th}$ class with given loss differentiation factor δ_L from Eq.(7) for PLD. This process is continued to obtain $max_{p,i+2}$ for next adjacent class and so on.

3 Evaluation

3.1 Evaluation Configuration

Rough guidelines for configuring RED were presented in the original RED paper by Floyd and Jacobson [5].It was suggested that w_q should be set greater than or equal to 0.002 and that max_{th} should be sufficiently large to avoid global synchronization. Also, min_{th} should be set sufficiently large to avoid low utilization of the output link. A more recent set of guidelines is presented in [6] which recommends that max_{th} should be three times min_{th}, max_p should be set to 0.1, and w_q should be set to 0.002. The proposal notes that the optimal setting for min_{th} depends on the tradeoff between low average delay and high link utilization. However, those settings are not considered for the PLD.

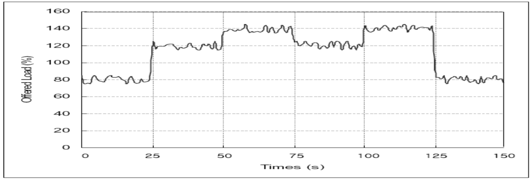


(Figure 2) Dynamic-VQSDDP with differential $max_{p,i}$ according to each class *i*.

Specifically, we limit our analysis to Dynamic-VQSDDP queues with different RED curves for dropping packets belonging to different service classes. Figure 2 depicts one example of three service classes. In this configuration, the parameters of $min_{th,i}$ and $max_{th,i}$ are same in all classes, $max_{th,i}$ has the same value as buffer size *K*, and $w_{q,i}$ is set to 0.002. We mainly focus on how to select the values of $max_{p,1}$, $max_{p,2}$, and $max_{p,3}$ based on the desired loss probability for the PLD.

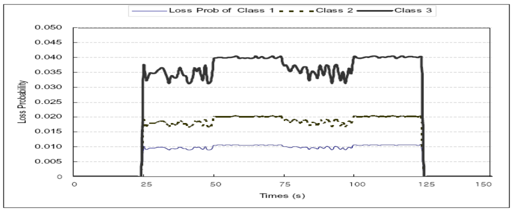
3.2 Numerical Analysis

We examine the accuracy of the analytic results obtained so far by comparing them with simulation results. We first consider the system with $K = 120$, $min_{th} = 40$, and $max_{th} = 120$ across dynamic offered load pattern shown in Fig.3, Using Eq. (3),



(Figure 3) Dynamic offered load

we can calculate the loss probability per service class shown in Fig. 4 and it shows that the desired PLD of $\delta_L = 2$can be achieved by changing $max_{p,i}(t)$ under dynamic offered load.

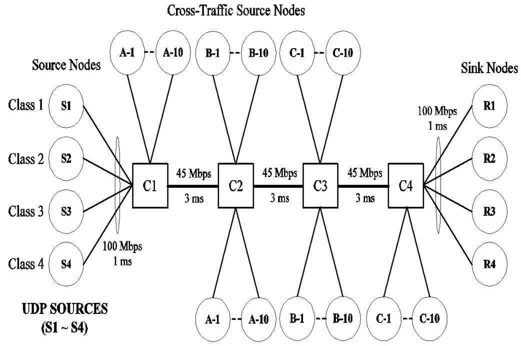


(Figure 4) Numerical result on PLD ($l_1 = 0.01, \delta_L = 2$)

As a practical guide we can realize the PLD model via our proposed setting of the value of $max_{p,i}$ using Eq. (7).

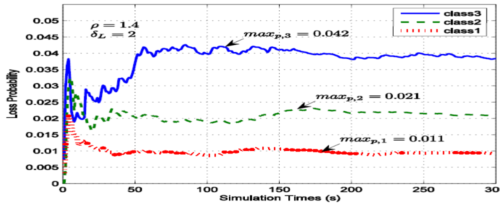
3.3 3.2 Simulation Analysis

We performs network simulation using ns-2 in order to verify the selection method of maxp,i for PLD. The simulation environment consists of a router, Cross Traffic a sink node, and a set of sources node, each sources node which generates packets with a fixed size of 100 bytes and has the same traffic pattern with a constant bit rate exponential distribution. Each source chooses only one class type among three service classes and is connected to the router node with a link, which bandwidth and delay are set to 45 Mbps and 3 ms, respectively.



(Figure 5) Using ns-2 Simulation Environment(Cross Traffic Souece/Sink Nodes module).

We set the router output link with the capacity of 7.15 Mbps resulting in the offered load as the value of 1.4 and the router has three Dynamic-VQSDDP queues in accordance with three classes of traffic, allowing each queue to have a queue length of 120. Following the guidelines of the previous section, Dynamic-VQSDDP parameters were identically set to $min_{th,i}$ = 40, $max_{th,i}$ = 120, and $w_{q,i}$ = 0.002 except for the main control parameter of ($max_{p,1}$, $max_{p,2}$, $max_{p,3}$) = (0.011, 0.021, 0.042) which is guided by Eq. (7) in the case of δ_L = 2 and n = 15. In addition, a weighted fair queue scheduler is used to allocate service rates equally among classes and the experiment lasts for 300 seconds of simulated time. Simulation results in Fig. 6 demonstrate that the proposed approach is desirable, for adjusting the PLD model among different classes after initial transient periods. This is also well-matched with numerical results, which means Dynamic-VQSDDP queue plays a major role for PLD among different classes.



(Figure 6) Simulation result on PLD (l_1:l_2:l_3=1:2:4, n=15)

4 Conclusions

We have performed an analysis of Dynamic-VQSDDP with differential drop probability in order to achieve the PLD model using a queuing model and given some guidance on how to select maximum drop probability in Dynamic-VQSDDP queues. Compared to the analytic results, we have also verified through network simulation that the guidance is suitable for determining an optimum value of the main control parameters. It will be of great assistance in terms of achieving the goals of differentiated services in the future Internet if network service providers are aware exactly of the setting of RED parameters for PLD.

Although conventional protection scheme does provide quick recovery time, it has disadvantage of using up too much bandwidth and lack of ability to find sufficient disjoint paths. This paper proposes a new enhanced path recovery algorithm that overcomes these problems of conventional recovery schemes. The great advantage of the proposed recovery algorithm is that it provides much more recovery path compared to the conventional m:n type recovery method.

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