Service Differentiation based on Packet Size and Flow Length in Best-effort Networks

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***Abstract*— In this paper, we propose flow level service classification according to application's deterministic characteristics in packet size and flow length, and design service differentiation scheme in best-effort networks with Packet size and Flow length based Random Early Detection (PF-RED). In our results, PF-RED can provide service differentiation without sacrificing overall performance.**

I. INTRODUCTION

There are many types of applications in best-effort networks. The Quality of Service (QoS) is very important in some real-time services such as Video on Demand (VoD) and Voice over IP (VoIP) services. In addition, recently there is a demand on QoS guarantee for some game services. To provide guaranteed QoS in packet based best-effort networks, Integrated Services (IntServ) and Differentiated Services (DiffServ) were proposed several years ago. Even though these mechanisms are good solutions, they are not widely deployed in current networks because they have some limitations such as scalability, interoperability, and complexity. Also these schemes require the great changes of the current networks. Thus, recent literature is more and more focused on differentiating the services depending on their characteristics with simple ways. The examples are the packet size and flow length based differentiation methods in [2][3][4][5][6].

Some applications have deterministic characteristics in packet size and flow length. In case of VoIP applications, the packet size and packet per second are determined by the codec type. Also, some VoD services have similar characteristics. In addition, the call session time is 3 minutes in average in Public Switched Telephone Network (PSTN), which is supposed to be similar in VoIP services. Another example is game. In general, the game application's average packet size is quite small and the session time is very long. Deterministic characteristics of game traffic have already been found in [7]. The deterministic characteristics of packet size and flow length can thus be utilized to identify flows of applications with high QoS requirements, such that differentiated processing can be applied to provide better QoS.

In this paper, we study some service differentiation methods in section II and then we show our Packet size and Flow length based Random Early Detection (PF-RED), packet processing method, in section III. At sections IV, we compare Random Early Detection (RED) and PF-RED in throughput and drop probability perspectives. Finally, we conclude our paper in section V.

II. RELATED WORKS

In order to provide differentiated QoS to each application, IntServ and DiffServ were proposed several years ago. IntServ can provide absolute guarantees for end-to-end QoS through explicit reservation of resources. However it causes a scalability issue due to the maintenance of per-flow state information. DiffServ classifies individual packets into aggregate classes. DiffServ can solve scalability problem, but significant network upgrade or equipment replacement is required to deploy DiffServ. Some recent researches proposed differentiation mechanisms in best-effort networks using packet discrimination methods based on QoS requirements. In order to discriminate the packets like DiffServ, some researches [2][3] use variants of RED. The RED's basic principle is that RED maintains a moving average of the queue length to manage congestion. If the moving average is greater than the minimum threshold and less than the maximum threshold, then the packet is either marked or dropped with a probability. If moving average greater than or equal to the maximum threshold, then the packet is dropped. RED based methods can be easily deployed in current networks because of simplicity. S. De Cnodder et al. define 3 classes depending on the packet size: small, medium and large [2]. They use several RED schemes adapting different drop probability and find the suitable method which has strength on fairness without performance degradation. In [3], the authors combine packet classification with RED to provide differentiated performance characteristics for different service classes. Other discrimination methods based on the job size are Shortest Job First (SJF), Shortest Remaining Processing Time First (SRPT), and Least Attained Service (LAS). To implement these optimal polices information such as the remaining processing time of a jot at any time is needed. [4][5][6] propose a differentiated control mechanism over web-based transactions to give preferential service for short web requests. It guarantees the short flow of web service.

These works are just focused on packet size or job size. They did not consider traffic characteristics of services. Thus, we classify some real-time applications which have quite Quality of Service (QoS) sensitive and distinctive characteristics in packet size and flow length. With this, we design service differentiation scheme which can control the service quality in best-effort networks without great changes.

III. Packet Size and Flow Length based Red (PF-RED)

We classify the applications depending on the packet size and flow length. The classes are classified into Small, Medium and Large based on the packet size. Our assumption is that most of VoIP, Game applications use average packet between 50 and 300 bytes. Thus we define theses applications' class as Small. The Medium class is VoD applications whose packet size is bigger than Small class but smaller than Maximum Transfer Unit (MTU) in IP layer. The other class is Large and this class use MTU packet size. This class's application is best-effort. In addition, we define the classes depending on the flow length. Traditionally, the average call session time is 3 minutes in PSTN, thus we assume the VoIP has a similar behaviour in average session time. The game application's session time is very long. According to game ranking reporting site, the popular game's average session time is over 30 minutes in Korea. Also, VoD service has long session time. In case of movie, most of movie time is almost 1 and half hours long. Thus, we define two classes depending on the flow length: Short and Long. We assume that the VoIP, game and VoD applications belong to the Long class and the other applications are the Short class. In this paper, we do not consider best-effort applications which have long session time because these are generally less QoS sensitive. We summarize the traffic classification in table I.

TABLE I
TRAFFIC CLASSIFICATION OF TYPICAL QOS SENSITIVE APPLICATIONS

	Average packet size			Flow Length	
	S	M	L	S	L
VoIP	√				√
VoD		√			√
Game	√				√
Best-effort			√	-	-

In order to differentiate the services, we use RED scheme because existing researches show that RED based solutions can differentiate the services efficiently in best-effort networks. $P_{d(red)}$ is drop probability of RED. According to [1], RED calculates the average queue size (*avg*) and it is compared to two thresholds; minimum and maximum threshold values (min_{th}, max_{th}). When the average queue size is less than the min_{th}, no packets are dropped. When the *avg* is greater than the max_{th}, every arriving packet is dropped. When the *avg* is between the min_{th} and max_{th}, each packet is dropped with probability which is function of average queue size. max_p is an upper bound on the temporarily packet drop probability. These are shown in (1).

$$P_{d(red)} = \begin{cases} 0 & if\ avg < min_{th} \\ 1 & if\ avg > max_{th} \\ \dfrac{avg - min_{th}}{max_{th} - min_{th}} max_p & if\ min_{th} < avg < max_{th} \end{cases} \quad (1)$$

And then, we define weights depending on the average packet size (*PS*) in (2).

$$W = \begin{cases} W_{small} & if\ PS \le PS_{small} \\ W_{medium} & if\ PS_{small} < PS \le PS_{medium} \\ W_{large} & if\ PS > PS_{medium} \end{cases} \quad (2)$$

We can efficiently control drop probability depending on the weights with (3).

$$P_d = \begin{cases} 0 & if\ avg < min_{th} \\ 1 & if\ avg > max_{th} \\ \dfrac{P_{d(red)}}{W^2} & if\ min_{th} < avg < max_{th} \end{cases} \quad (3)$$

As far we define drop probability based on the average packet size. Now we will define flow length based policy. Like [8], PF-RED monitors the connection time for each flow and this connection time will be reset when there is no traffic during specific time. Note that we use connection time and flow length interchangeably. The policy is given in table 2.

TABLE II
FLOW LENGTH BASED DROP POLICY.

- ✧ Small
  - *If* $T_F > T_S$, *decrease* P_d
- ✧ Medium
  - *If* $T_F > T_S$ && $T_F < T_L$, *decrease* P_d
  - *If* $T_F > T_L$, *increase* P_d
- ✧ Large
  - *If* $T_F > T_s$, *increase* P_d

* T_F : Flow duration, T_S : Short duration, T_L : Long duration

* P_d : Drop probability of PF-RED

We adjust PF-RED's drop probability with weight depending on the flow length. We define two threshold values for flow length; T_S and T_L. T_S and T_L are time for adjusting weight. The VoIP, game and VoD services have long connection time. In our policy, these applications' class is defined as Small and Medium. In case of Small and Medium class, if the flow length is greater than T_S, then increase the weight. In addition, if medium's flow length is greater than T_L, then reduce the drop probability according to the flow length characteristics. In case of Large class, if the flow length is greater than T_S, then increases the drop probability.

IV. Simulation Results

We implemented PF-RED using ns-2 and perform simulation with the simple dumbbell topology with 3 different source nodes in order to show differentiation of flows. We define the Short duration as 20 seconds and Long duration as

40 seconds to show performance changes between different classes depending on the flow length. In our simulation, we assign same bandwidth to all classes. The offered load is 1.33, so almost 33% of packets are drop in a bottleneck link. We assigned the biggest weight to the Small class and the smallest weight to the Large class.

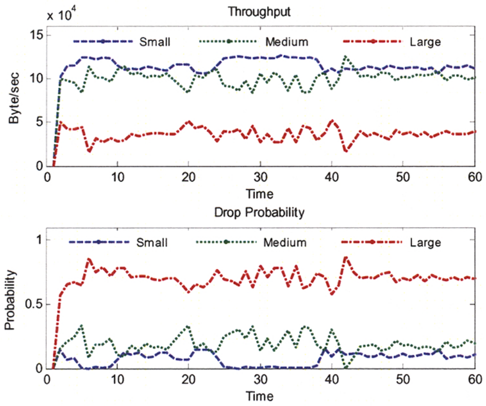

Fig. 1 RED.

Fig. 1 shows the basic RED's throughput and drop probability. One of RED's issues is that the greedy flow uses more resources. In this figure we can see that the Large class's performance is quite low compared to other classes. The main reason is that the assigned bandwidths of all classes are same. Thus, other classes generate more packet that Large class. This is RED's one of limitations.

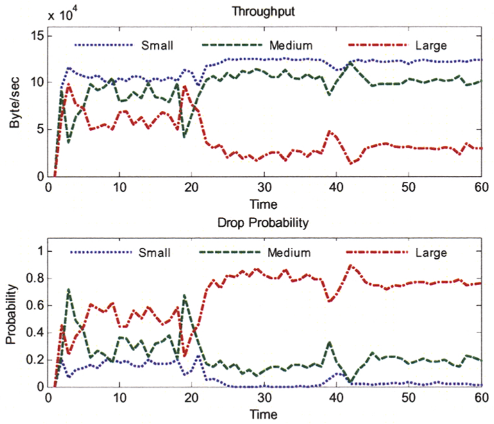

Fig. 2 PF-RED.

Fig. 2 shows the PF-RED's throughput and drop probability. In this figure we can see that the Large class's throughput is higher than that of RED's and the drop probability is decreased. It means that the greedy flow can be control with the PF-RED. Also we can see that there is transition around 20 and 40 second which are the threshold points due to our policy. At 20 second, we change drop probability of the tiny and Large classes. Also we change the drop probability of medium class at 40 second. In figure2, we can also see that our PF-RED can regulate the classes efficiently.

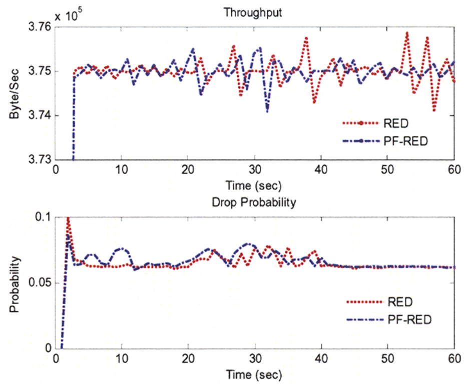

Fig. 3 Overall performance of RED and PF-RED.

Fig. 3 shows the overall throughput and drop probability of RED and PF-RED. In this figure we can see that there is no performance degradation on the throughput and drop probability when we use PF-RED.

V. CONCLUSIONS

With deterministic characteristics of QoS guaranteed services such as VoIP, VoD, and games in packet size and flow length, we proposed to do flow level classification according to packet size and flow length. PF-RED is a lightweight extension of RED. In our PF-RED scheme, the drop probability is varied depending on the packet size and flow length based on the policy. PF-RED has almost same performance with RED in throughput and drop probability without sacrificing overall performance. However, PF-RED can efficiently differentiate services. PF-RED can be applied to networks where applications with deterministic characteristics constitute a considerable portion of overall network bandwidth.

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