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# Evaluation of Video Streaming over DiffServ Domain

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***Abstract***

*With the development of image processing and network technologies, video applications become more and more popular. DiffServ (Differentiated Services) is a suitable architecture to ensure quality of service for simultaneously transmitted video and data streams. In this paper, we evaluate video streaming performance over DiffServ Domain, using myEvalvid extension in ns2. From a comprehensive evaluation, we find that: (1) Employing TSW2CM or other policies with more than one dropping priority is not necessary. (2) Scheduling mode influences the video transmission greatly, especially for parameter weight in WRR or WIRR mode and parameter "maximum consumed bandwidth" in PRI mode. (3) The influence of RED parameters is slight.*

***Keywords:*** *Video streaming; differentiated services; performance evaluation; RED*

## 1. Introduction

With the development of video compression technologies and the increase of network bandwidth, more and more video applications emerged. For example, live video broadcasting, video conference, video on demand (VoD), video surveillance, etc. An important issue of video streaming is how to deal with the coexistence of video streams and traditional data streams. Since video streams always have higher data rates, an appropriate mechanism should be employed to ensure video streaming and data transmission.

***Differentiated services*** (DiffServ) [1-2] is an good architecture to classify and manage network traffic and provide quality of service (QoS) for different kinds of streams. For example, Diffserv can provide low-latency for voice or video streams while providing best-effort service to data streams such as web access or file transfer.

Therefore, DiffServ could guarantee QoS of both video and data streams. Then the next issue is how to deploy it. Several existed studies talked about this issue. Some of them attempted to protect video transmission within DiffServ framework [3-5], some others paid attention to the modification of DiffServ framework to satisfy video streaming [6,7,8], and the others focused on specific aspect such as further differentiation of video applications [9] and fairness scheduling [10]. In this paper, the performance evaluation of video streaming over DiffServ domain is presented and the deployment strategies are discussed.

The rest of the paper is organized as follows. Section 2 gives introduction of simulation environments. Performance evaluation of video streaming over DiffServ domain and corresponding discussion are presented in Section 3. Finally, Section 4 concludes the paper.

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## 2. Simulation Environments

Simulations are based on the integrated platform of ns-2 [11] and Evalvid [12], implemented by C. H. Ke [13].

### 2.1. Evalvid in ns-2

***Evalvid*** is a framework for real or simulated video transmission evaluation. It provides a tool-set which supports video packet encapsulation before transmission, packet receiving recording during transmission and video decoding after transmission. The original metric of video decoded quality is the frame-by-frame PSNR, which can be extended.

To enable the functions of Evalvid in ns-2, C. H. Ke wrote an extended version of Evalvid named ***myEvalvid***. Thus researchers can easily evaluate the novel video codecs or network designs in ns-2 simulator.

### 2.2. DiffServ in ns-2

When employing DiffServ in NS-2, traffic is classified into different categories at first. Secondly, each packet is marked with a corresponding code point to indicate its category. Finally, packet is scheduled accordingly. There are four traffic classes supported in NS-2 DiffServ module (refer to four physical queues), each of which has three dropping precedences (refer to three virtual queues). Consequently, there are twelve treatments of traffic. Each packet is enqueued into a physical RED queue and assigned a dropping precedence.

Each virtual queue is assigned a code point and regarded as a RED queue, which has three parameters: (1) the lower queue length threshold; (2) the higher queue length threshold; (3) the dropping probability. Different priorities could be achieved by setting distinct parameters for different virtual queues. As a result, the packet in the virtual queue with higher priority will receive better treatment when congestion occurs.

There are three major components in NS-2 DiffServ module. The first one is Policy, defining the service level that a traffic class should receive. Several policy models are defined, and each model could be bound with different parameters. The second one is Edge router, answering for code point marking on packets according to the specified policy. The last one is Core router, answering for examining packets' code points and forwarding them according to predefined virtual queue parameters. In addition, there is a PHB table. Both edge router and core router use this table to perform mapping between code points and physical/virtual queues.

There are six policy models defined in NS-2 DiffServ module: (1) Time Sliding Window with 2 Color Marking (TSW2CMPolicer); (2) Time Sliding Window with 3 Color Marking (TSW2CMPolicer); (3) Token Bucket (tokenBucketPolicer); (4) Single Rate Three Color Marker (srTCMPolicer); (5) Two Rate Three Color Marker (trTCMPolicer) and (6) NullPolicer. The numbers of dropping priorities of the six policies are 2, 3, 2, 3, 3 and 1 respectively.

NS-2 DiffServ module provides Round Robin (RR), Weighted Round Robin (WRR), Weighted Interleaved Round Robin (WIRR), and Priority (PRI) as scheduling mode among different physical queues. And RR is the default scheduling mode.

In addition, NS-2 DiffServ module provides four dropping modes: (1) RIO-C (RIO Coupled), the default dropping mode; (2) RIO-D (RIO De-coupled); (3) WRED (Weighted RED); and (4) DROP, similar to the drop tail queue.

### 2.3. Simulation Topology

Figure 1 presents the simulation topology. S1 and S2 generate a video stream and a CBR data stream respectively. *E1*, *E2* and *C* forward packets for the sources. Packet size is 1500 bytes. Bandwidth of each link is set as the figure shows.

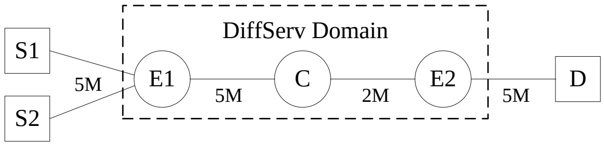



**Figure 1. Simulation Topology**

### 2.4. Video Sequences

In most experiments, sequence ***news*** with CIF resolution is employed. Sequence foreman and akiyo with CIF resolution are also adopted in particular experiment. Table 1 shows data rate at each second of the three sequences.

**Table 1. Data Rate at Each Second of Three Sequences (kbps)**

| Second No. | news | foreman | akiyo |
|---|---|---|---|
| 1 | 1280.94 | 2105.10 | 721.42 |
| 2 | 1086.26 | 1901.77 | 668.98 |
| 3 | 1228.94 | 2002.18 | 700.13 |
| 4 | 1414.52 | 2011.04 | 761.26 |
| 5 | 1205.35 | 2120.10 | 639.94 |
| 6 | 1184.26 | 2172.62 | 624.94 |
| 7 | 1326.05 | 2470.14 | 692.36 |
| 8 | 1171.31 | 2714.23 | 695.72 |
| 9 | 1232.28 | 3153.16 | 663.18 |
| 10 | 1372.17 | 3332.78 | 773.25 |

## 3. Evaluation

According to the type of policy model, experiments are classified into two categories. Some experiments employ NullPolicer, and the other use TSW2CMPolicer.

NullPolicer does not downgrade any packets. We use this policer to evaluate the interaction between video and data streams, and discuss the influences of employing different parameter settings. Since there is no downgrade queue, each physical queue has only one virtual queue.

### 3.1. Interaction between Two Streams

To evaluate the interaction between video and data streams, we adopt the default scheduling mode (RR), the default dropping mode (RIO-C) and the default RED parameters. The lower and the higher queue length thresholds are 5 and 15, and the dropping probability is 0. That is to say, RED mechanism is not active.

In the first experiment, the relationship between video receiving quality and generating rate of data stream ($R_d$) is investigated. Figure 2 presents the results, including the number of received packets (pktNum) and average PSNR (avgPSNR). If the video stream (news) is perfectly received, there must be 1690 packets and the corresponding average PSNR must be 43.987173, as the results when $R_d$ equals to 0.6/0.65/0.7Mbps show. When $R_d$ is increased to 0.75Mbps, packet loss occurs. With the continuous increase of $R_d$, more and more packets are dropped, resulting in low average PSNR. To give explanation of the results, let's recall from figure 1 that the bottleneck bandwidth of the network is 2Mbps, locating in the link from node C to node E2. From table 1 we can find that the data rate of news sequence ($R_v$) varies from 1086.26 to 1414.52 kbps, and at the most of the simulation time, $R_v$ is lower than 1.3Mbps. Even if $R_v$ becomes higher than 1.3Mbps, the queue of video sequence in node C could hold part of the bursting packets. However, the queue becomes full when $R_v$ increases continuously, leading to packet dropping.

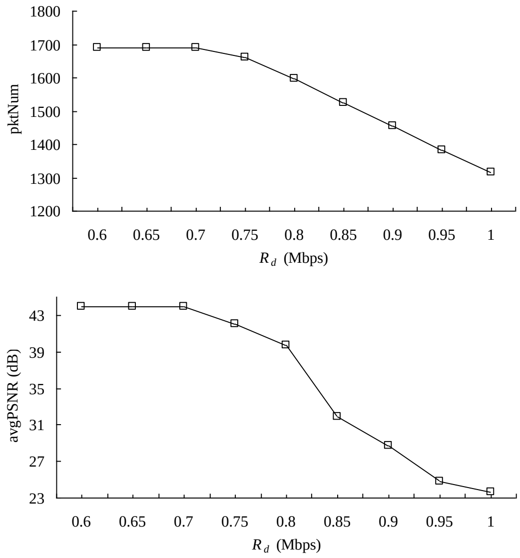



**Figure 2. pktNum and avgPSNR vs. $R_d$**

### 3.2. Influence of Scheduling Mode

Figure 3 to 6 show the results when employing WRR and WIRR scheduling modes. In these two modes, a weight is assigned to each physical queue. In the figures, the x-axis gives two weights of video stream and data stream queues. For example, “2-1” means the weight of video stream queue is 2 and the weight of data stream queue is 1. Since high weight means high scheduling priority, we only employ the weight pairs with higher or equal weight assigned to video stream.

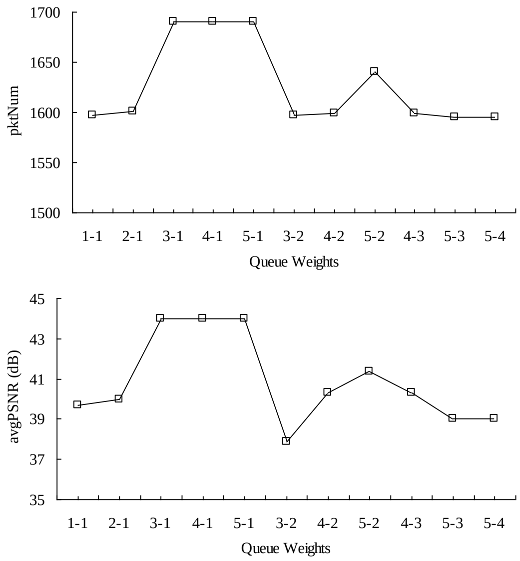



**Figure 3. Results of WRR with $R_d$=0.8Mbps**

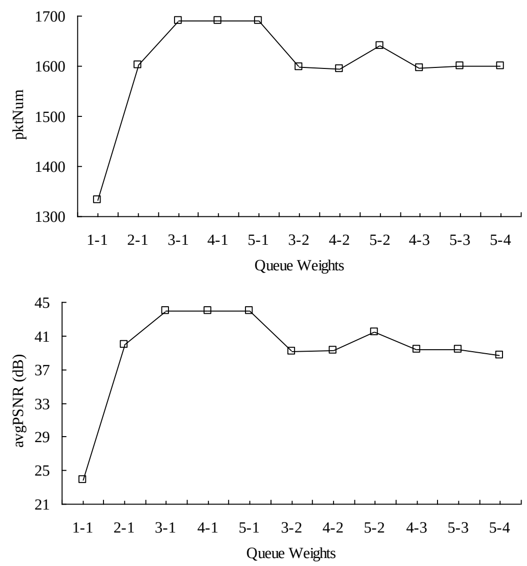



**Figure 4. Results of WIRR with $R_d$=0.8Mbps**

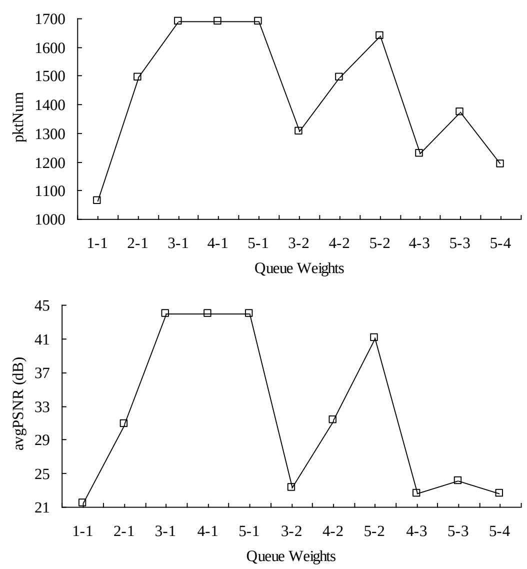
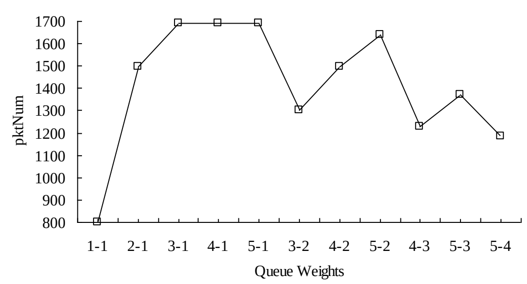



**Figure 5. Results of WRR with $R_d$=1.5Mbps**



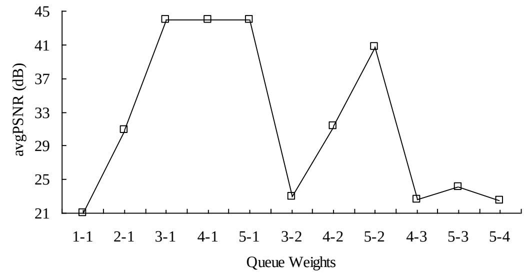



**Figure 6. Results of WIRR with $R_d$=1.5Mbps**

From these figures, we can find that:

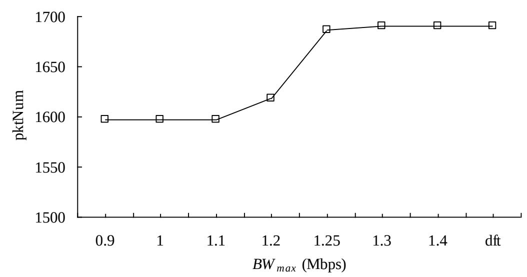
(1) The results of WIRR are similar to WRR;

(2) If the weight of video stream is much higher than that of data stream, the decoded video quality is fairly good (especially for 3-1, 4-1, 5-1 weight pairs). Otherwise, the distortion cannot be ignored.

(3) When using different $R_d$ (0.8Mbps and 1.5Mbps), the difference can be ignored if the weight of video stream is not much higher than that of data stream. Otherwise, the difference is significant.

Figure 7 to 9 show the results when employing PRI scheduling mode. Since the PRI mode has a parameter which specifies the maximum bandwidth ($BW_{max}$) that a queue can consume, we employ different video sequences to investigate this mode in details. In this experiment, we use three video sequences, *i.e.* news, akiyo and foreman. To answer for the variation of data rates of different sequences, the bandwidth of the link from node C to node E2 ($BW_{C,E2}$) also changes . In this experiment, only $BW_{max}$ of video stream is set and Rd always equals to 0.8Mbps. In the x-axis, dft means $BW_{max}$ is not set, using the default value.

Since the priority of video stream is higher than that of data stream and PRI scheduling mode is used, each video is perfectly received when $BW_{max}$ is not limited. From table 1 we know that the average data rates of news and akiyo sequences are 1250.21 and 694.12 kbps. Thus we find that when $BW_{max}$ is higher than 1.25 and 0.7 Mbps, both videos are perfectly received too. As for foreman sequence, although its average data rate is only 2398.31, its maximum bursting data rate reaches 3332.78 kbps. Therefore, even if $BW_{max}$ is higher than the average data rate, distortion still exists.



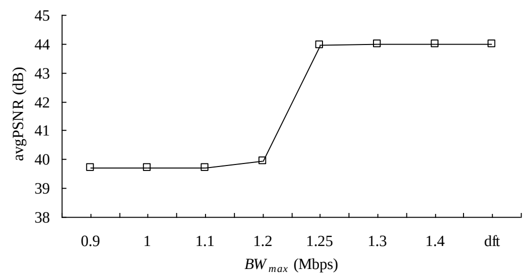




**Figure 7. Results of PRI with $BW_{C,E2}$=2Mbps, News**

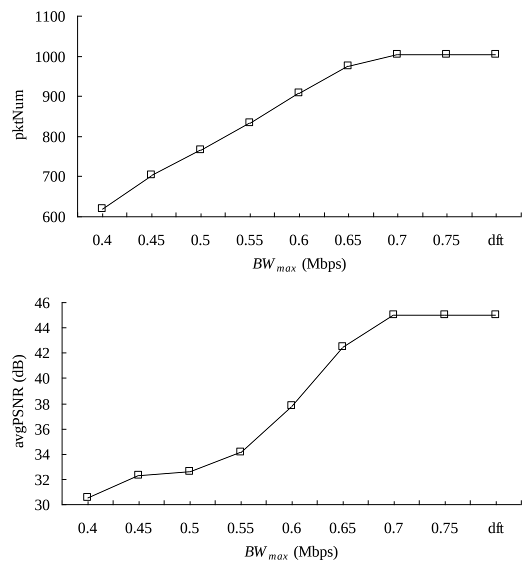



**Figure 8. Results of PRI with $BW_{C,E2}$=1.2Mbps, Akiyo**

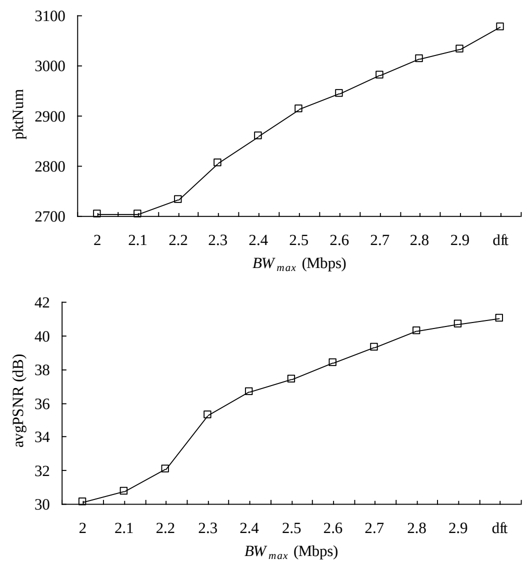



**Figure 9. Results of PRI with BWC,E2=3Mbps, Foreman**

### 3.3. Influence of RED Parameters

Figure 10 to 13 show the results when employing different RED parameters settings. Figure 10 to 11 present the experiment results when $R_d$ =1.2Mbps, and figure 12 to 13 show the experiment results when $R_d$ =1.5Mbps. In the experiment of figure 10, RED parameters of data stream queue are set as default values. For "20-40-0.1" in the x-axis, "20" and "40" mean the lower and the higher queue length threshold values respectively, and "0.1" means the dropping probability value. And "dft" means all the parameters adopt default values. Since RIO-C dropping mode is employed, the default setting of RED parameters is 5-15-0.0.

From figure 10 we can find that only when the lower and the higher queue length thresholds are set to 1 and 5, the received video quality will degrade significantly. Such a thresholds setting means, the capacity of video stream queue is too small to hold bursting video packets. Thus many bursting packets are dropped. From figure 11 we find that it is useless to change RED parameters setting of data stream queue when $R_d$ =1.2Mbps.

The results of figure 12 are similar to those of figure 10. However, the results of figure 13 show that the influence of RED parameters settings of data stream queue is related to $R_d$.

From the values in y-axis of all the figures, we can draw the conclusion that the influence of RED parameters setting is small.

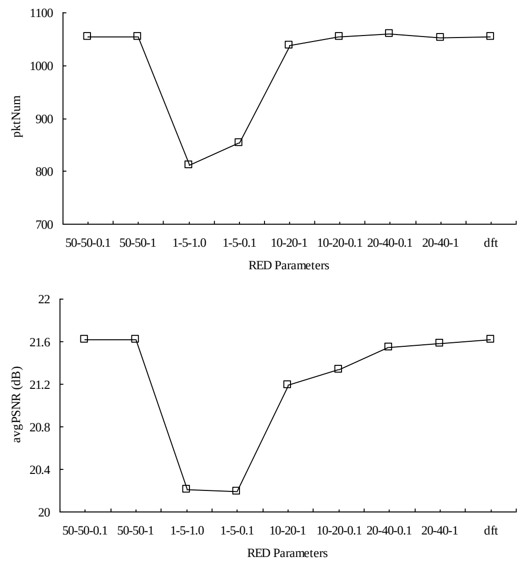



**Figure 10. Results of Various RED Parameters Settings of Video Stream Queue, $R_d$=1.2Mbps**

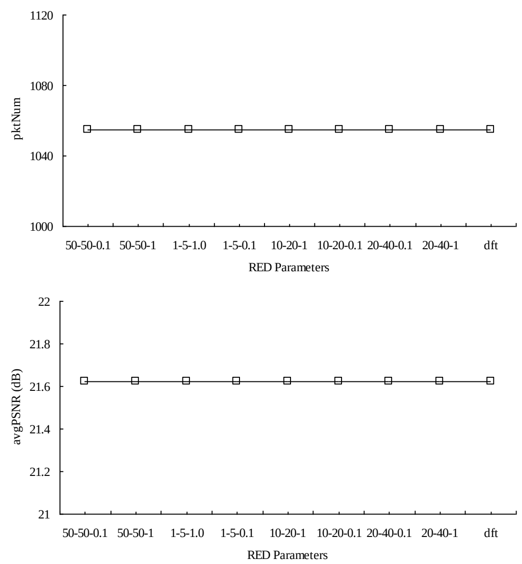



**Figure 11. Results of Various RED Parameters Settings of Data Stream Queue, $R_d$=1.2Mbps**

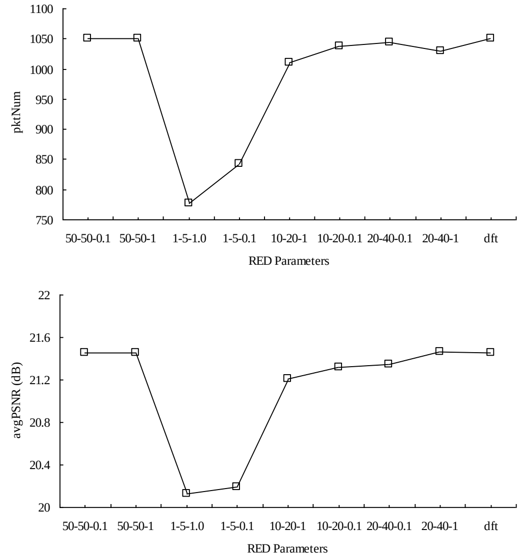



**Figure 12. Results of Various RED Parameters Settings of Video Stream Queue, $R_d$=1.5Mbps**

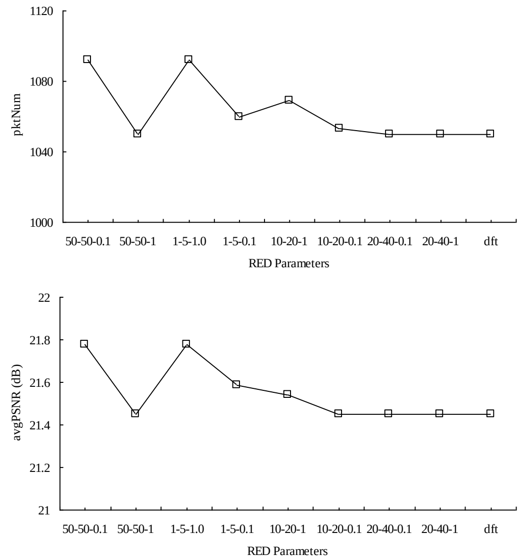



**Figure 13. Results of Various RED Parameters Settings of Data Stream Queue, $R_d$=1.5Mbps**

### 3.4. Experiments under TSW2CMPolicer

Using TSW2CM policy, each physical queue has two virtual queues and a parameter CIR. If CIR is not exceeded, virtual queue 0 is use. Otherwise, virtual queue 1 will be adopted.

In the experiment of figure 14, CIR of video stream (CIR0) equals to 1Mbps and Rd equals to 1.2Mbps. RED parameters of two virtual queues of the video stream are set as default values. RED parameters of two virtual queues of the data stream are set as 20-40-0.1 and 0-0-1.0 respectively. “0-0-1.0” means if CIR of data stream (CIR1) is exceed, the packet will be dropped definitely. From the figure we can find that, with the increase of CIR1, the received video quality degrades continuously. This is because that a higher CIR1 means more data packets could be transmitted, leading to more video packets dropped.

In the experiment of figure 15, CIR1 equals to 1.2Mbps which is just like Rd. RED parameters of two virtual queues of the data stream are set as default values. RED parameters of two virtual queues of the video stream are set as 20-40-0.1 and 0-0-1.0 respectively. The figure shows that with the increase of CIR0, the received video quality upgrades continuously.

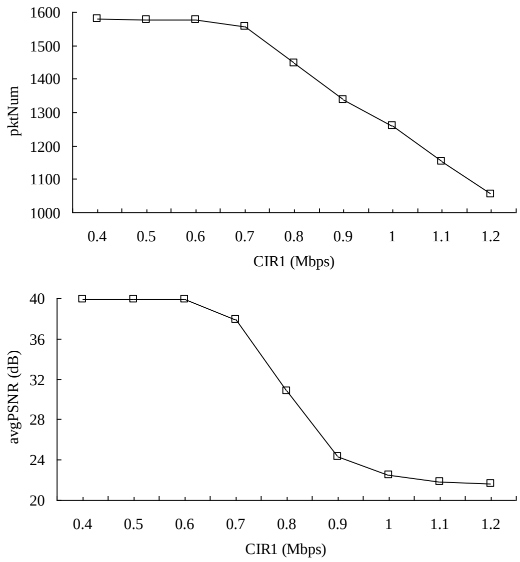



**Figure 14. Results of TSW2CMPolicer, CIR0=1Mbps, $R_d$=1.2Mbps**

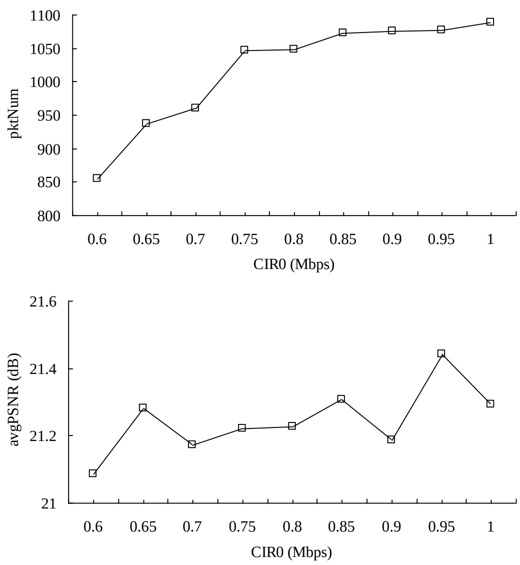



**Figure 15. Results of TSW2CMPolicer, CIR1=1.2Mbps, $R_d$=1.2Mbps**

From these two experiments we can find that only particular RED parameters setting (for example 0-0-0.1 for the second virtual queue) could help CIR bring impact on the received video quality. Therefore, employing TSW2CM or other policies with more than one dropping priority is not necessary.

Furthermore, we also investigate the influence of dropping mode under TSW2CMPolicer (all virtual queues use the default RED parameters setting). However, we find that RIO-C, RIO-D and WRED have the same results. And when DROP is employed, all the packets including video and data packets are dropped. This is because the default lower and higher queue length thresholds are both 0 and DROP has a 100% dropping probability.

## 4. Conclusions

In this paper, we investigate the performance of video streaming over DiffServ Domain. Null and TSW2CMP policers are evaluated, and most experiments are performed under NullPolicer.

(1) Firstly, when transmitting video and data streams simultaneously, the two streams will compete for the bandwidth. Thus the received number of video packets and average PSNR are both decreased with continuous increase of the data rate of data stream.

(2) Secondly, scheduling mode influences the video transmission greatly. If WRR or WIRR scheduling mode is employed, the decoded video quality is fairly good when the weight of video stream is much higher than that of data stream. Otherwise, the distortion can not be ignored. If PRI scheduling mode is employed, the video quality depends on the value of parameter $BW_{max}$ of video stream, which specifies the maximum bandwidth that a stream queue can consume.

(3) Thirdly, the influence of RED parameters is slight.

Under TSW2CMPPolicer, we find that the received video quality mainly depends on the CIR of video stream. And only particular RED parameters setting could help CIR bring impact on the received video quality. Thus, employing TSW2CM or other policies with more than one dropping priority is not necessary.

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