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Inner-Priority based Video Streaming in DiffServ Domain

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Abstract

Although standard DiffServ (Differentiated services) framework allows simultaneous transmission of video and data streams, it can not distinguish the importance of different video frames. Consequently, more received video packets may not lead to better decoded video quality. In this paper a novel inner-priority based video streaming scheme and its corresponding IP policy are proposed. Using IP policy, the importance of video packet could be recognized and corresponding RED queue will be assigned. Comprehensive evaluation results show that the average PSNR of IP policy is much higher than that of traditional policy in most cases and RED parameters settings influence the performance of IP policy. The best choice of RED parameters settings depends on many factors, including available bandwidth of the video stream, coding structure of video sequence, and the employed scheduling mode and dropping mode.

Keywords: *Video streaming; inner-priority; DiffServ; RED*

1. Introduction

More and more video applications (such as live video broadcasting, video conference, video on demand (VoD), video surveillance, etc) emerged in recent years for technique advancement in the areas of image processing and networking. Then how to deal with the coexistence of video streams and traditional data streams becomes a critical issue.

Although ***DiffServ*** (Differentiated services) [1-2] could ensure QoS of both video and data streams, how to deploy it becomes a new issue. There are several existed studies about this issue. Some studies tried to ensure video streaming within DiffServ framework [3-5], some others focused on improvement of DiffServ framework for video streaming [6-8], and the others paid attention to specific aspect such as fairness scheduling [9] and further differentiation of video applications [10]. In this paper, the performance evaluation of video streaming over DiffServ domain is presented and the deployment strategies are discussed. In our previous work, we performed comprehensive evaluation of video streaming over DiffServ Domain and find: (1) the influence of RED parameters is slight; (2) employing those policies with more than one dropping priority is not necessary; (3) scheduling mode influences the video transmission greatly.

Although the previous work achieved some valuable results, it did not consider the characteristics of video streams. A key characteristic of video streams is that the importance of various video frames is different. For example, there are three frame types in MPEG-4 codec: I, P and B. I frames are called “key frame”, and P frames are the supplement of I frames. And B frames are the supplement of P frames. Therefore, I frame is the most important and should be assigned a high transmission priority. To improve the decoded video quality, video frame/packet priority must be considered in video streaming procedures. In this paper, we propose a new policy named “inner-priority” (abbreviated as “IP”) policy for video streaming. There are three dropping priorities in IP policy, each for

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a video frame type. I frames have the lowest drop probability. Simulation results show that the IP policy outperforms the traditional policies.

The rest of the paper is organized as follows. Section 2 explains the IP policy in details. Section 3 gives introduction of simulation environments. Evaluation results of IP policy and comparative policies and corresponding discussion are presented in Section 4. Finally, Section 5 concludes the paper and points out the future work.

2. Inner-Priority Policy for Video Streaming

In DiffServ domain, a flow is marked by the source-destination node pair. Several flows could be aggregated and be assigned a policy. Investigating the current DiffServ standard, a policy may include one, two or three code points. A PHB, which indicates the forwarding behavior in core routers of DiffServ domain, is assigned to each code point. Conforming to the DiffServ architecture, a video stream could belong to only one aggregated flow. To forward MPEG-4 videos, IP policy must have three code points. Each code point indicates a dropping priority. The function to achieve dropping priority for a video packet is as follows:

```
enum frameType {I_Frame, P_Frame, B_Frame};
enum dropPriority {initialPri, downPri1, downPri2};
int getDropPriority(Packet *pkt) {
  hdr = pkt->hdr;
  if(hdr->frametype_ == I_ Frame)
    return initialPri;
  else if (hdr->frametype_ == P_Frame)
    return downPri1;
  else
    return downPri2;
}
```

3. Simulation Environments

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

3.1. 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 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.

As for scheduling mode among different physical queues, NS-2 DiffServ module supports Round Robin (RR, the default one), Weighted Round Robin (WRR), Weighted Interleaved Round Robin (WIRR), and Priority (PRI). Furthermore, NS-2 DiffServ module supports four dropping modes: (1) RIO-C (RIO Coupled); (2) RIO-D (RIO De-coupled); (3) WRED (Weighted RED) and (4) DROP. Please refer to the ns-2 document for more details of scheduling and dropping modes.

3.2. Implementation of IP Policy

In section II, the function of achieving dropping priority for a video packet is presented. As section III.C describes, DiffServ in ns-2 assign a virtual RED queue to each dropping priority and all these virtual queues constitute a physical queue. That is to say, the difference among forwarding behaviors of various types of video packets is the parameters of the virtual RED queue, including the lower and the higher queue length thresholds, and the dropping probability.

3.3. Simulation Topology

Simulation topology is presented as Figure 1. S1 generates a video stream and S2 produces a CBR data stream. Edge router (E1 and E2) and core router(C) forward packets for the sources. Packet size of both steams is 1500 bytes. Bandwidth of each link is set as the figure shows.

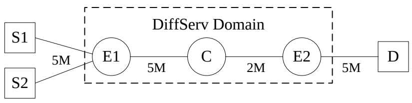


Figure 1. Simulation Topology

3.4. 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. Each sequence lasts 10 seconds and has 300 frames.

Table 2 presents the frame numbers (N_f) and packet numbers (N_p) of different frame types (packet size is 1500 bytes). This table shows the differences of data rates and coding structures among these sequences. The percent of I frames in akiyo and news sequences is higher than that in foreman sequence. And foreman sequence has more P frames. From this table we can also know that I frames always have many packets, P frames often have several packets and B frames often have few packets.

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

Table 2. N_f and N_p of Three Sequences

	news	foreman	akiyo
$N_{f,I}$	34	34	34
$N_{f,P}$	67	79	67
$N_{f,B}$	199	187	199
$N_{p,I}$	834	1084	544
$N_{p,P}$	499	1328	262
$N_{p,B}$	357	665	199

4. Evaluation

4.1. Basic Experiments

In this kind of experiments, we focus on the performance comparison between IP policy and Null policy and the influence of RED parameters setting in IP policy. Only the Null policy is considered as comparative policies because in our previous work we have achieved the conclusion that employing those policies with more than one dropping priority is not necessary for video streaming in standard DiffServ domain.

As mentioned before, each frame type has it own RED parameters. Since I frame has the highest priority, a “50-50-0” setting should be employed. The first and the second “50” mean the lower and the higher queue length threshold values respectively, and “0” means the dropping probability value. Thus “50-50-0” means do not drop I frame packets actively. The first experiment evaluates the influence of RED parameters setting of P frames. In this experiment, news sequence is adopted. RED parameters of B frames are set to “0-0-1” which means drop all the B frame packets. The generating rate of data stream (R_d) is 1.2Mbps. And the data stream is assigned a TSW2CM policy, with CIR=1.0Mbps. Figure 2 gives the number of total received packets (pktNum) and average PSNR (avgPSNR) results, and table 3 gives the number of lost frames (L_f) and the number of lost packets (L_p) of various frame types.

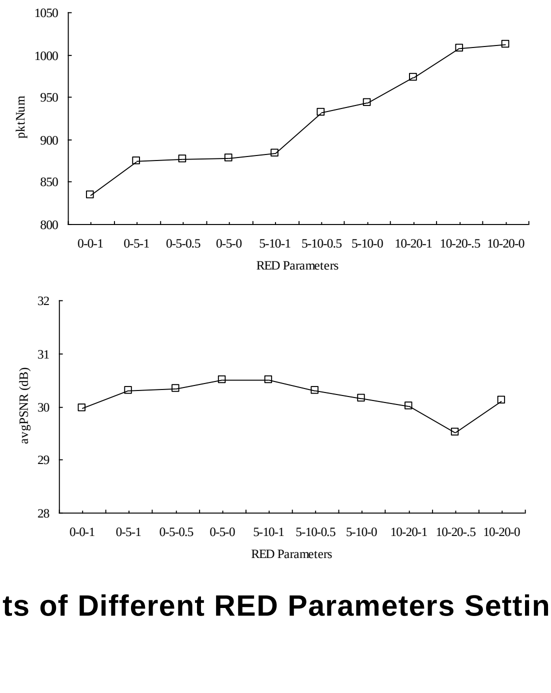


Figure 2. Results of Different RED Parameters Setting of P Frames

Table 3. L_f and L_p in Figure 2

RED of **P** frames	$L_{f,I}$	$L_{f,P}$	$L_{f,B}$	$L_{p,I}$	$L_{p,P}$	$L_{p,B}$
0-0-1	0	67	199	0	499	357
0-5-1	0	63	199	0	458	357
0-5-0.5	0	62	199	0	456	357
0-5-0	0	61	199	0	455	357
5-10-1	0	61	199	0	449	357
5-10-0.5	1	61	199	3	398	357
5-10-0	2	60	199	11	379	357
10-20-1	4	57	199	20	340	357
10-20-0.5	6	56	199	30	296	357
10-20-0	8	38	199	64	257	357

From the results we can find that: (1) With the degradation of RED parameters setting of P frames, more P frame packets are received, which finally leads to loss of I frame packets. But from the perception of pktNum, it increases continuously. (2) The average PSNR is determined mainly by frame loss distribution, not pktNum. We find that the two curves of pktNum and avgPSNR are not accordant. (3) The importance of I frames is higher than that of P frames. Take “5-10-0” and “10-20-1” as the comparison example. Since the avgPSNR of “5-10-0” is larger than that of “10-20-1”, we can draw the conclusion that the distortion caused by 2 (4-2) I frames is larger than that caused by 3 (60-57) P frames.

The second experiment investigates the influence of RED parameters setting of B frames. In this experiment, RED parameters of P frames are set to “5-10-1”, whose avgPSNR is the best in the former experiment. R_d and CIR of data stream remain unchanged. Figure 3 and table 4 give the results. Although pktNum increases, the received video quality degrades continuously. This is because that: (1) The increase of the number of received P and B frame packets leads to the decrease of the number of received I frame packets. (2) The importance of I frames is higher than those of P frames and B frames.

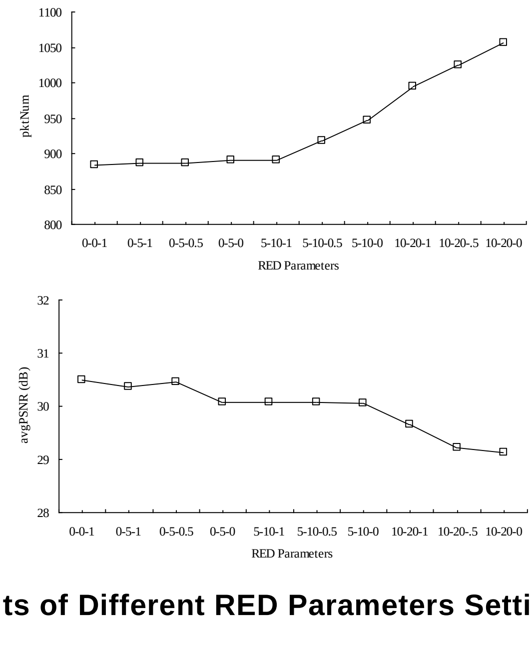


Figure 3. Results of Different RED Parameters Setting of B Frames

Table 4. L_f and L_p in Figure 3

RED of **B** frames	$L_{f,I}$	$L_{f,P}$	$L_{f,B}$	$L_{p,I}$	$L_{p,P}$	$L_{p,B}$
0-0-1	0	61	199	0	449	357
0-5-1	1	61	197	2	450	352
0-5-0.5	1	61	195	7	450	347
0-5-0	3	62	189	8	451	341
5-10-1	3	62	188	11	449	339
5-10-0.5	3	62	186	12	448	312
5-10-0	3	62	156	15	451	278
10-20-1	5	60	150	25	437	233
10-20-0.5	6	60	139	31	436	198
10-20-0	6	60	92	33	435	166

As the opponent of IP policy, Null policy is employed. Figure 4 and table 5 present the results. Compared to figure 2 and figure 3, figure 4 has different x-axis because there is only one dropping priority in Null policy and we want to show the comprehensive results. Notice that "50-50-0" means do not drop any packet actively. Making a comparison between the results of this experiment and those of the former two experiments, we find that: (1) Although pktNum of Null policy is relatively high, avgPSNR of it is much lower than that of IP policy because more I frame packets are dropped. (2) Packet loss distribution influences the decoded video quality significantly. Decoded avgPSNR when dropping probability equals to 1 is much lower than that when dropping probability equals to 0, even if pktNums of both instances are comparative. The reason is that the number of perfect received frames (frames having no lost packets) is much lower when dropping probability equals to 1. Particularly, the setting "0-5-1" shows zero avgPSNR because all frames are not decodable.

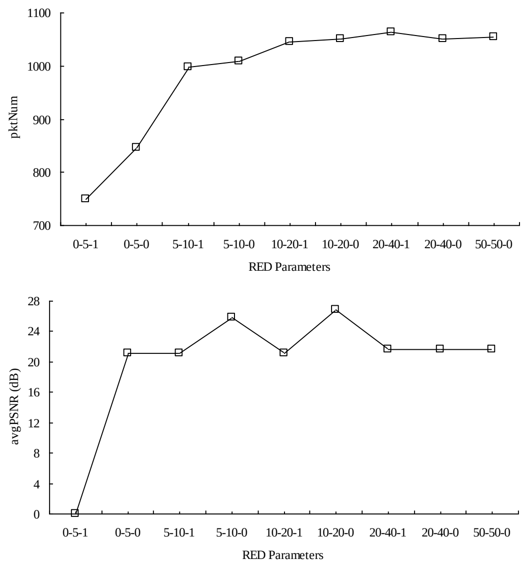


Figure 4. Results of Different RED Parameters Setting under Null Policy

Table 5. L_f and L_p in Figure 4

RED parameters	$L_{f,I}$	$L_{f,P}$	$L_{f,B}$	$L_{p,I}$	$L_{p,P}$	$L_{p,B}$
0-5-1	34	67	199	447	298	196
0-5-0	32	60	153	193	377	273
5-10-1	32	61	136	328	205	160
5-10-0	20	51	123	154	310	217

10-20-1	32	60	125	308	188	149
10-20-0	23	37	113	241	209	190
20-40-1	32	51	126	312	157	157
20-40-0	32	27	155	345	53	241
50-50-0	32	27	155	344	50	241

4.2. Influence of Scheduling Mode

Figure 5 shows the results when adopting WRR and WIRR scheduling modes. WRR_IP refers to WRR mode with IP policy and WRR_Null means WRR mode with Null policy. When IP policy is used, the RED parameters settings of I, P and B frames are “50-50-0”, “20-40-0.25” and “10-20-0.5” respectively. And when Null policy is employed, default setting is used. In the figure, 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. From the figure we can find that:

(1) Performance of WIRR_IP is close to that of WRR_IP.

(2) pktNum of WRR_Null is slightly higher than that of WRR_IP.

(3) avgPSNR of WRR_IP is much higher than that of WRR_Null when the weight of video stream queue is higher (but no much higher) than that of data stream queue, i.e. the instances of “2-1”, “3-2”, “4-2”, “4-3”, “5-3” and “5-4”. Otherwise, if the weight of video stream queue is much higher than that of data stream queue (“3-1”, “4-1”, “5-1” and “5-2”), WRR_Null achieves better performance.

Remember that RED mechanism is always active when IP policy is employed. Since default setting is used in Null policy, RED mechanism is not active so that more video packets could be received. When the weight of video stream queue is not much higher than that of data stream queue, WRR_Null achieves lower avgPSNR because it does not consider the importance of different types of video frames, just like the last sub-section described. However, the numbers of dropped video packets are very small in the instances of “3-1”, “4-1”, “5-1” and “5-2” (zero in “3-1”, “4-1” and “5-1” instances of Null policy). Therefore, Null policy achieves better performance. Table 6 verifies the conclusion.

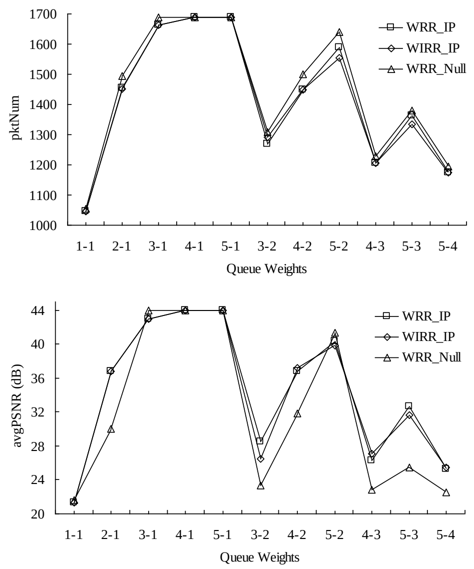


Figure 5. Results of WRR and WIRR Scheduling Modes

Table 6. L_f of WRR_IP and WRR_Null in Figure 5

	WRR_IP			WRR_Null		
	$L_{f,I}$	$L_{f,P}$	$L_{f,B}$	$L_{f,I}$	$L_{f,P}$	$L_{f,B}$
1-1	32	46	181	32	27	155
2-1	2	3	137	22	3	89
3-1	0	0	26	0	0	0
4-1	0	0	0	0	0	0
5-1	0	0	0	0	0	0
3-2	12	41	168	30	14	117
4-2	2	1	141	19	4	84
5-2	0	0	84	3	1	34
4-3	18	49	178	31	20	130
5-3	11	1	161	28	7	98
5-4	21	44	171	31	18	126

Figure 6 and table 7 show the results when employing PRI scheduling mode. PRI mode has a parameter which specifies the maximum bandwidth (BW_{max}) that a queue can consume. In this experiment, only BW_{max} of video stream is set. RED parameters settings of this experiment are similar to those of the last experiment. In the x-axis, dft means BW_{max} is not set, using the default value.

Since PRI scheduling mode is used and the priority of video stream is higher than that of data stream, each video is perfectly received when BW_{max} is not limited. From table 1 we know that the average data rate of news sequence is about 1.250Mbps. Thus we find that when BW_{max} is higher than 1.25Mbps, the video is perfectly received in both policies. If BW_{max} is lower than 1.25Mbps, although pktNum of PRI_IP is smaller than that of PRI_Null, avgPSNR of PRI_IP is much higher than that of PRI_Null. The reason is similar to the former sub-sections. When BW_{max} equals to 1.25Mbps, avgPSNR of PRI_IP is lower than that of PRI_Null because the number of lost video packets is very small in PRI_Null.

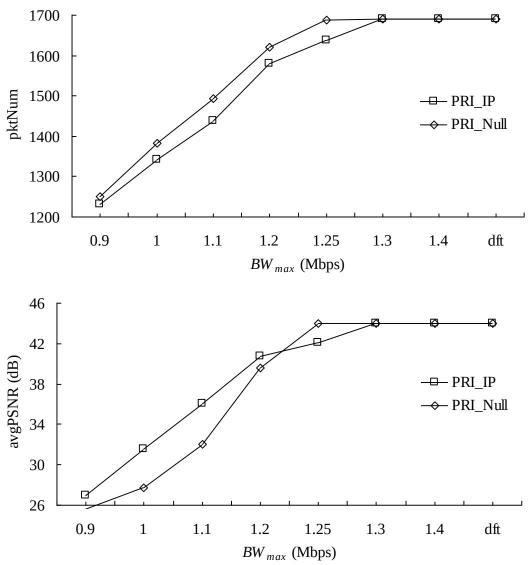


Figure 6. Results of PRI Scheduling Mode

Table 7. L_f in Figure 6

BW_{max}	PRI_IP			PRI_Null		
(Mbps)	$L_{f,I}$	$L_{f,P}$	$L_{f,B}$	$L_{f,I}$	$L_{f,P}$	$L_{f,B}$
0.9	21	37	150	26	18	116
1.0	11	33	138	24	12	93
1.1	4	12	131	19	4	81
1.2	0	0	80	7	2	36
1.25	0	0	48	0	1	0
1.3	0	0	0	0	0	0
1.4	0	0	0	0	0	0
dft	0	0	0	0	0	0

4.3. Influence of R_d

Figure 7 gives the results when employing different R_d. The results are similar to those presented in the last two sub-sections. If R_d is not higher than 0.6Mbps or not lower than 1.2Mbps, pktNum and avgPSNR of both policies are comparative. When R_d equals to 0.9/1.0/1.1Mbps, avgPSNR of IP policy is much higher than that of Null policy. Otherwise, Null policy outperforms IP policy a little.

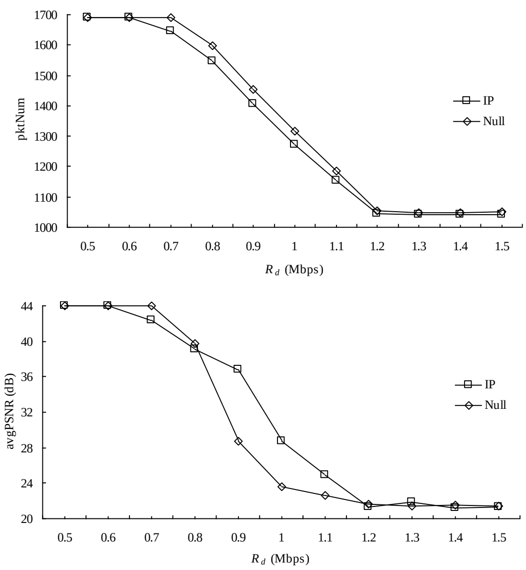


Figure 7. Results of Different R_d

4.4. Influence of Dropping Mode

Dropping mode among multiple virtual RED queues may influence the decoded quality of a video stream. In this experiment, RIO-C, RIO-D, WRED and DROP modes are employed respectively. R_d equals to 1.2Mbps. RED parameters settings of different frame types are the same as section IV.B. Table 8 describes the results, which show that dropping mode influences the composition of received video significantly. RIO-C and WRED modes protect I frames well while RIO-D mode ensures the transmission of P frames. Although DROP mode receives more packets, its avgPSNR is poor for discontinuous receiving.

Table 8. Results of Various Dropping Modes

Dropping Mode	$L_{f,I}$	$L_{f,P}$	$L_{f,B}$	$L_{p,I}$	$L_{p,P}$	$L_{p,B}$	avgPSNR
RIO-C	32	46	181	220	106	318	21.35207
RIO-D	32	27	155	344	50	241	21.621211
WRED	30	52	181	184	146	318	22.337872
DROP	34	0	62	64	0	83	11.319805

4.5. Influence of Characteristics of Video Sequence

Figure 8 to 11 show the results of various RED parameter settings of foreman and akiyo sequences. To cause properly packet loss, the bandwidths of the link from node C to node E2 are set to 3Mbps and 1.2Mbps for foreman and akiyo respectively. And R_d is set to 0.8Mbps for both sequences. From these figures we find that the best choices of RED parameters setting of different video sequences (to achieve the highest avgPSNR) are distinct. For RED parameters setting of P frames, “5-10-1”, “10-20-0” and “0-5-0.5” are the best choices for news, foreman and akiyo sequences respectively. For RED parameters setting of B frames, “0-0-1”, “10-20-0” and “0-0-1” are the best choices for news, foreman and akiyo sequences respectively.

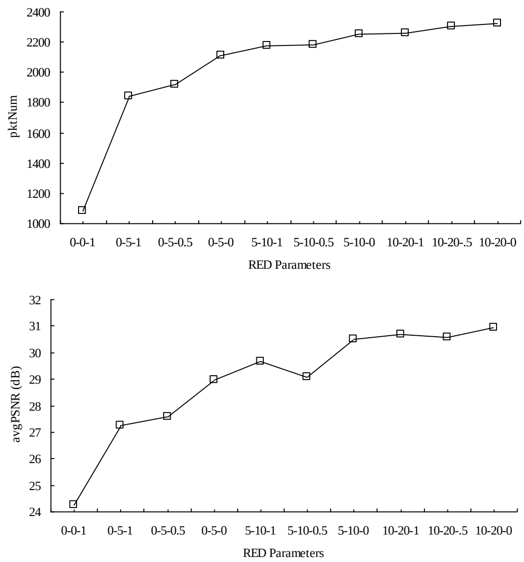
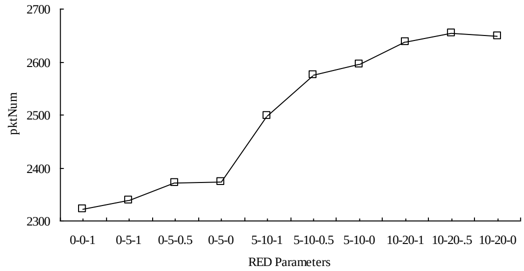


Figure 8. Results of Different RED Parameters Setting of P frames, Foreman Sequence



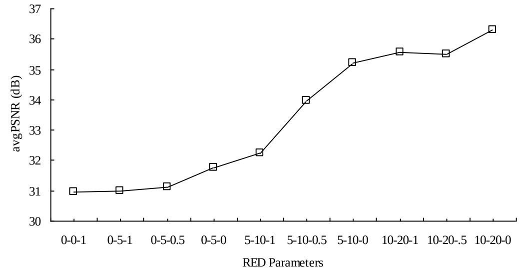


Figure 9. Results of Different RED Parameters Setting of B Frames, Foreman Sequence

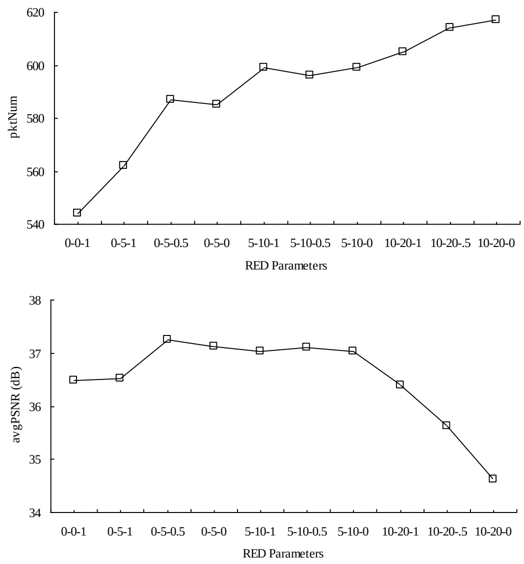


Figure 10. Results of Different RED Parameters Setting of P frames, akiyo Sequence

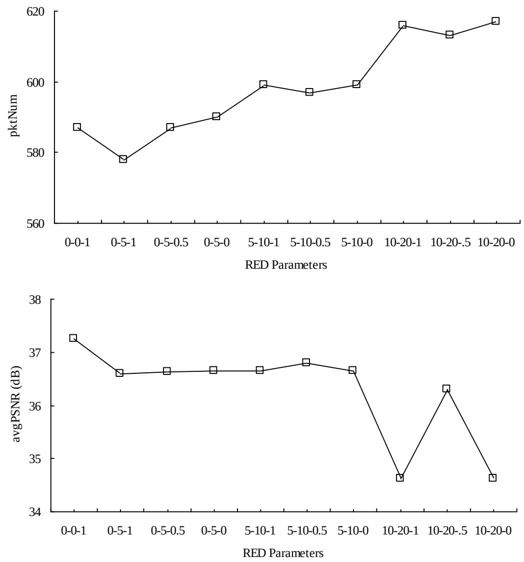


Figure 11. Results of Different RED Parameters Setting of B frames, Akiyo Sequence

5. Conclusions

In this paper we propose an inner-priority based video streaming scheme for DiffServ domain. Accordingly, an inner-priority (IP) policy is designed for video streaming. Adopting IP policy, the importance of video packet could be recognized and corresponding RED queue will be assigned. Comprehensive evaluation results show that:

(1) Even if the number of received packets of IP policy is less than that of Null policy, the average PSNR of it is much higher than that of Null policy in most cases.
(2) RED parameters settings influence the performance of IP policy. Particularly, strict settings will lead to a slight degradation of average PSNR compared to Null policy when available bandwidth for the video stream is relatively abundant.
(3) Scheduling mode influences the performance greatly. When a high weight is assigned to the video stream in WRR/WIRR mode or the bandwidth limitation of the video stream is not strict in PRI mode, the received video quality is quite good. And no matter what scheduling mode is employed, IP policy shows its advantage in most cases.
(4) The received video quality degrades with the increase of data rate of the data stream.
(5) Dropping mode influences the composition of received video significantly. A specific dropping mode always protects particular frame type. And DROP mode is not suggested.
(6) The best choice of RED parameters settings depends on the video coding structure.
(7) In the future, we plan to design an adaptive parameter adjustment mechanism for IP policy.

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References

[1] K. Nichols, S. Blake, F. Baker and D. Black, "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers", IETF RFC 2474, (**1998)** December.
[2] S. Blake, D. Black, M. Carlson, E. Davies, Z. Wang and W. Weiss, "An Architecture for Differentiated Services", IETF RFC 2475, (**1998)** December.
[3] L. Chen and G. Liu, "A Delivery System for Streaming Video Over DiffServ Networks", IEEE Transactions on Circuits and Systems for Video Technology, vol. 20, no. 9, (**2010**), pp. 1255-1259.
[4] D. Ong and T. Moors, "Deferred discard for improving the quality of video sent across congested networks", IEEE International Conference on Local Computer Networks (LCN 2013), October (**2013),** pp.743-746.
[5] J. Jaffar, H. Hashim, H. Zainol Abidin and M. K. Hamzah, "Video quality of service in Diffserv-aware multiprotocol label switching network", IEEE Symposium on Industrial Electronics & Applications (ISIEA 2009), (**2009)** October , pp. 963-967.
[6] I.-H. Peng, M.-H. Lin, Y.-W. Chen, F.-M. Yang and A. Y. S. Su, "Improvement of Streaming Video in Differential Service Networks by Using Opportunity RED Mechanism", International Conference on Complex, Intelligent, and Software Intensive Systems (CISIS 2013), (**2013),** July, pp.644-648.
[7] H. Wang, G. Liu, L. Chen, Q. Wang, "A novel marking mechanism for packet video delivery over DiffServ Networks", International Conference on Multimedia and Expo (ICME 2011), (**2011)** July**,** pp. 1-5.
[8] F. Li and G. Liu, "A Novel Marker System for Real-Time H.264 Video Delivery Over Diffserv Networks", IEEE International Conference on Multimedia and Expo (ICME 2007), (**2007)** July**,** pp. 2142-2145.
[9] S. Zoric and M. Bolic, "Fairness of scheduling algorithms for real-time traffic in DiffServ based networks", IEEE Mediterranean Electrotechnical Conference (MELECON 2010), (**2010)** April**,** pp. 1591-1596.

[10] S. Askar, G. Zervas, D. K. Hunter and D. Simeonidou, "Service differentiation for video applications over OBS networks", European Conference on Networks and Optical Communications (NOC 2011), (**2011)** July**,** pp. 200-203.
[11] The Network Simulator - NS (version 2), http://www.isi.edu/nsnam/ns/
[12] J. Klaue, B. Rathke and A. Wolisz, "EvalVid-A Framework for Video Transmission and Quality Evaluation", In Proceedings of 13th International Conference on Modelling Techniques and Tools for Computer Performance Evaluation, (**2003),** pp. 255-272.
[13] C. H. Ke, C. K. Shieh, W. S. Hwang and A. Ziviani, „An Evaluation Framework for More Realistic Simulations of MPEG Video Transmission", Journal of Information Science and Engineering, vol. 24, no. 2, (**2008**), pp. 425-440.

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