TFRC for Congestion Control in Wired Environment

P. Sreenivasa Rao,M. Janani,P. Chenna Reddy

Abstract: The applications for which Internet is used has changed over the years. File transfer and e-mail are no longer the dominant applications of Internet. Multimedia streaming is one of the applications which is generating lot of revenues in Internet market. For these type of applications congestion has to be controlled. TCP has congestion control mechanisms but has lot of overhead associated with it making it not suitable for multimedia applications. UDP has no congestion control mechanisms and can lead to instability in the network. TCP Friendly Rate Control (TFRC) is a new protocol designed by Internet Engineering Task Force (IETF). It has congestion control mechanisms which enable it to be fair with TCP and prevents UDP from using its share of the bandwidth. In this paper performance of TFRC is compared with TCP and UDP in wired environment.

Keywords- : TFRC, TCP, UDP, ns-2.

I. INTRODUCTION

Internet which started with four computers has reached every corner of the world. The applications for which Internet is used is changing continuously. File transfer was the main application in the initial stages of Internet. Even e-mail was initially transferred using file transfer protocol. The dominant applications of today are multimedia streaming, game playing, etc. These applications have stringent constraints. IP provides only best efforts service which is not suitable for these applications. These applications require quality of service.

The commonly used transport protocols are TCP and UDP. TCP provides reliable byte stream transfer of data and the order of the data is preserved. But it is not suitable for applications like multimedia streaming where bandwidth and delay are more important than the reliability. More and more such applications are using UDP as the transport protocol. But since UDP has no congestion control mechanisms it can lead to instability. We require protocols which have congestion control mechanisms similar to TCP and which can compete with protocols like UDP in providing the required level of quality of service.

TFRC is one such protocol that is designed for applications that require the quality of service. TFRC is fair with TCP and prevents UDP from using its share of the bandwidth. But TFRC is still not standardized and further investigation of the protocol is needed to verify its suitability in various domains.

TFRC mechanism [3] works as follows:

- The receiver calculates the loss event rate and the received rate, then inform it to the sender in a feedback message.
- This feedback to the sender besides the loss event rate and the received throughput includes the echoed timestamp of the last data packet and a delayed time between the arrival of the last data packet and the generation of the feedback. These last two parameters are necessary to calculate the round trip time (RTT) at the sender.
- The feedback packets are sent at least each round trip time or immediately after a new loss event rate is detected (without waiting one RTT).

II. RELATED WORK

Seongho Cho, Heekyoung Woo [4] compared the performance of Adaptive TCP Friendly Rate Control (ATFRC) protocol compared to TFRC and TCP using single bottleneck topology and the bottleneck queue is managed with the RED (Random Early Detection) mechanism. They found that TCP is not sufficient for providing multimedia and multicast services. To support new services, several TCP-friendly protocols have been proposed.

However, TFRC has been too conservative in utilizing available bandwidth effectively. And unlike TCP protocol, rate-based TCP-friendly protocols response slowly to network congestion notifications. So they developed a new protocol, called ATFRC, to provide faster responsiveness and convergence time with less conservativeness.When compared to ATFRC and TFRC, seongho cho found that the ATFRC improved over TFRC, ATFRC is less conservative in utilizing bandwidth than TFRC and ATFRC provides a faster convergence time than TFRC and ATFRC converges to the fair share faster than TFRC.

Xiao fu, Hu Ting, Yu JianPing, Sun Lijuan, Wang RuChuan [5] proposed a real-time video transmission system based on TFRC protocol and the evaluation model about the system is improved in the framework. It assesses the quality and efficiency of the video transmission according to the actual video file, and analyzes loss of frame in different video types during transmission as well as the video quality in receiver. They analyze the real-time transport of MPEG-4 video based on UDP and TFRC. Their simulation results show that TFRC protocol is very suitable for video transmission in a wire network, and quality assessment is also essential for a video transmission system. It assesses the quality and efficiency of the video transmission according to the actual video file, and analyzes different types of video frame losses during transmission as well as the picture quality in receiver. Simulation experiment results indicated that compared with the traditional TFRC, the TFRC-JI suites well for real-time service transmission.

III. PERFORMANCE METRICS

Packet delivery ratio: The ratio of total number of packets successfully received by the destination nodes to the number of packets sent by the source nodes.

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End-to-End delay: The average delay of all the packets while travelling from source node to destination node.

Packet loss ratio: The ratio of number of lost packets to the sum of number of packets received and number of lost packets.

IV. SIMULATION ENVIRONMENT

The network simulator NS-2, version 2.34 is used for simulation. NS2 [6] is an event driven simulation tool that has proved useful in studying the dynamic nature of communication networks. NS-2 supports TCP, UDP traffic with FTP, CBR and Telnet applications. Simulation for TCP, UDP and TFRC traffic is presented in wired network. The topology we are using is dumbbell topology with bottleneck link of capacity 2Mbps and other links capacity of 2Mbps.

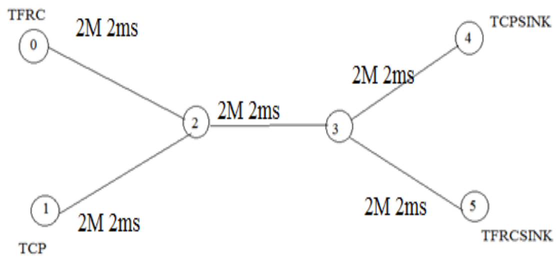

Figure 1: Simulation Topology

V. RESULTS AND ANALYSIS

In this, we compare the performance of TCP, UDP and TFRC through Packet delivery ratio, End-to-End delay and Packet loss ratio.

Table 1 shows the performance of TFRC and TCP.

TFRC rate (Mbps)	TCP Window Size	TFRC		TCP	
		Sent	Received	Sent	Received
1	4	12239	12238	12241	12240
1.25	5	15283	15282	15292	15291
2.48	10	30554	30552	30558	30556
4	15	45783	45779	45788	45785
4.8	21	59864	59832	59833	59807
4.85	30	60088	60005	60052	60037

Table 1: Performance of TFRC and TCP with 6 nodes at same sending rates in Wired Environment

Table 1 shows the comparison table of TFRC and TCP. The packet size is set to be 1000, TFRC rate and TCP Window Size increased simultaneously for allowed same sending rates.

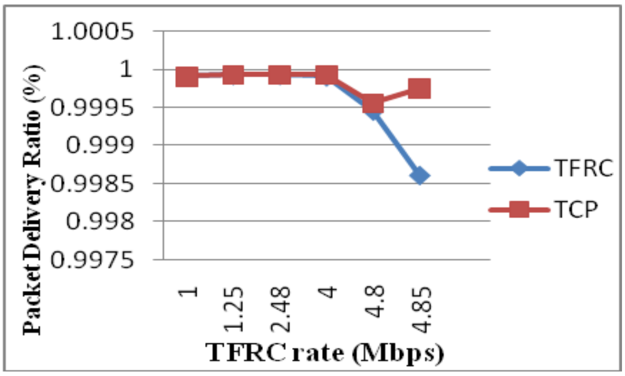

Figure 2: Packet Delivery Ratio of TFRC and TCP with 6 nodes.

Figure 2 shows the packet delivery ratio of TFRC. TFRC shares fair bandwidth with TCP until 4Mbps and after 4Mb packet delivery of TFRC is less than TCP. In this, the number of nodes set to be 6.

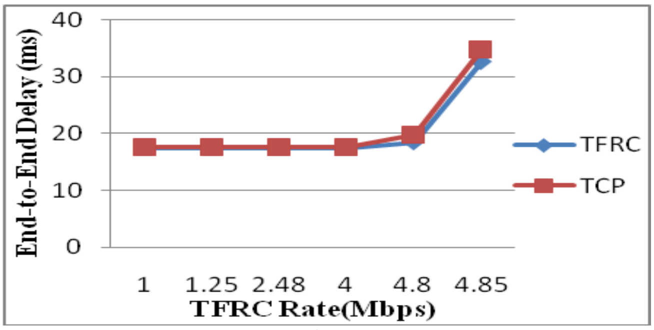

Figure 3: End-to-end delay of TFRC and TCP with 6 nodes.

Figure 3 shows the end-to-end delay of TFRC. TFRC and TCP are similar until 4Mbps, after that end-to-end delay of TFRC is less than the TCP.

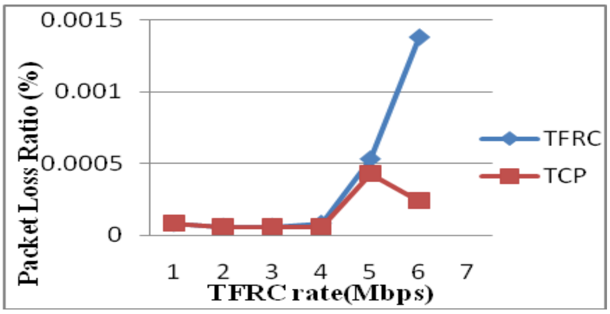

Figure 4: Packet Loss Ratio of TFRC and TCP with 6 nodes.

Figure 4 shows the packet loss ratio of TFRC. Its performance is similar to TCP until 4Mbps, after that packet loss ratio of TFRC is less than the TCP.

Table 2 shows the performance of TFRC and UDP.

TFRC Rate (Mbps)	UDP Rate (Mbps)	TFRC		UDP	
		Sent	Receive	Sent	Receive
0.51	0.49	6370	6369	6357	6356
1	1	12487	12486	12488	12487
2	2	24971	24969	24975	24974
3	3	37458	37455	37463	37460
4	4	49944	49926	49951	49933
5	4.87	60762	60740	60752	60691

Table 2: Performance of TFRC and UDP with 6 nodes

Table 2 shows the comparison of TFRC and UDP. In this work, packet size is set to be 1000, TFRC rate and UDP rate increased simultaneously for allowed same sending rates.

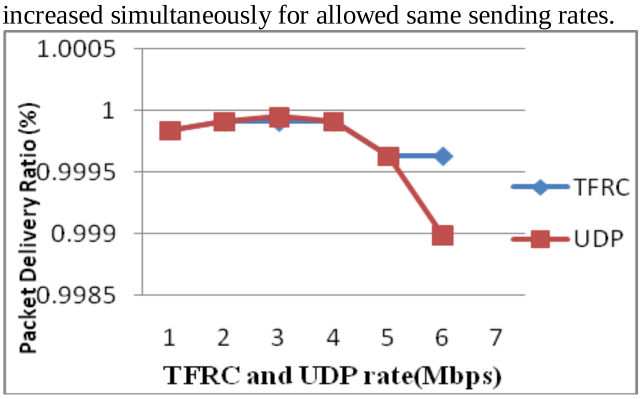

Figure 5: Packet Delivery Ratio of TFRC and UDP with 6 nodes

Figure 5 shows, the packet delivery ratio of TFRC is more than the UDP. In this work, we increased TFRC rate and UDP rate simultaneously for allowing same sending rates.

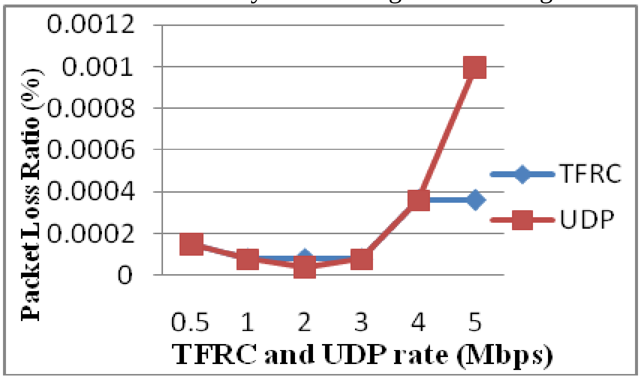

Figure 6: Packet Loss Ratio of TFRC and UDP with 6 nodes.

Figure 6 shows the packet loss ratio of TFRC is less than the UDP. In this work, number of nodes is set to 6, TFRC rate and UDP rate is varied from 0.5 to 5 Mbps.

Table 3 shows the performance of TCP and UDP.

UDP Rate (Mbps)	TCP		UDP	
	Sent	Receive	Sent	Receive
0.5	6040	6021	6244	6225
1	74	47	12488	12438
1.5	57	31	18732	12455
2	36	17	24975	12469
2.5	28	10	31219	12477
3	23	7	37463	12480
3.5	21	7	43707	12480
4	20	6	49951	12481

Table 3: Performance of TCP and UDP with 6 nodes.

In this work, packet size set to be 1000, by keeping TCP window size constant UDP rate is increased substantially. The results show that UDP does not share bandwidth fairly with the TCP traffic. TCP reduces the sending rate in reaction to congestion. UDP does not react to congestion and it continues to send the data at the same rate. This makes UDP take advantage over TCP and ultimately may result in instability of the network.

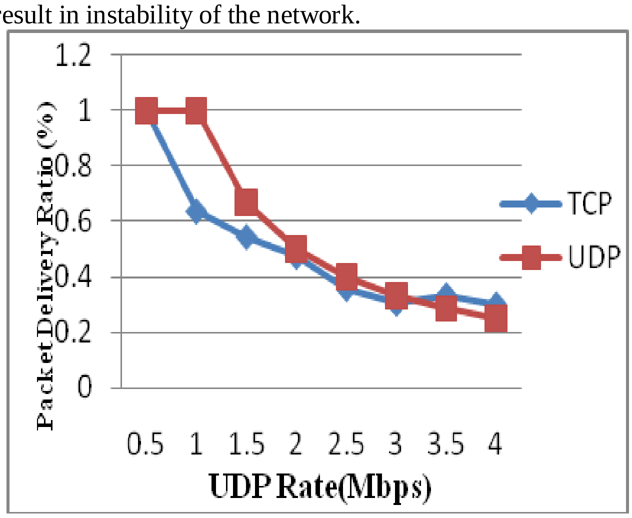

Figure 7: Packet Delivery Ratio of TCP and UDP with 6 nodes in Wired Environment.

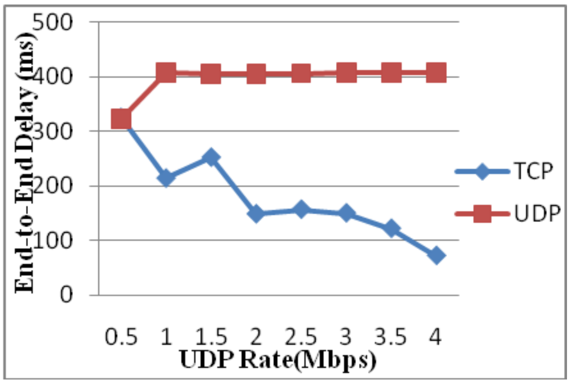

Figure 8: End-to-end delay of TCP and UDP with 6 nodes in Wired Environment.

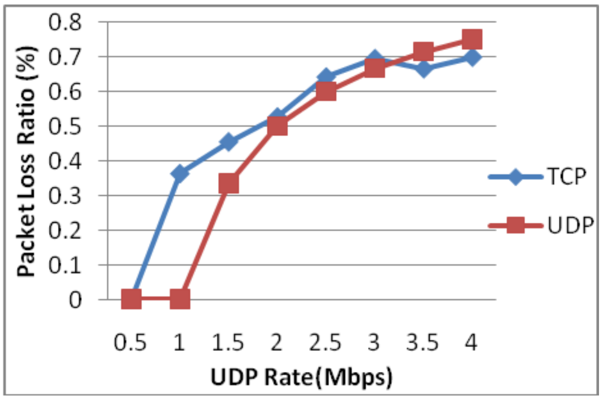

Figure 9: Packet Loss Ratio of TCP and UDP with 6 nodes in Wired Environment.

Figure 7, Figure 8, Figure 9 shows the performance of TCP and UDP through packet delivery ratio, end-to-end delay and packet loss ratio. The results specify that the UDP does not share bandwidth fairly with the TCP.

VI. CONCLUSION

TFRC is a protocol that is designed to be fair with TCP and compete with aggressive UDP. In this paper performance comparison of TFRC, TCP and UDP are done. From the results obtained, it can be concluded that TFRC shares bandwidth fairly with TCP and TCP successfully addresses the congestion problem but it does not support requirement of multimedia streaming. The average end-to-end delay of TFRC is less compared to UDP protocol and the packet loss ratio of TFRC is less when compared to UDP. The packet delivery ratio of TFRC is more when compared to UDP.

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