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Performance Enhancement of TCP Friendly Rate Control Protocol over Wired Networks

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ABSTRACT

One of the main aims of transport layer protocol is achieving best throughput without any congestion or reduced congestion. With rapid growing application needs and with increasing number of networks in Internet, there is a primary need to design new protocols to transport layer. To transmit multimedia applications, one of the suitable congestion control mechanisms in transport layer is TCP Friendly Rate Control Protocol (TFRC). It controls congestion based on its equation. However, every packet requires an acknowledgement in TFRC. It creates congestion in the network when the transmitted data is very large, which results in reduced throughput. This paper aims to increase the throughput when the transmitted data is large with minimal congestion by reducing the number of acknowledgements in the network. We modified some fixed parameters in the TFRC equation. The results show the increased throughput with minimal congestion.

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1. INTRODUCTION

Wired networks are known for their high bandwidth. Among the networks that are used by the users of the Internet, wired networks have the best characteristics. The layer which is directly related to user satisfaction is transport layer. TCP and UDP are the two transport protocols that are designed for wired networks. Because of the increasing demand for streaming applications TFRC is designed. From the inception TCP is the transport protocol used by many applications of Internet [1].

In recent trends, the usage of multimedia applications has increased. Some transport layer protocols are designed to transmit multimedia applications. Among these, Transmission Control Protocol (TCP) is a popular transport layer protocol in wired and wireless ad hoc networks. But TCP has experienced an unhealthy environment while transporting multimedia applications. To avoid the potential threat to the health of internet, TFRC [2] is proposed. TFRC adjusts its sending rate based on TCP Reno.

$$X = \frac{S}{RTT\sqrt{\frac{2bp}{3}} + 3*RTO\sqrt{\frac{3bp}{8}}\,p(1+32p^2)} \quad (1)$$

where X is the expected sending rate in bytes per second, S is the packet size in bytes, *RTT* is the round-trip time, *b* is the number of packets that are acknowledged by one ACK, *p* is the loss event rate, and *RTO* is the retransmit timeout value.

This equation maintains a steady state sending rate to network to avoid the abrupt fluctuations. By setting b value to 1 and retransmission time out value to 4 times of round trip time, TFRC sending rate X is a function of packet size S as follows:

$$X = \frac{S}{RTT\sqrt{\frac{2p}{3}} + 12 * RTT\sqrt{\frac{3p}{8}}\, p(1+32p^2)} \quad (2)$$

Based on the above equation, TFRC congestion control mechanism is as follows.

a. At first step, the loss event rate will be measured by receiver and pass this information to sender.
b. Sender measures round trip time based on received information
c. Sender measures its sending rate as a function of loss event rate and round-trip time
d. Sender maintains its sending rate based on its calculated rate from the equation.

2. LITERATURE SURVEY

Arjuna Sathiaseelan, Gorry Fairhurst, [3] proposed the introduction of congestion control for multimedia traffic to ensure the stability of the next generation Internet. TFRC algorithm was first specified in RFC 3448 [4]. S.Floyed, E.Kohler [5] proposed TFRC-SP (Small-Packet TFRC) a variant of TFRC which supports fixed sending rate by using variable sized small packets. The design goal for TFRC-SP is to achieve the same bandwidth in bps as a TCP flow using packets of up to 1500 bytes. Pedro Reviriego Vasallo [6] proposed an extension to the TFRC protocol in order to support variable packet size flows. In this paper, numerator of TFRC equation is changed to MTU, so that it is suitable for variable packet size flows. Mohammad A. Talaat, Gamal M. Attiya, and Magdi A. Koutb [7] predicted that Video traffic is booming over Internet and to be the prevailing traffic type in the coming few years. TFRC is the most promising candidate congestion control algorithm over Internet that handles such type of traffic appropriately satisfying its QoS requirements. Agnieszka Chodorek and Robert R. Chodorek [8] suggest that although TFRC protocol is suitable for multimedia transmission, they proposed to substitute the original TFRC throughput equation with a linear throughput equation. Results allow us to believe that the proposed linear equation is more suitable for multimedia transmission than the equation originally included in the RFC 3448.

3. RESEARCH METHOD

The main purpose to do modifications is to improve throughput of TFRC by smoothing its sending rate. Many researchers tried to improve TFRC performance over wired and wireless adhoc networks by changing some fixed parameters in its equation like packet size S. But a little research work is done so far on the fixed parameters like the number of packets that are acknowledged by one ACK (b), and retransmission time out (RTO). This paper introduces some modifications to the parameters, number of packets acknowledged and RTO values to get smoother throughput when transmitted data is large with minimal congestion.

Our proposed scheme introduces some modifications to classical TFRC equation. Our changes in the TFRC equation are case (i) Go back-N methodology is applied to b along with linear arithmetic progression applied to Retransmission time out case (ii) Selective Repeat methodology is applied to b along with exponential back off algorithm applied to Retransmission time out.

3.1. Case (i)

TFRC requires an acknowledgement per every packet. To reduce the congestion in the network, when the transmitted data is very large, there is a choice to reduce the number of acknowledgements from receiver to sender for every packet. Increasing the value of b (i.e. b=2, b=3., etc) reduces number of acknowledgements. We simultaneously apply linear arithmetic progression technique to retransmission timeout for every non-acknowledged packet (i.e. RTO=4R, RTO=5R., etc). The following algorithm illustrates the above scenario.

Algorithm for case (i):

1. *Choose buffer size at sender side with clock_t.*
2. *Choose the suitable value of b(Limited increase)*
3. *If (all packets are received by receiver)*
   {
   No change in RTO.
   Send next sequenced segments
   }
   Else
   {
   Retransmit the unacknowledged segments
   Apply linear arithmetic progression to RTO
   }
4. *Continue this process until all segments completed*.

3.2. Case (ii)

In this case, increasing the value of b (i.e. b=2, b=3., etc) reduces number of acknowledgements. We simultaneously apply exponential back-off algorithm to retransmission timeout for every non-acknowledged packet (i.e. RTO=4R, RTO=8R., etc). The following algorithm illustrates the above scenario.

Algorithm for case (ii):

1. *Choose buffer size at both sender and receiver sides with clock_t.*
2. *Choose the suitable value of b(Limited increase)*
3. *If (all packets are received by receiver)*
   {
   No change in RTO.
   Send next sequenced segments
   }
   Else
   {
   Retransmit the unacknowledged segments
   Apply exponential back-off algorithm to RTO
   }
4. *Continue this process until all segments are completed*.

4. SIMULATION ENVIRONMENT

Dumbbell topology with multiple bottle neck links consisting of 10 nodes with different bandwidths like 5Mbps, 4Mbps, 10Mbps, and 2 Mbps with transmission delay 10ms is used. For both cases, TFRC packet size is fixed at 1000 bytes and total simulation time is 150 sec. NS2.35 is used as network simulator. Figure 1 is shows dumbbell topology.

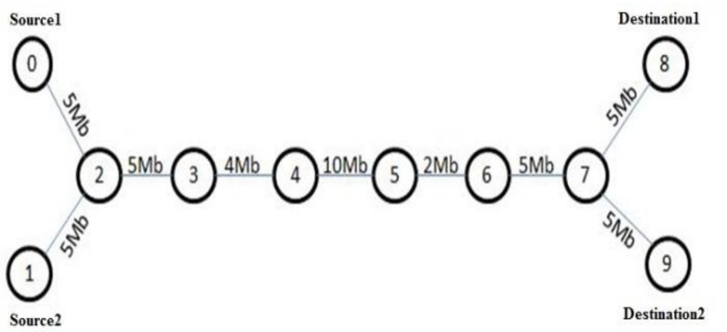

Figure 1. Dumbbell Topology

TFRC throughput equation is present in dccp_tfrc.cc file of ns-2.35. The original code for calculating sending rate using throughput equation is as follows.

```
Inline double DCCPTFRCAgent::tfrc_calcX(u_int16_t s, double R, double p)
{
double temp = R * sqrt(2*p/3)+(4*R*(3*sqrt(3*p/8))*p*(1+32*p*p));
return ((double)s/temp);
}
```

CBR objects are used to generate packets at a constant bit rate. A CBR traffic generator uses a C++ class CBR_Traffic which is bound to an OTCL class Application/Traffic/CBR. We have done a number of simulations with different values of b and RTO using above two cases. The simulation environment parameters are as follows.

5. PERFORMANCE METRICS

The performance parameters that are used are as follows:

Throughput:

Throughput is the rate at which a network sends or receives data. It is rated in terms of bits per second (bit/s).

Packet Loss Rate:

Packet loss rate is the ratio between number of packets dropped or lost and number of packets sent through the network

6. RESULTS AND ANALYSIS

In this, we compare performance of modified TFRC and classical TFRC via throughput and packet loss rate. Figure 2 illustrates throughput efficiency of TFRC using case (1). The graph shows that throughput increases for limited increase in b value and RTO is a function of linear arithmetic progression for negative acknowledgement. A limited increase is required for b value; otherwise avalanche effect will decrease throughput efficiency.

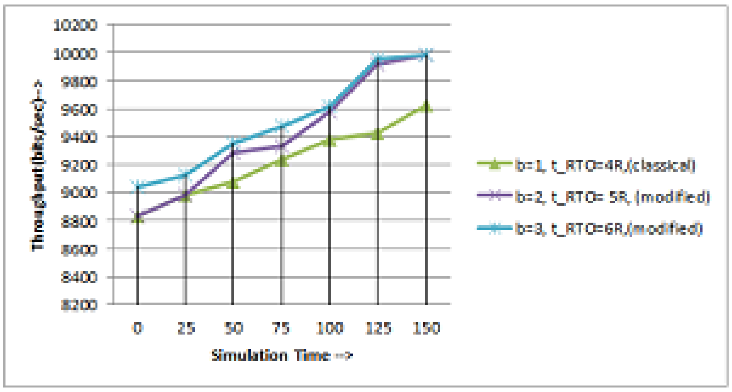

Figure 2. Throughput Efficiency of TFRC Using Case (i)

Figure 3 illustrates packet loss ratio of TFRC using case(1). The above figure depicts comparison of packet loss ratio with TFRC's modified and classical TFRC. With increasing data rate, modified TFRC gives less packet ratio than classical TFRC according to case (1).

Figure 4 illustrates throughput efficiency of TFRC using case (2). The graph illustrates that throughput increases for limited increase in b value and RTO is a function of exponential back-off algorithm for resending selective segment.

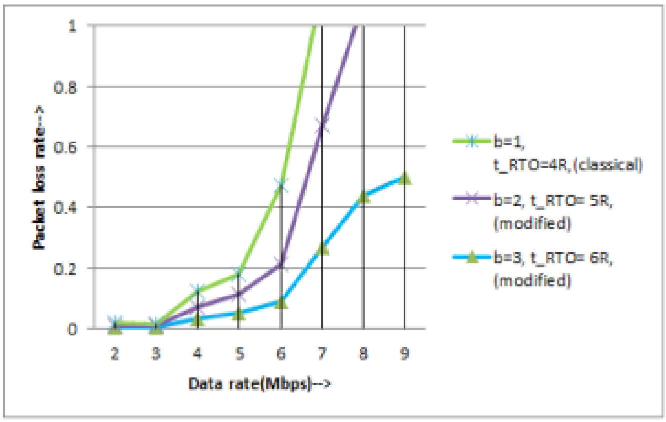

Figure 3. Comparison of Packet Loss Ratio Using Case (1)

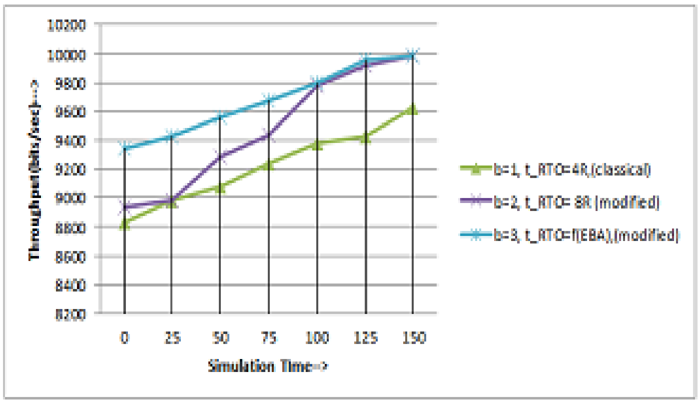

Figure 4. Throughput Efficiency of TFRC Using Case (ii)

Figure 5 depicts that comparison of packet loss ratio of TFRC's modified with classical TFRC. With increasing data rate, modified TFRC gives less packet loss ratio than classical TFRC according to case (2).

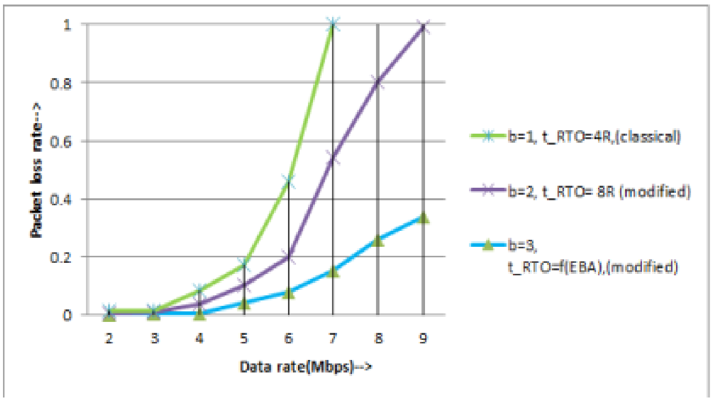

Figure 5. Comparison of Packet Loss Ratio Using Case (2)

7. CONCLUSION

This paper presents modifications to the equation of TCP Friendly Rate Control to enhance the performance over wired networks when the transmitted data is large and suitable to applications which requires smoother throughput. Overall results show that modified TFRC has achieved good throughput with minimal congestion when compared to classical TFRC. Further future work is aimed at measuring throughput of TFRC in adversities like, measuring round trip time during dynamically changing bandwidth.

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