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An Enhancement to TCPW BBE by Modifying the Bandwidth Estimation Using Modified EWMA

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Abstract— **Transport Control Protocol (TCP), the dominantly used transport protocol, execute well over wired networks. As far as wireless network is brought into use, TCP should be altered to work with wireless networks. TCP is designed for congestion control in wired networks. Since congestion is not only the main problem in wireless networks, it cannot find out non-congestion related packet loss from wireless networks. TCP-Westwood is a solution to this problem for wireless networks. TCPW buffer and bandwidth estimation (TCPW BBE) a variant of TCPW, is found to perform better in congested environments. In this paper, we are modifying TCPW BBE with modified EWMA (Exponentially weighted moving average) as bandwidth estimation technique to get accurate bandwidth and refine the congestion control algorithm.**

Keywords— TCP Westwood, TCPW BBE, Wireless networks, Congestion Control, Bandwidth Estimation, Modified EWMA.

I. INTRODUCTION

TCP is a connection oriented reliable transport protocol. It estimates the available capacity in the network by gradually increasing the number of outstanding segments. The congestion window (cwnd) limits the amount of data the TCP sender can inject into the network. If time outs or duplicate acknowledgements occur, it reduces the congestion window size to half. In the wired environment, packet losses are mainly due to congestion. Duplicate acknowledgements and timeouts give a clear indication of congestion. Thus TCP becomes the predominant protocol in the wired networks.

The performance of TCP is generally lower in wireless networks than in the wired. This is explained by the fact that TCP cannot distinguish problems that typically occur in wireless networks from congestion. The congestion control algorithms in TCP are based on the assumptions that data is lost mainly due to congestion. Therefore, data loss is interpreted as a signal of congestion in the network. On a wireless link, a noisy, fading radio channel is the more likely cause of loss. Even in a wireless network, data loss still signals congestion to the sender. There will be sudden decrease in the congestion window size and that will result in a poor performance.

To improve the performance of TCP in wireless environments a number of different approaches have been proposed. Among them, strictly end-to-end schemes at the transport layer have been paid much attention because they require no support from the network.

TCPW is a TCP based end to end approach. The distinguishing quality of the TCPW is congestion control based on the estimated bandwidth. Available Bandwidth estimated for each packet loss. Then algorithm adjust the slow start threshold value based on the estimated bandwidth. Thus the performance degradation of TCP in wireless networks can be controlled in a much better way. TCPWBBE ameliorate the performance of TCPW by incorporating buffer capacity estimation. Then slow start threshold value will be adjusted based on the estimated buffer capacity and bandwidth.

In the proposed solution we are using estimated buffer capacity as a discriminator for separating congestion losses and random losses. Slow start threshold value will be changed only for the congestion cases. Otherwise value remains the same and cwnd size will be gradually increased. For packet losses due to congestion cases, estimate the bandwidth using modified EWMA (Exponentially weighted moving average) and ssthresh will be adjusted. Modified ewma generates a better estimation compared to other estimation

Paper is organized as follows. Section 2 gives an overview of TCPW protocol and its important variants. Enhanced solution and its features are described in section 3.Conclusion is given in section 4.

II. RELATED STUDIES

A. TCPW Overview

TCPW is a sender side modification of TCP Reno[15]. The general idea is to use the bandwidth estimate (BWE) to set the congestion window (cwnd) and the slow start threshold (ssthresh) after a congestion episode.It forms the basis for a large number of TCPW variants.

The pseudocode of the algorithm is the following:

if (n DUPACKs are received)
ssthresh = (BWE*RTTmin)/seg_size;


```
if (cwnd>ssthresh) /* congestion avoid.*/
cwnd = ssthresh;
endif
endif
if (coarse timeout expires)
ssthresh = (BWE*RTTmin)/seg_size;
if (ssthresh < 2)
ssthresh = 2;
endif;
cwnd = 1;
endif
```

Here the seg_size identifies the length of a TCP segment in bits.

B. Principal TCPW Variants

Under certain network conditions the bandwidth estimation (BE) technique in TCPW gives highly inaccurate results. To solve this problem TCPW CRB (Westwood with Combined Rate and Bandwidth estimation) has been proposed. To tackle both underestimation and overestimation problems simultaneously, CRB maintains two estimates, an old and a new. Available Bandwidth Estimation (BE) and Rate Estimation (RE).A TCPW sender uses ACKs to estimate BE. BE sampling method "overestimates" the connection fair share, while providing (in the bursty case) a reasonably good estimate of the available bandwidth at the bottleneck. Upon detecting a packet loss, CRB chooses one of the estimates depending on the assumed predominant loss type: the old estimate for random loss and the new one for congestion loss [11].

TCPW ABSE (Westwood with Adaptive Bandwidth Share Estimation) is an enhancement to TCPW CRB. Instead of two predetermined sample intervals for CRB (ACK inter-arrival and a long predefined constant period), ABSE continuously changes the interval depending on an estimated network state. In addition to the adaptive calculation of a sampling interval, ABSE also defines a varied exponential smoothing coefficient for averaging bandwidth estimation samples. ABSE method produces a more accurate estimation of the connection bandwidth share. TCPW ABSE estimation accuracy and throughput are robust in the face of ACK and data packet compression and varying buffer sizes., ABSE also maintains friendliness to TCP NewReno connections. [12].

TCPW Bulk Repeat has only three sender side modifications, Bulk Retransmission, Fixed Retransmission Timeout and Intelligent Window Adjustment. BR permits efficient recovery from multiple losses in the same congestion window. To discriminate error from congestion loss, a Loss Discrimination Algorithm (LDA), based on Spike and Rate Gap Threshold, is used. TCPW BR can solve the TCP degradation problem caused by high loss rates [5].

Congestion control algorithms can be highly unfair to standard TCP flows if the network has limited buffering capabilities. To resolve this problem authors introduced TCPW BBE.A Bottleneck and Buffer Estimation algorithm that refines the Westwood policy of reducing the congestion window size upon detecting a loss..All its distinguishing characters are based on its buffer capacity estimation. TCPWBBE estimates RTTmax using a distribution of RTTs measured immediately before packet losses. Here we adopt an exponential average of the RTT measurement. A loss is estimated to be a random loss when its associated RTT is smaller than the estimated RTTmax. It shows high fairness properties [7].

III. TCP WESTWOOD: ENHANCEMENT

A. Bandwidth Estimation

In the proposed model we employ modified EWMA(exponentially weighted moving average) as bandwidth estimation technique[3].The is defined in (1).

$$BEn=(1-\alpha)\, BEn-1 + \alpha\, Bn + (Bn-Bn-1) \qquad (1)$$

Where BEn,BEn-1,Bn,Bn-1 stands for estimated bandwidth for nth packet loss, estimated bandwidth for n-1th packet loss, current and previous samples of bandwidth. α is the timely changed filter weight value and the taking value of it is in the same way as TCPW algorithm.

The Modified EWMA considers past observations similar to EWMA scheme and additionally considers past changes, as well as latest change in the process. Modified EWMA is capable for capturing signals of small shift in the process, as well as abrupt changes in an autocorrelated process. It solves the problem of inaccurate estimation of bandwidth in TCPW variants.Thus iit improves the performance in terms of throughput

B. Enhanced Model

Here we modify TCPW by distinguishing random and congestion losses. Marking of random loss packets and congestion loss packets are based on the buffer capacity estimation. In the case of congestion we set the cwnd size based on the estimated bandwidth using modified ewma method.

Packet Loss in a wireless network can be due to the random losses and congestion. Each indication of the packet loss is considered to be because of congestion leads to the poor performance of TCP in wireless networks .Packet loss indications include duplicate acknowledgements and retransmission timer out. Functioning of algorithm in presence of duplicates is shown in the figure.

In this method we are differentiating the cause of the loss by buffer capacity estimation. We are estimating the maximum value of RTT using an exponential averaging of RTT measurements immediately before packet loss .We are utilizing the method incorporated in TCPW BBE for measuring RTT max[15] using (2).

$$RTT^{i}_{max} = (1-\beta)RTT^{i-1}_{max} + \beta\, RTT \qquad (2)$$

RTT max, RTTmax upon i-th packet loss,i-th RTT and exponential smoothing factor respectively. We take β = 1/8.

A loss is regarded to be a congestion loss if the current RTT is greater than the estimated RTT_{max}.Then Bandwidth is estimated as explained in the previous session.

The new value of the slow start threshold is set according to the following equation (3).

$$ssthresh_{new} = RE*RTT_{min}. \qquad (3)$$

Then the congestion window size reset to the new threshold value(4).

$$cwnd_{new} = ssthresh_{new} \qquad (4)$$

If current RTT is found to be less than estimated RTTmax,then loss is assumed to be random loss. We do not reduce the congestion window size in the case of random loss. Congestion window size increases as before the packet loss. So it improves the throughput by avoiding reduction in cwnd size.

If the time out occurs instead of the duplicate acknowledgements, algorithm performs the same steps as a congestion event. First it estimates the bandwidth. Then set the slow start threshold value as BE*RTT min.Congestion window size will be adjusted to 1.Then enter into the slow start procedure. Digrammatic representation is shown below in figure1.

Pseudocode of the algorithm is the following.

```
if (n DUPACKs are received)
if(RTTmax<RTT)
ssthresh = BWE*RTTmin;
if (cwnd>ssthresh) /* congestion avoid.*/
cwnd = ssthresh;
endif
endif
if (coarse timeout expires)
ssthresh = (BWE*RTTmin);
if (ssthresh < 2)
ssthresh = 2;
endif;
cwnd = 1;
endif
```

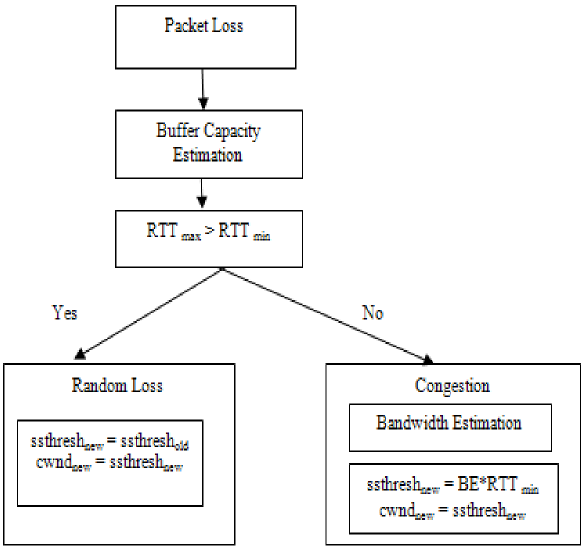

Fig1 : Diagrammatic view of the proposed algorithm

C. Significance of the enhanced model

End to end bandwidth estimation forms the basis for all better results in TCPW and its variants. Modified EWMA is used to find out a more accurate value for BE. cwnd and ssthresh values adjusted based on BE. So we get a better throughput compared to other TCPW variants. TCPW BBE shows better fairness properties compared to other TCPW variants. Since it is a modification of TCPW BBE, enhanced solution also shows the fairness properties. Distinguishing the random packet losses and congestion losses based on buffer capacity estimation improves the performance. Cwnd changes only in the case of congestion. Otherwise it increases gradually as before.It also improves the throughput.

IV. CONCLUSION

This paper examines TCPW and its important variants. Then an enhancement to TCPW BBE has been proposed. It rely on the bandwidth estimation based on the modified EWMA. Modified EWMA performs well compared to other bandwidth estimation techniques. Accuracy in bandwidth estimation improves the performance of the congestion control algorithm in TCPW BBE and thus it improves the throughput.

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