International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 1 Issue 3, May - 2012

Experimental Analysis of congestion control using delay & loss based control approaches

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***Abstract*- It presents an experimental analysis and results of network supported congestion control using delay and loss based congestion control approaches. It uses packet loss information to determine whether the window size should be increased or decreased, and uses queuing delay information to determine the amount of increment or decrement.**

Finally perform simulations to verify the properties of the proposed HCC TCP. The simulation results demonstrate HCC TCP satisfies the requirements for an ideal TCP variant in high-speed networks, and achieves efficient performance on throughput.

***Keywords*-Congestion Control, Network support approaches, Delay-based approach, Loss-based approach, HCC TCP, Simulation**

1. INTRODUCTION

A fundamental challenge for congestion control is the flow startup phase after the connection setup or after long idle periods. The Transmission Control Protocol (TCP) uses the time consuming Slow-Start mechanism in that case. The objective of fast startup congestion control is to fully utilize a path much more rapidly. Faster startups can either be realized by new end-to-end congestion control mechanisms that change the Slow-Start algorithm, or by additional on-path signaling providing information about the path[11].

In this paper, a new congestion control protocol for high-speed networks. It uses packet loss information to determine whether the window size should be increased or decreased, and uses queuing delay information to determine the amount of increment or decrement [5]. A new congestion control TCP, a new congestion control algorithm using the delay-based and loss-based approach for the adaptation to high speed and long distance network environment. The algorithm uses queuing delay as the primary congestion indicator, and adjusts the window to stabilize around the size which can achieve the full utilization of available bandwidth. On the other hand, it uses packet loss as the second congestion indicator, and a loss-based congestion control strategy is utilized to maintain high bandwidth utilization in the cases that the delay-based strategy performs inefficiently in the networks. The two approaches in the algorithm are dynamically transferred into each other according to the network status.

The protocol utilizes the delay information as the primary congestion indicator and utilizes the loss information as the second congestion indicator to jointly adjust the window size so as to satisfy the design requirements on efficiency, fairness, TCP-friendliness and robust, and outperforms the standard TCP and other TCP variants in high-speed networks. Due to the delay-based strategy and loss-based strategy, new Congestion Control TCP is a hybrid scheme of congestion control. Finally perform simulations to verify the properties of the proposed new congestion control TCP. The simulation results demonstrate new congestion control TCP satisfies the requirements for an ideal TCP variant in high-speed networks, and achieves efficient performance on throughput.

In this paper, a new congestion control protocol, named hybrid congestion control TCP (HCC TCP), for high speed networks. The protocol utilizes the delay information as the primary congestion indicator and utilizes the loss information as the second congestion indicator to jointly adjust the window size so as to satisfy the design requirements on efficiency, fairness, TCP-friendliness and robust, and outperforms the standard TCP and other TCP variants in high-speed networks. Due to the synergy of the delay-based strategy and loss-based strategy, HCC TCP is a hybrid scheme of congestion control.

2. Principles of operation: HCC TCP mechanisms and development

The synergic methods, as CTCP and TCP-Illinois [5-7], inherit the advantages from both the loss-based and delay-based approaches. Although these approaches still suffer some limitations, they are able to effectively overcome the weakness which is difficult to be remedied by either loss-based methods or delay- based methods themselves. Therefore, a new Congestion Control TCP also adopts the method that uses the synergy of the loss-based and delay-based approach to realize the congestion control for high-speed networks. Since a measurement of delay provides multi-information related to congestion but a measurement of packet loss only provide one bit information, it uses the delay information as the primary congestion indicator and uses the loss information as the second congestion indicator. This mechanism fundamentally differentiates HCC TCP from CTCP and TCP-Illinois.

2.1. Delay-based congestion control

From the perspective of a delay-based congestion control approach, such as FAST TCP, if the queuing delay on the reverse path is heavy, the full utilization of available bandwidth will never be achieved and thus lead to potentially serious degradation of throughput on the forward path. For the design of the delay-based estimation component, the mechanisms of the EEFAST algorithm are used to estimate the congestion in a network. In addition, based on this algorithm, it also adopts a set of new control strategies for adjusting the window size in order to achieve a further performance improvement.

HCC TCP utilizes delay information as the primary congestion indicator. Let $baseD_i^f$ be the minimum D_i^f observed so far, the forward queuing delay of source i is $Q_i^f = D_i^f - baseD_i^f$.

It takes the size of the anticipated window as a delay-reference in HCC TCP. As the delay-reference is determined, it adjust the window according to the value ∂wi so that enable the current window size approach the delay-reference.

2.2. Loss-based congestion control

Delay-based congestion control algorithms require a specified number of packets queued in routers so as to keep the average throughput around the full utilization. Therefore the buffer size of routers should be larger than the specified value in the delay- based algorithms, and the specified value for a network increases as the increment of source numbers. However, if the buffer size of the routers is not large enough for the specified value, packet loss might happen in the networks. To tackle this, it use packet loss as the second congestion indicator and design a loss-based congestion control strategy for the operation of new Congestion Control TCP.

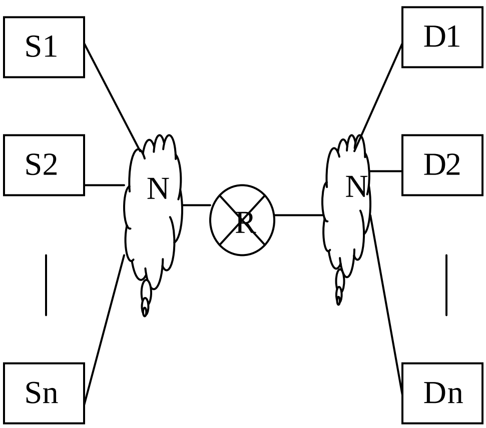
For the loss-based congestion control, when the network is close to the congestion status, the fast increment of window size could lead to the congestion event more easily and cause a heavy oscillation of window size so that degrade the throughput performance for each traffic source. The linear to logarithmic increase function, is an efficient way to avoid the heavy congestion induced by fast increment of window size. The approaches increase the window linearly at the initial stage and then increase logarithmically to get close to the reference point that a congestion event may happen. Fundamentally, the change of the window size is from fast to slow. Therefore, using such mechanisms, the traffic source can rapidly catch up the available bandwidth and also prolong the time interval between two successive congestion events so as to achieve better performance on average throughput.

2.3. Implementation Issues

At startup, HCC TCP relies on the delay-based algorithm to increase the window size. Firstly, like FAST TCP, it set a threshold value, mi_threshold, to estimate the congestion on the forward path.

If $avgQ_i^f$<mi_threshold, it indicates that the forward queuing is light, the multiplicative increase (MI) scheme can be used to rapidly

increase the window size. Otherwise, the protocol should periodically update the congestion window using the delay-based algorithm in terms of the queuing along the forward path becomes heavy. Secondly, it set the loss-reference to be a default maximum value until it is updated by a congestion event. During the start up period, the congestion window is adjusted by the delay-based congestion control algorithm and can lead to a rapid growth in congestion window size.



S1,S2…...Sn: Source; D1,D2…..Dn: Destination; R:Router; N:Network.

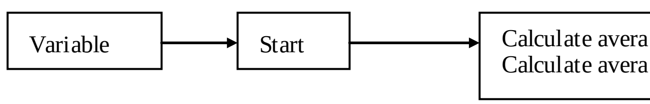
Fig1: Network Topology

3. Experimental Setup

Using ns-2, it conducted extensive simulation experiments to evaluate the HCC TCP protocol and compare its performance with TCP Reno, TCP Vegas, HSTCP, STCP, HTCP, BIC- TCP, TCP-Illinois and FAST TCP [15].

It perform simulations to evaluate the efficiency of a single traffic flow with different values of buffer size. The simulation period for one simulation run is 300 s. Figure 3 shows the average throughput for the buffer sizes varied from 100 to 4000 pkts. From the graph, it can be seen that the average throughput of all the protocols increases as the buffer size grows, and the high-speed TCP variants uniformly achieve a better throughput performance than TCP Reno and TCP Vegas which are not designed for high-speed networks. However, the average throughput of FAST TCP falls rapidly when the buffer size is less than 400 pkts. HCC TCP throughput does not change significantly for the varied buffer size. For the higher buffer sizes, its through- put slightly increases, and then approximately achieves the full utilization when the buffer size becomes higher than 400 pkts. Moreover, HCC TCP performs better on throughput performance than other high-speed TCP variants almost in all cases of buffer size.

From the simulation results, it demonstrates that HCC TCP outperforms the current high-speed TCP variants in the performance of average throughput and queuing size. This is mainly because of the hybrid nature of HCC TCP. Since HCC TCP should maintains a packets at routers when reaches the equilibrium state. If the buffer size is higher than 400pkts and it gives no packet loss, the delay-based strategy is used for congestion control, as shown in Fig.5 (b), HCC TCP rapidly converges to the equilibrium state and achieves full bandwidth utilization. Moreover, a number of packets a are maintained at the routers along the path so that results in a fix average queuing size for the traffic flow. When the buffer size is less than 400pkts and it gives packet loss events for the delay-based strategy, then HCC TCP turns to the loss-based strategy for congestion control. The linear to logarithmic increase of window size realized by the loss-based strategy keeps the window close to the congestion point for a longer time and decreases the probability of packet loss event, thus it still achieves high bandwidth utilization in the high-speed networks, as shown in Fig. 5(a).



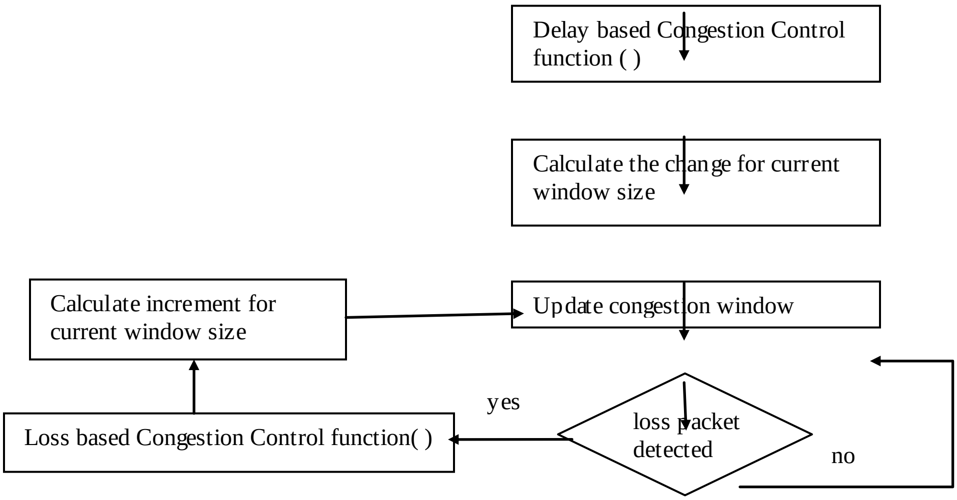


Fig2: Flowchart of congestion control algorithm

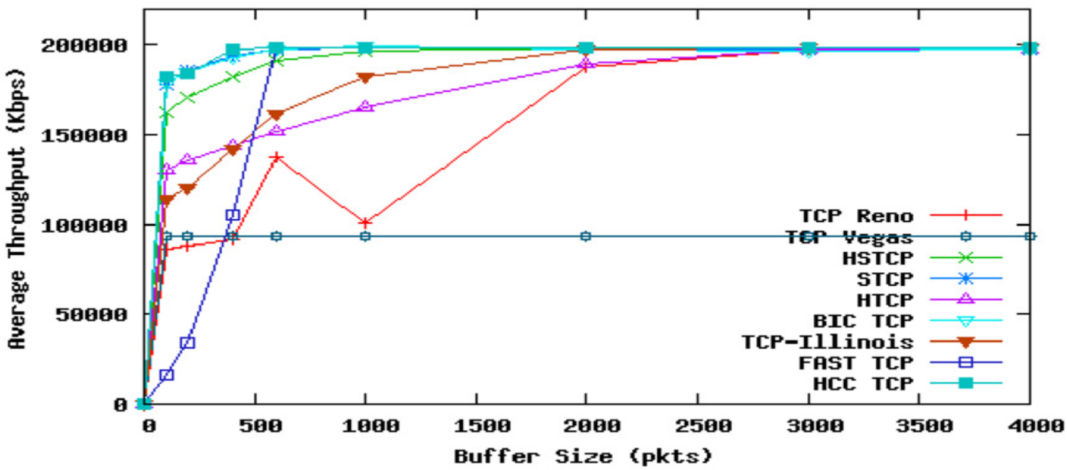


Fig.3 .Average throughput versus buffer size.

ISSN: 2278-0181
Vol. 1 Issue 3, May - 2012

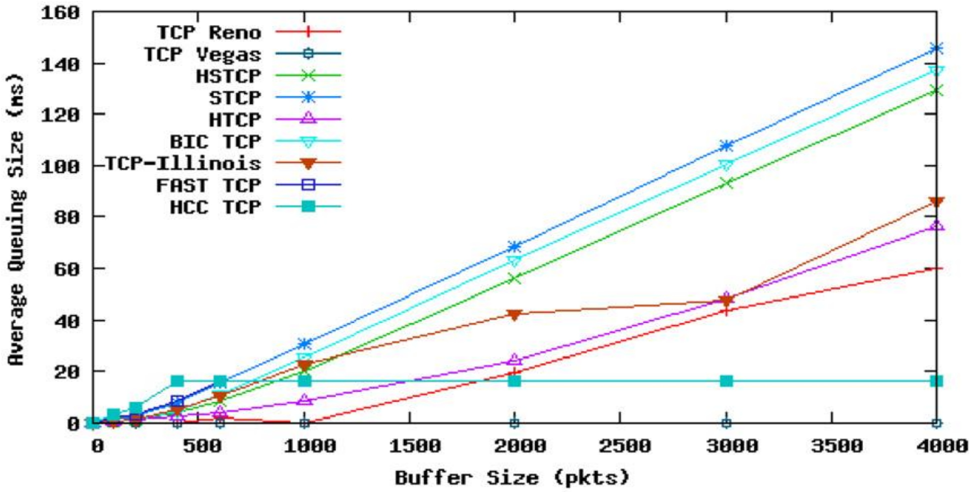


Fig.4 . Average queuing size versus buffer size.

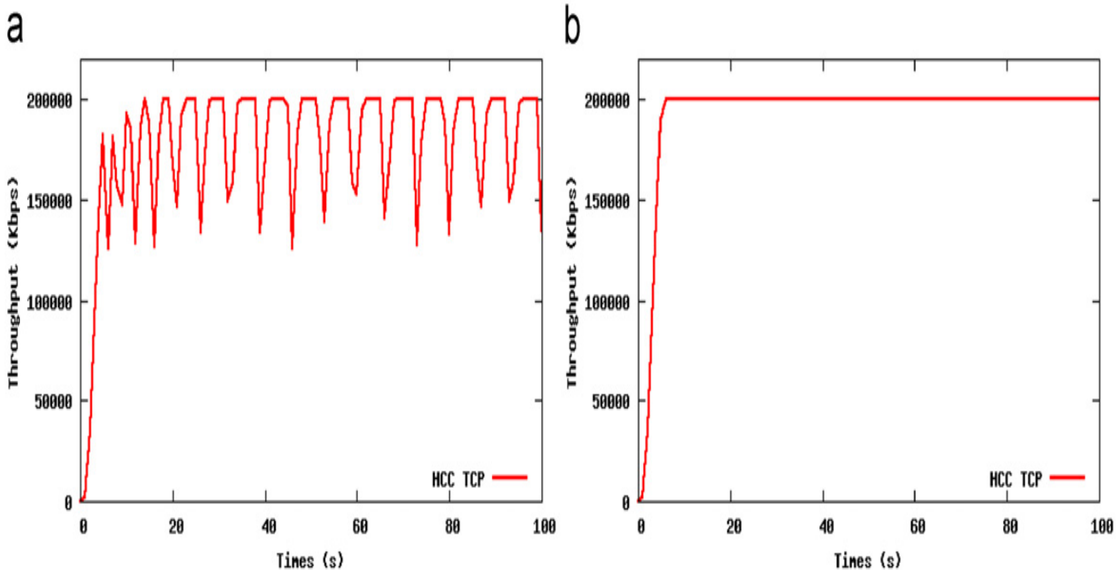


Fig.5.Rate dynamics of HCC TCP.(a)Buffer size is 200pkts and (b)Buffer size is 6000pkts

4. CONCLUSION

This paper present initial experimental results for network supported congestion control using delay and loss based control approaches. It has considered some natural requirements for a new TCP protocol for high-speed networks. A novel congestion control protocol using the delay-based and loss-based strategies is presented for performance enhancement of data transfer in high-speed net- works.

The idea is rooted in the following two assumptions or understanding of the entire congestion control system: (i) delay is indeed a useful signal, i.e., congestion or packet loss is indeed correlated to delay information; (ii) delay is not an accurate signal, i.e., the correlation between loss and delay is weak. Combining these two, it should use loss as the primary signal and delay as the secondary signal.

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