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Application of Newton Raphson Algorithm for Optimizing Transmission Control Protocol Performance

[1]Viji Priya, J. and [2]S. Suppiah

[1]Department of CSE, A.M.S Engg. College, Namakkal, TamilNadu, India
[2]P.S.Y. Engg College, Sivagangai, TamilNadu, India

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ABTRACT

Wireless networks are growing rapidly. TCP is the most widely-used protocol on Internet and so optimizing TCP performance is very important for fast efficient data transfer. The different existing TCP variants and solutions they have not been analyzed together to identify the bottlenecks in wireless networks. TCP has a major problem in its congestion control algorithm which does not allow the flow to achieve the full available bandwidth on fast long-distance links. This problem has been studied in this study using a new high speed congestion control TCP protocol based on the Newton Raphson algorithm This study further analyses involving six TCP performance evaluation constraints namely, TCP full bandwidth utilization, throughput, packet loss rate, fairness in sharing bandwidth, friendliness in short-RTT and long-RTT and these constraints are used to evaluate the proposed Newton Raphson Congestion Control (NRC-TCP) performance. This study shows that the proposed algorithm performs better compared with the other methods of application.

Keywords: TCP Congestion Control Protocol, Wireless Networks, Loss-Based Protocol, Full Bandwidth Utilization, RTT Fairness, Friendliness, Packet Loss Rate

1. INTRODUCTION

Wireless networks are increasingly being deployed throughout the world. Few attempts and solutions have been proposed to improve TCP performance (Abed *et al*., 2012; Bagde *et al*., 2013; Aarya, 2012; Torkey *et al*., 2012). Several high speed data applications require the stability of the Internet which is evolving from very high speed and long distance TCP network paths. One of current challenges of Internet is performance of TCP. These High speed TCP Networks are characterized by (BDP) Bandwidth and Delay Product which represents the total number of packets to be sent while keeping the bandwidth fully utilized. The stability of Internet is achieved by developing mechanisms to reduce transmission errors, to provide better bandwidth sharing of resources, to reduce the RTT and mainly to provide congestion control by TCP. TCP WestwoodNew estimated congestion window algorithm based on the network status and Retranmission TimeOuts to achives better throughput than TCP Westwood and decreases the delay (Hagag and EI-Sayed, 2012; Sheth *et al*., 2013).

Challenging problem is Multimedia stream over Internet Protocol (IP) networks. Several solutions exist to attain loss-tolerant multimedia applications and good perfromance. But Still current approches having limitations (Shiang and Schaar, 2012). To modified Standard TCP, the new congestion control algorithms are being developed because of more and more computers get interconnected only using TCP. The existing linear congestion algorithms generalize (AIMD) Additive Increase and Multiplicative Decrease to increase congestion window for increasing the bandwidth of the TCP connection and when the congestion occurs, the window size is multiplicatively reduced by a factor of two.

Corresponding Author: Viji Priya, J., Department of CSE, A.M.S Engg. College, Namakkal, TamilNadu, India

This study evaluates the performance of proposed NRC-TCP using simulation of proposed model in NS-2 with TCP-Linux modification (Singh *et al*., 2012). The results of this simulation are compared with the high speed TCP variants. The comparison shows that the proposed algorithm provides better performance in terms of performance evaluation constraints.

The remainder of the study organized as follows, Section 2 gives related work, Section 3 includes analysis and discussion related to property of NRC-TCP, Section 4 presents the results of experimental evaluation and Section 5 gives conclusion.

1.1. Related Works

High-speed TCP protocols can be broadly categorized into two categories based on how they sense congestion in the network: (1) Loss-Based Protocols (2) Delay-Based Protocols. Loss-based protocols use packet loss in the network to detect congestion where as delay-based protocols use queuing delays at the routers, in addition to loss, to detect congestion. Congestion control is an important component of a transport protocol in a packet-switched shared network. The congestion control algorithm is responsible for detecting and reacting to overloads in the Internet and has been the key to the Internet's operational success. However, as the link capacity grows and new Internet applications with high-bandwidth demand emerge, the performance of the TCP is unsatisfactory, especially on high speed and long distance networks A number of solutions have been proposed to overcome the aforementioned problem of TCP by changing the way in which TCP adapts its congestion window: BIC-TCP, CUBIC, Reno, TCP NewReno,Vegas,TCP Compound, TCP-Westwood,Predictive Congestion Control Protocol (Subburam and Khader, 2012; Dave *et al*., 2013; Rad and Kourdy, 2012; Tiyyagura *et al*., 2011). These new protocols promise to improve TCP performance on long distance wireless networks.

Parvez *et al*. (2010) TCP NewReno predicts the steady-state throughput for bulk data transfers as a function of round-trip time and loss behaviour under a wide range of network conditions. As their experiments are performed over a real production network path, they don't have any control over the background traffic on the network. High speed congestion control protocol performances were evaluated by calculating the efficiency,faireness while varying the RTT and the queuesiz. In conclution,Some protocols perform well in some defined cases, but weak in others and the network architecture has got an important impact on the protocols performance. Most of the protocols,exhibit substantial unfairness in their experiments and did not have any background traffic in their experiments and the results may be subject to the deficiencies such as unfairness, degradation in throughput, unfriendliness and packet loss.

TCP responds to all losses by invoking congestion control and avoidance algorithms, resulting in degraded End-to-End performance in wireless environment. The TCP congestion control should be modified to utilize the available bandwidth efficiently in wireless environments. Shakya *et al*. (2013) in thesse networks,shared wireless channal and dnamic topology cause interference and fading during packet transmission.Packet loss and bandwidth variation are caused due to congestion. Therefore time and enaergy are wasted during during is recovery.The Enhanced TCP mechanism get improve result of TCP previous technique and eliminate the congestion from the network by analyzing various network parameter like throughput, packet delivery ratio, routing overhead,TCP packet analysis.The packet loss can be caused by congestion control over a mobility and failure adaptive routing protocol at the network layer (Sharma and Bhadauria, 2012). Ahmed *et al*. (2010), they identified that throughput redection in route change results in link disconnections. Mobile Adhoc Network have dynamic number of nodes connectivity in mobility. When the number of nodes is higher, DSR and TORA would be avoided and AODV has better throughput performance (Paul *et al*., 2012).

The wireless communication TCP/IP protocol provides better and reliable communication capabilities in almost all kinds of networking environment. The wireless networking technology need some extensions to the original design of TCP for networking environment The TCP Vegas giving better result than other congestion control algorithms in the overall performance (Jehan *et al*., 2011; Zhang *et al*., 2013).

Congestion control mechanisms also have to contend with sudden changes in the bandwidth-delay product due to mobility. Such bandwidth-delay product changes are expected to become more frequent and to have greater impact than path changes today. As a result of both mobility and of the heterogeneity of wireless access types both the bandwidth and the round-trip delay can change suddenly, sometimes by several orders of magnitude. (Le *et al*., 2012) has shown that a class of non-linear TCP compatible congestion control schemes called Binomial Congestion Control schemes, which are well suited for real time streaming applications.

1.2. NRC Algorithm

Newton Raphson Congestion Control TCP is similar to High Speed TCP. It uses the value of the previous congestion window to compute its new congestion window value. It behaves like standard TCP when the congestion window (cwnd) is below a threshold value. Above the threshold, High Speed TCP acts more aggressively in attaining bandwidth by increasing its congestion window size aggressively. It suggests a modified slow start, congestion avoidance, modified fast retransmission and Fast recovery mechanism. It generalizes AIMD. If sending rate is too fast between two communication hosts, result in congestion. The router will start to discard packets to avoid congestion. As the sender detects to packet loss, it infers that congestion happens in the network. NRC-sender will start a succession of congestion control at the moment and reduces sending rate. In this case, action is taken following a recovery procedure.

1.3. Modified Slow Start

NRC-TCP differs from other algorithms during its slow start phase. The reason for this modification is that when a connection first starts it has no idea of the available bandwidth and it is possible that during exponential increase it over shoots the bandwidth by a big amount and thus introduces congestion. To end this, it increases exponentially only every other RTT and calculates the actual sending throughput to the expected. When congestion window exceeds or equals slow start threshold, it exits slow start and enters the congestion avoidance phase.

1.4. Congestion Avoidance

When congestion window exceeds or equals slow start threshold, the state enters congestion avoidance. The congestion window is increased by ea where α is window scaling factor determined by real roots of algebraic equation which are found by Newton Raphson method for every arrival of a new acknowledgement until congestion occurs.

1.5. Modified Retransmission

As packet loss happens, the TCP sender receives three duplicate ACK and triggers modified fast retransmission and fast recovery immediately. Then the sender does not wait for retransmission timeout to send lost packet back. Besides slow start threshold will be set as e^{β} or double Maximum Transmission Unit (MTU) and set up congestion window as slow start threshold plus 3 MTU.

1.6. NRC-TCP Window Growth Function

The window adjustment policy is only one component of the congestion control protocol derived from Newton Raphson congestion control algorithms. The proposed algorithms mainly aim in increasing the window size faster and to gain the bandwidth quicker. NRC-TCP is similar to High Speed TCP. It uses the value of the previous congestion window to compute its new congestion window value. NRC-TCP behaves like standard TCP when the congestion window is below a threshold. Above threshold NRC-TCP acts more aggressively in attaining bandwidth by increasing its congestion window size aggressively. In Equation 1 on each arrival of a new acknowledgement, NRC-TCP increases its congestion window. In Equation 2 When congestion is detected through packet loss, the congestion window is decremented:

$$W' = w + e^{\alpha};\ \text{if no loss} \quad (1)$$

$$W' = w - e^{\beta};\ \text{if loss} \quad (2)$$

Where:

W' = Current congestion window
w = Previous congestion window
α = Real root of rational integral equation for increasing congestion window size
β = Real root of rational integral equation for decreasing congestion window size

Both α and β are determined by Newton Raphson Method.

1.7. Results of Experimental Evaluation

A lot of experiments have been performed with any congestion in the following network to study and test the performance of High speed TCP variants with the proposed NRC congestion control mechanism and the results are compared with the previous high speed TCP variants such as BIC-TCP, CUBIC, High Speed TCP, H-TCP, Scalable TCP, using NS-2 with TCP-Linux modification.

It consists of six wired nodes, one router, one base station and six mobile nodes. First six wired nodes are connected with a router through 100MB (Mega Bytes) bandwidth and 10 ms delay duplex wired connection. The router is connected with a base station through 10

Mb and 100 ms (milli sec) delay duplex wired connection. Then six mobile nodes and the base station are connected with a wireless duplex link a number of flows which traverses the bottleneck Router R and Base-station BS in between. Here the Adhoc routing protocol (DSDV) used to route the packets to its correct destination. The traffic used File Transfer Protocol (FTP). The flow of NRC-TCP is started 50 sec after flows of the previous High Speed TCP variants for 300ms. The result shows that the NRC-TCP is able to increment its congestion window very quickly so that it can attain the whole of available bandwidth by increasing the congestion window accordingly. The mean throughput of the existing algorithms is quantity low. A better performance with the NRC-TCP Agent is observed. NRC-TCP gives an improvement in the value of mean throughout obtained after a simulation of 50ms.

TCP-Packet Loss Rate and Fairness for each flow are measured as shown in **Fig. 1 and 2** respectively. From the graph NRC-TCP algorithm is better and its PLR is zero, even if the number of packets sent is very high. The proposed NRC-TCP is much fair in sharing the bandwidth compared to previous High Speed TCP Variants.

In the above experiment, we vary the bottleneck bandwidth from 20 Mbps to 1 Gbps and set RTT to 10ms for Short-RTT and 100 ms for Long-RTT. TCP Friendliness in Short-RTT and Long-RTT Networks are measured as shown in **Fig. 3 and 4** respectively. NRC-TCP can still use the full bandwidth. Overall, it shows a better friendly ratio than the other protocols.

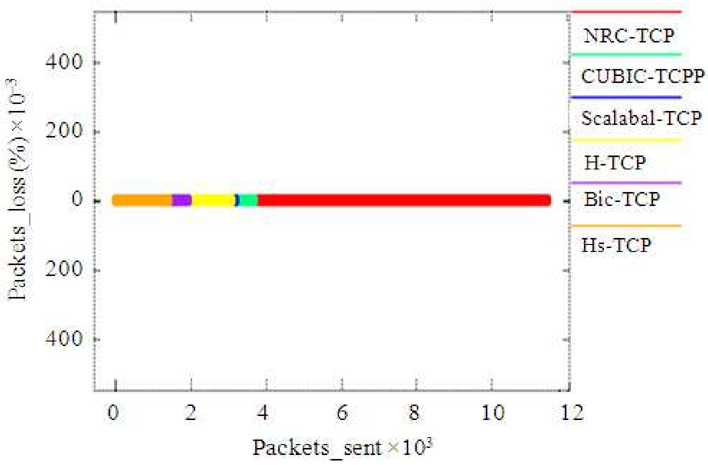

Fig. 1. TCP-Packet Loss Rate

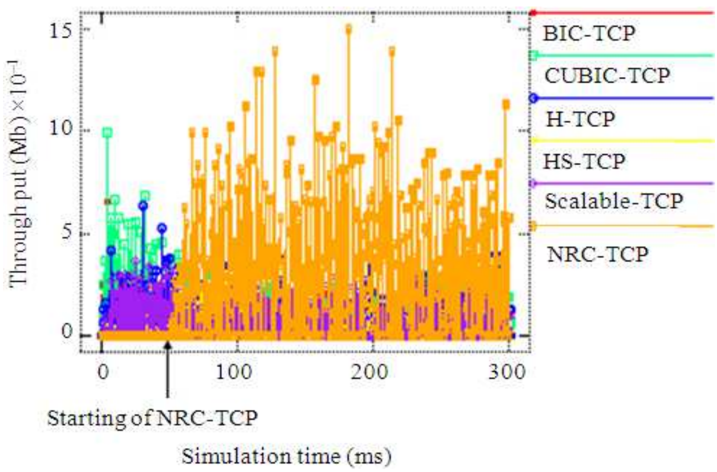

Fig. 2. TCP-Fairness

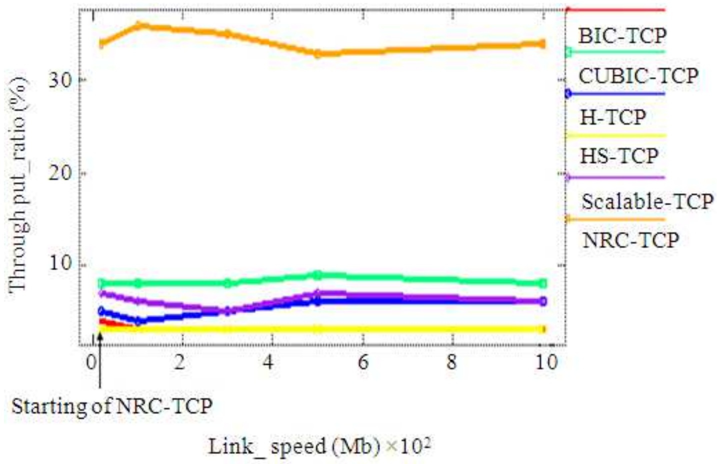

Fig. 3. Friendly Ratio in Short-RTT Networks

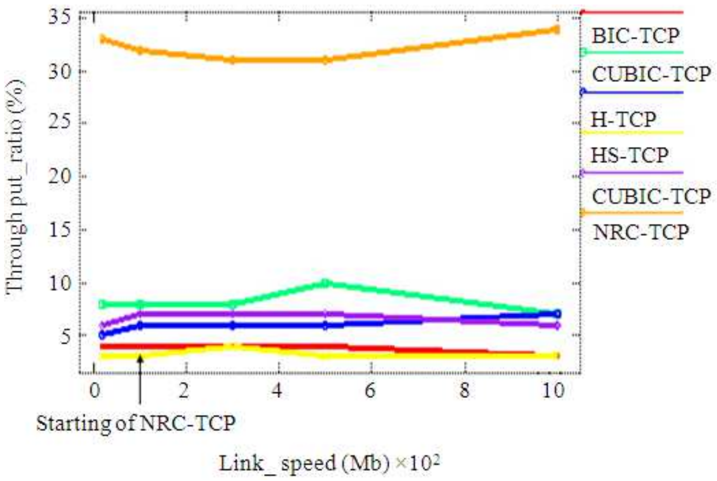

Fig. 4. Friendly Ratio in Long-RTT Networks

2. CONCLUSION

A detailed evaluation of a new friendly NRC-TCP with previous high speed TCP variants has been developed using NS2 simulator. The outcome of the study shows that (1) NRC-TCP is able to increment its congestion window rapidly when compared to previous high speed TCP variants. (2) The mean throughput of NRC-TCP has improved after a simulation of 50 ms. (3) when compared to PLR, the present algorithm (NRC-TCP) performs better. (4) The fairness has been improved when NRC-TCP algorithm is being improved. (5) Friendliness and fairness have improved, when NRC-TCP algorithm is adapted. The above comparison shows that the present study based on NRC-TCP performs better than the previous high speed congestion control mechanism such as BIC-TCP, CUBIC, HS-TCP, H-TCP and Scalable-TCP.

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