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TCP Window Based Congestion Control Mechanism

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Abstract: As we know Transmission Control Protocol (TCP) is improving itself with the help of many researchers working in this area all over the World. Many papers and proposals have been submitted by the different researchers to improve the performance of TCP by the congestion control mechanism. In this concern paper, we are able to improve the transmission speed through the window size congestion control technique which is playing an important role in the field of communication. As we already know there are two main important techniques to overcome the congestion and these are the Avoidance algorithm and Slow start mechanism. Now to specify the TCP there are multiple start-ups are existing to specify that start-up speed is selectable from an n-array set of algorithms. If well work and implement these algorithms we can improve our performance and control the congestion. This paper provide the depth analysis of the existing congestion control techniques and provide the model which is helpful to control congestion.

Keywords: Algorithm, Congestion avoidance and control, TCP.

I. Introduction

The Internet was specially designed to provide the best performance to the user's needs. That's why the TCP was designed, so that, the delivery of data among the sender and receiver should be reliable and they feel comfortable by sharing the concerned material over the internet [1]. If we observe in earlier days work, there were no specific work or techniques to improve the performance or provide the best delivery. Therefore, it is noteworthy that the main focus is on user's applications having low network utility in comparison to the heavy network congestion. They appreciate working on the internet by TCP data flows carrying data from the concern applications i.e. HTTP, FTP, SMTP, etc. With the passage of time, the internet works also changing gradually and there is much other existing traffic those are including some extra and different data of transmission protocol. Some protocols and applications are not dynamics to the Internet. However, the TCP is always dynamic to the Internet which is great in today's life. TCP creates the data into the segments so that the network congestion can be reduced to the minimum level. There are some specific applications and protocols that are not dynamics to the concerned internet are TCP unfriendly protocols. Such types of protocols and applications are consuming the specific bandwidth which is wasted by them. So, at bandwidth consumption also not responding to network congestion as well. As we above discussed regarding the TCP unfriendly applications there are some for example; video-conference, voice-over-IP, and online video streaming. These all are belonging to UDP and TCP unfriendly.

If we discuss Congestion Control, so it is the method to put the condition by using some techniques to save the packets that are dropping due to congestion. We can control the congestion by putting network condition and save the lost packet and end-to-end delay with some effort. In the World still, there are two main techniques of congestion control. those are Rate-based and window-based congestion control. If we talk about Window-based Congestion, by using this type of approach we can adjust the transmission rate of the specific data by setting a congestion window size through AIMD (Additive increase and multiple decreases) algorithm. This will help us smoothly data flow and congestion will occur at the minimum level. While if we come to another technique the Rate-based, it is a set of specific equations that are used to overcome the transmission speed of the concern data. However, our research paper is totally dependent upon controlling the congestion over the TCP. Therefore, the Window-based approach will be our main focus to control the congestion and improve the transmission speed over the internet [1-2].

The AIMD (Additive increase and multiple decreases) algorithm, as well as the changing and modifications besides the algorithm in the cross, traffics and different flows are also appreciated and motivated material to us. Therefore, we take an overview of the similar and significant efforts by the researcher including proposals and researches which are concentrating on the implementation, and understandable regarding the window-based congestion control. Having especially focus on the congestion avoidance stage. Moreover, by studying

recent researches by different researchers our attention will be towards better modification and understanding of window-based congestion control by specific concern on slow-start and acknowledgement congestion control. Both congestion control techniques are playing their important role to improve the TCP transmission speed of the data [1].

The main focus of our concern paper is to overview the existing proposals in the TCP field of congestion avoidance and slow-start mechanism. By using these techniques, we are putting effort to build and motivate a new direction in the area of network utility with maximum output. The paper is arranging and organized into the following aspects: Section II: Standard Congestion Control Algorithm. Section III: Delay-Based Congestion Control Algorithm. Section IV: Summary of Proposed TCP Congestion Control Implementation. Section V: Models Regarding Controlling the Congestion. Section VI: Routing Congestion Issues. Section VII: Research Direction. Section VIII: Conclusion.

II. Standard Congestion Control Algorithm

Some different algorithms of TCP are existing and already been implemented, those are serving the concern slow-start algorithm.

A. TCP Tahoe

The TCP Tahoe [3] was the first algorithm being implemented for the TCP to serve as a congestion control algorithm. In this specific algorithm, we used to AIMD congestion control mechanism. TCP Tahoe algorithm technique method is used to adjust the window size by the AIMD approach. In this concern approach, at its beginning stage, it increases the window size in exponent form but if some threshold occurs, it changes itself to the linear window size and increases, i.e. by one packet per RTT to save it from congestion occurring method. Therefore, at this point, the TCP Tahoe changes to the congestion avoidance state. If this condition occurs and the ACK is not received before the timeout happens, the threshold is automatically reduced by half, therefore the congestion window is also reduced to one packet (with multiplicative decrease) in the scenario. The working of TCP Tahoe is as following:

Whenever the specific congestion window will below the concern threshold, it will grow the window in exponent form which is a slow start state. However, if the concerning window will above the threshold, it grows the window in linear form which will be an additive increase in terms of congestion avoidance. After threshold procedure it there is an occurrence of the timeout, threshold set to one half of the updated or current congestion window will set to one. Moreover, the packet will be retransmitted which terms multiplicative decrease.

B. TCP New Reno

By using the technique of this algorithm at the sender's end with the idea to remove Reno's wait related to retransmit the timeout if multiple Number of packets have been lost from a window. New Reno provides us with the technique to update or modify the sender's data during the fast recovery. However, when such types of situations occur, New Reno does not exist from the concern and important fast recovery state. But it also waited for the receipt form of all the outstanding ACKs for the specific window. TCP New-Reno technique is the good one technique to overcome the congestion control as window-based principles. If we talk about the summary of New-Reno when we are taking the fast recovery actions which are given below:

- While entering into the fast recovery first, it notes the maximum packets containing the request.
- When a new ACK is received and it acknowledges all the outstanding packets, then the fast recovery exists and cwnd is set to half the value of ssthresh, then it transits to the congestion avoidance state. But, if a partial ACK is received, then, it assumes the next packet in the link is lost and tries to retransmit. It exists fast recovery when all data in the window is acknowledged.

III. Delay Based Congestion Control Algorithms

In this algorithm [4] the packets which are in queuing and in delay form and forward the signal needed for the adjustment of the window-based algorithm. This technique is useful and beneficial as compared to others. It resolves the issue of fairness by using the queuing delay principle. Therefore, for the implementation of the delay-based congestion control algorithm, it is obligated to get the propagation delay, without measuring the propagation delay you can't do the delay-based congestion control algorithm. If we talk about the propagation delay which takes an individual packet to travel from the concerned sender to its specific destination defined by the sender. Moreover, this type of delay is commonly set to the smallest observed Round-Trip Time (RTT). If we observed in the specific area, there exist many observed problems for the estimation of the queuing deleted. Few types of research have been conducted in the area of delay-based congestion regarding wireless mobile networks and proposed the congestion control scheme to CDMA (Code Division Multiple Access). This is the specific scheme to improve the wireless network which is increasing day by day.

Many other researchers are also existing and still working on such type of field likewise High-Speed, Large-Delay Networks, etc. We have some famous among them are HSTCP (High-Speed TCP) and STCP (Scalable TCP) which are rarely experimental protocols. By using these protocols we better comprehend the TCP performance under large bandwidth-delay products.

IV. Summary of Proposed TCP Congestion Control Implementation

As we already discussed related to the TCP Tahoe, Reno, and New Reno Algorithm. They are also called and referred to as

New-Reno. However, it depends upon the transport protocol and implementing approximately 90% in today's internet traffic which involving all over the world. In Fig. 1 we thoroughly explain the comparison between TCP New-Reno and other important TCP algorithms [4-5].

The specific TCP protocols are organized which are totally based upon their control mechanism or any type of feedback. They are in categorized form so that it can be understandable. Here, we also mentioned the challenges related to the performance of New-Reno which it tries to address. The Transmission Control Protocol (TCP) having highlighted algorithm those are loss-based, delay-based, loss-based delayed, bandwidth estimating and extra signalling, etc. These all the important ones and playing their role in the congestion control mechanism. There were and still proposing as well as providing the researches so that the performance can be improved for the benefit all over the world and save the packets that are lost due to congestion in the network.

A newly TCP technique termed as west-wood technique proposed the estimation of bandwidth congestion. Moreover, by measuring the specified that in TCP a sender regularly computing the connection bandwidth to properly estimate the averaging to return the ACKs and the rating value at which the concern ACKs are received. When a loss has occurred during the ACKs, then the specific sender uses the estimated bandwidth at properly sending rate as well as according to the congestion window where the size of the packet has been specified. This is used for a safe procedure to avoid the loss of packets. Therefore, by using this technique we can save our data from loss and it will detect the loss when it half its window size. This is an improvement in standard TCP. If we review the other proposed protocols likewise XCP which requires the changes or modify the direct router algorithm to avoid loss of packets or congestion avoidance. High-Speed TCP (HSTCP) was also specially designed to provide high bandwidth-delay product. HSCTCP particularly used to loss-delay so it can detect congestion. Moreover, other protocols in this category including BIC TCP, STCP, CUBIC TCP, etc. Such types of protocols especially work with modification of window function related to TCP, so that, TCP can match the large bandwidth-delay product. However, this seems easy to implement but the main problem or issue of fairness that involving such types of protocols is tremendous and still having a challenge which is unbearable.

V. Models Regarding Controlling the Congestion

Models regarding controlling the congestion have been proposed to provided by different researchers to overcome the problem for betterment. By understanding and implementing these types of ideas we can improve the TCP performance. Classified models for congestion control are related tools as: Higher throughput with high capacity and large delay Packet level models: First the packet level model which Higher throughput with high capacity and large delay take care or responsible for the specific location of each individual packet as the packers are in queue and also Higher throughput with high capacity and large delay forwarding by the network to reach its destination. The Higher throughput with high capacity and large delay related system state is evolving a series of discrete events Higher throughputs and reduced loss rate those are not similar to each other and showing unique. The arrival and departure of packets showing specific Higher throughput with high capacity and large delay events and their timeout when the session will be ended. Fluid flow models: Secondly, the model of the fluid flow supervises the data transport as is continuous fluid, which having no packet boundaries. In congestion control, it is not responsible to capture all the related details of the dynamics to the internet, instead, it just represents averages of the system. Hybrid Models: The third one is Hybrid models, Between events, there is an evolution of the state as a result of discrete events together with continuous changes between events. For queuing, dynamics continuous model is used and end-host actions like multiplicative decrease of TCP is shaped as a discrete event [6].

A. Slow Start Phase

1) cwnd = 1; then Starting point with a window size of 1
2) while (ssthreshcwnd OR not 3-DUPACK [

   IF ACK, then

   cwnd = cwnd + 1;] will Increase the window size by 1 for every

   ACK received. then Repeat until;

   The specific ssthresh will reach OR packet-loss is detected
3) if (ssthresh == cwnd) then

   should Transit to congestion avoidance; If ssthresh will reach, then go to congestion avoidance phase.
4) if 3-DUPACK then

   ssthresh = 0.5 * cwnd;

   cwnd = 1;

   branch to step 2; If a packet loss is detected

B. Congestion Avoidance Phase

1) First, Increase the window size by 1 (cwnd) whenever every ACK received. This will show us that the concern window size is increasing by 1 then at specific time all ACKs for that window will have been received.
2) Whenever packet loss is detected by the phase, then decrease the concern window size, afterwards transit to the slow start phase.

By Detecting and decreasing the window size, it as being the most important area or researchers are focusing to provide the formation of different TCP variants as we already discussed above likewise TCP-Tahoe, TCP-Reno, and New-Reno, etc.

VI. Routing Congestion Issues

In terms of Routing congestion, it occurs when there are numbers of routers that need to pass through an area with limited "routing tracks,". Then it can cause a problem like a delay in packets to their destination [7]. It will be in queue until the packets or routers get their turn. Such type of problem will cause a delay in our project schedule which we can't afford in today's life. The concern Logic designer, if try to attempt to avoid such type of problem and achieve betterment by organizing or adopting a physically aware and congestion-aware synthesis methodology. These methodologies reduce iteration between the front-end and back-end teams and provide products that positively impact die size and its schedule time. Nowadays there are fewer routing resources per cell are existing, which will create or produce acute problems in the future. Such types of routing resources will create a congestion problem in the upcoming days. But it not limited furthermore, the "metal 2" layer is commonly the part of today's life. It is providing easiness to pin access but at disadvantage also decreasing the routing resources which is an alarm to us.

There are some complex power architectures such as multi-supply voltage or power shutoff-all are very commonplace occurrences today. It means by fewer resources for signal routes it will create a greater probability of congestion. Therefore, higher-speed designs have more signal integrity constraints, likewise, there are extra route spacing or wide routes as well, this also reduces available routing resources. This is a fact, By creating lower frequency designs it doesn't mean to remove congestion either, in terms of the higher ratio of combinational logic to more registers, it means there will be more pins to route to per unit of area. These types of issues are impacting like physical design problems; however, they can negatively impact the overall success of the project in the future. If there will be not enough resources with which to route, some routes must be diverted around the congestion.

The overall difference between each technique is shown in Fig. 1.

VII. Research Direction

Now there are different research directions existing and intend to produce or develop TCP betterment to make it efficient towards the future. By improving TCP performance over the link with huge bandwidth-delay product, also puts effort by improving wireless and reducing the queuing delay which having limited values over the links thereby improving quality for real-time applications. However, other focus of research includes finding a suitable startup speed for a slow start most especially including the product which using high bandwidth-delay. The modification of TCP for future's use will work well with gigabit networks as well as the low-speed networks having backward compatibility [8-9]. A protocol fair to both itself and to other flows in the network i.e. Intra and inter protocols fairness. By Controlling acknowledgement packets congestion is a novel problem and differs from the technique used in controlling data packet congestion.

TCP Congestion Control Variants	Supported Features	Problems
TCP Tahoe	• Slow start algorithm • Congestion avoidance • Fast retransmit	• Coarse grain timeout • Multiple decreases in cwnd
TCP Reno	• Slow start algorithm • Congestion avoidance • Fast retransmit • Fast recovery	• Multiple packet loss in the same window
TCP New Reno	• Slow start algorithm • Congestion avoidance • Fast retransmit • Modified fast recovery algorithm	• Only one packet can be retransmitted in a RTT
TCP SACK	• Slow start algorithm • Congestion avoidance • Fast retransmit • SACK options at the receiver	• Current receivers are unable to support the SACK options

Fig. 1: TCP Congestion Control Varitains and Findings

VIII. Conclusion

There is a large number of works done in the area of TCP. We reviewed here and focused on window-based congestion control. The choice depending upon the internet protocol, TCP New-Reno, has performed very well in today's internet, the question is that how the TCP combine with a different type of protocols those are more responsive and aggressive to produce the congestion and show its indication? In future protocols, they may have their aggressiveness matching while controlling congestion effectively.

What should be the slow start behaviour of TCP under this situation? Will TCP be both backward, and forward compatible including high speed and low-speed network without using necessary resources of network sub-optimally? In addition, it

was observed that all reviewed congestion control techniques used only a single start-up for TCP, this is in most cases the slow start or its modification. Research in this area called e-speed start uses specific environmental those are operating parameters to determine either again to use the traditional TCP slow start or any type of start-up algorithms depend upon network operating condition. In upcoming days the term E-speed start will work resolve the issue related to TCP which is an important challenge for the logic designer to start-up in both high-speed and low-speed networks.

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