STUDIES ON THE PERFORMANCE IMPROVEMENT OF WINDOW ADJUSTMENT PROCEDURE IN HIGH BANDWIDTH DELAY PRODUCT NETWORK

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ABSTRACT:

High bandwidth environment is useful for sending large volumes of data within short period of time. As there is a growing demand for high bandwidth networks, data transfer must take place without any congestion. Hence attempts have been made to find a suitable window adjustment procedure for congestion avoidance. In TCP, since window size is usually increased by 1 MSS/RTT and halved upon packet losses in any network, it is not suitable for high speed network. In this paper a study is made on window adjustment procedure for high bandwidth networks using XCP protocol. The window adjustment procedure is based on the queue and admitted rate .This proposed idea will be useful for high bandwidth environment for congestion avoidance. Performance of bandwidth utilization and throughput is presented.

Index terms-*TCP/IP, congestion window, Explicit control, bandwidth-delay product, congestion control.*

1. INTRODUCTION:

As with increase in the amount of data transfer across the various networks, to achieve low delay, maximum throughput and predictable performance on an end-to-end basis [1], a high bandwidth environment is required. An increase in bandwidth and data rate leads to congestion. So congestion has to be avoided while sending large volumes of data within short period of time.

Congestion window mechanism in TCP increases the window size to their threshold value and drastically decreases at the time of congestion in high speed network [3]. This is because TCP increases and decreases its congestion window size too slowly with non duplicate ACK packets 9. If we require responses to be quicker, then a connection with large RTT must be present than a connection with smaller RTT, because increase of TCP is tied to each RTT.

If large amounts of data have to be sent then TCP sends all these packets based on the window size and which can increase the congestion problems, because the window size is halved [8]. In TCP, loss of packets by itself acts as a signal which indicates the sender to lower down the congestion window to limit the number of packets to be sent and thereby congestion can be reduced.

Thus TCP initiates congestion control only if a packet is considered lost. To recover from the packet loss, congestion window size is reduced by half, and so the congestion window size is increased by 1 segment for every Round Trip Time. For example, in 10 Gbps connection, initially the link will operate at 10 bps connection and then gradually increase to 10 Gbps and hence by means of TCP it will take more time to transfer data on high speed networks. Due to the gradual increase and sudden decrease in high speed network, utilization of bandwidth by TCP is very poor [13].

The chief characteristic of high-speed TCP is that it is not delay based and it increases network utilization. But high speed TCP will not compete fairly with TCP in reliable and high speed network. Scalable TCP scales well on high bandwidth-delay networks and provides alternative to standard Transmission Control Protocol. Delay variation information is collected at sender's side and depending upon the gathered information. A decision is made to change the congestion window size. BICTCP identifies a target window size using binary search scheme. This protocol utilizes the bandwidth effectively when compared with the HSTCP and Scalable TCP. The high speed protocols like HSTCP, Scalable TCP and BIC TCP perform well when compared with TCP. But compared with all the above TCPs the protocol XCP performs very well. The comparison of high speed protocols with XCP is shown in Table. 1.

Protocol	Router feedback	Delay based	Loss based
TCP	No	No	Yes
HSTCP	No	No	Yes
Scalable TCP	No	No	Yes
BIC TCP	No	Yes	No
XCP	Yes	Yes	No

Table 1: Comparison between the various protocols available for high speed networks.

Section 2 explains the basic concepts of XCP. Section 3 explains proposed scheme and model. Section 4 indicates the Simulation Results. Section 5 has the concluding remarks.

2. XCP BASICS:

2.1 XCP overview:

The per-flow product of bandwidth and latency increase leads to TCP becoming inefficient and prone to instability [2] [5]. The new Explicit Control Protocol outperforms TCP and remains efficient, fair, scalable, stable and XCP generalizes Explicit Congestion Notification proposal. XCP is modeled and demonstrated as stable and efficient regardless of link capacity, round trip delay. XCP achieves fair bandwidth allocation, high utilization, small standing queue size, and near-zero packet drops with both steady and highly varying traffic. Additionally, XCP does not maintain any per-flow state in routers and requires few CPU cycles per packet, which makes it suitable for high speed networks. The overview of the XCP is shown in Fig.1.The senders informations are sent to the router and the router is performing the data flow through the EC (Efficiency Controller) and FC (Fairness Controller).

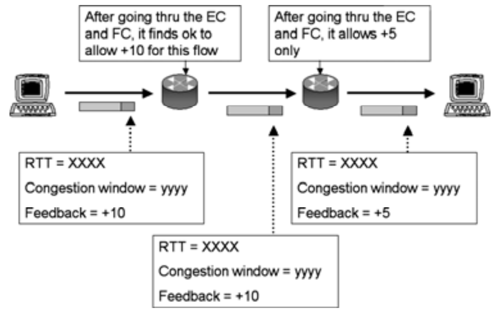

Fig 1. XCP Overview

2.2 XCP header

The XCP or congestion header is present between IP and transport headers and it is 32 bits in size. XCP is an end-system-to-network communication [2] [5]. The Header format of the Explicit Control Protocol (XCP) is shown in Fig.2.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|version|format |   protocol    |    length     |    unused     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              rtt                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          throughput                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       delta_throughput                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       reverse_feedback                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Fig .2.The XCP header Structure depicting various fields

The XCP congestion header consists of the following fields:

Version(4 bits): This field indicates the version of XCP that is in use.

Format(**4 bits**): This field contains a code to indicate the congestion header format

Protocol (**8 bits**):This field indicates the protocol to be used in data level portion of the packet.

Length(8 bits): This field indicates the length of the congestion header, measured in bytes.

Unused(8 bits): This field is unused and MUST be set to zero in this version of XCP.

Rtt(32 bits): This field indicates the round-trip time measured by the sender, in fixed point format with 28 bits after the binary point, in seconds.

Throughput(32 bits): This field indicates the inter-packet time of the flow as calculated by the sender, in fixed point format with 28 bits after the binary point, in seconds

Delta Throughput (32): This field indicates the desired or allocated change in throughput.

***Reverse Feedback*(32):** This field indicates the value of Delta Throughput received by the data receiver. The receiver copies the field Delta throughput into the Reverse Feedback field of the next outgoing packet in the same flow.

In a high speed network, network congestion may cause more losses due to the fact that congestion windows may grow to very high values[10]. But in the proposed scheme window adjustment procedure is to control the congestion in the network based on the feedback given from the receiver end. The features that make explicit control protocol (XCP) usable in high speed networks is that control information is carried in congestion header and the explicit congestion notification proposal is generalized [2] [4] [5]. The extent of congestion is sent to the sender by the receiver or router. Then the sender can increase or decrease their sending windows in response to the network state.

2.3 XCP layer

XCP is a joint design of end systems and routers and it differs from the end-to-end design of TCP and the hop-by-hop design of IP[2][5][7]. The Position of XCP in the protocol suite is shown in Fig.3.This protocol is placed between the TCP and IP and it is a transport level protocol.

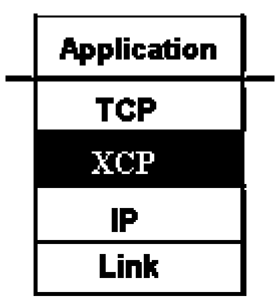

Fig .3. XCP Layer

3. PROPOSED SCHEME:

To avoid the congestion in high speed network, window adjustment procedure is being used. Here the arrival rate is compared with the service rate. If the arrival rate is less than service rate then at the same time the queue position (Qp) is compared with the queue threshold value (Qth) and operates as follows.

If (arrival_rate < service_rate) and Qp < Qth
then normal flow will occur

Otherwise the network is under congestion state. So according to the receiver's feedback, the sender has to resize the window. In the existing system, the window adjustment procedure is after sending the packets from sender to receiver, the end system (receiver) has to send the acknowledgement to the sender. At the time of congestion, the sender will receive the duplicate acknowledgements for the same packets. When the sender receives the third duplicate acknowledgement from the receiver, then the congestion window size is modified according to the admitted rate and rtt value.

In the proposed work, the congestion header has Protocol, Version, Format, RTT and Delta Throughput, Reverse_Feedback with 1 bit value added. If the bit value is 1, then the network is under congestion at the time of sending the header information from receiver to the sender. Else if the bit value is 0, the normal flow will occur. So in this proposed work, duplication is avoided. During the flow time, the congestion bit value is sent to the sender and the window size is updated based on the queue and admitted rate. So the sender is sending the data according to the window size.There is no drastic changes in the window size. So automatically the transfer time is minimized and throughput is maximized.

Here, according to the bit value the congestion window size will be modified. If the bit value is 1, then the congestion window(Cwnd) size becomes modified based upon queue size.

If the queue position is equal or greater than Qth implying the utilization of the bandwidth is maximum due to traffic, then the sender rate has to be reduced. So the window size is minimized using the following expression.

*Cwnd =max(admitted_rate * rtt * 0.02,MSS)*

Otherwise, if the queue position is less than the threshold value then the window size will be modified according to the admitted rate and conversion factor. The expression is,

*Cwnd = max(admitted_rate * rtt * 0.05,MSS)*

3.1.ALGORITHM

1. Intialize all the header information and add the bit value in the Reverse_feedback field.

2. If(arrival_rate < service_rate) and Qp < Qth
   then normal flow will occur
   else

   /check the bit value/

   If bit_value = 0 then
   /* normal flow */
   Else
   /* congestion occurred */

a) If(Qp >= Qth) then
   / *Queue is full, AR-admitted rate*/
   Cwnd=max(AR*RTT*0.02,MSS)
   Else
   /* Queue is normal */
   Cwnd=max(AR* RTT* 0.05,MSS)

3.2. ARRIVAL MODEL AND SERVICE MODEL

a) Arrival Model (λ)

Assumptions:

1) The network will not be idle at any circumstance.
2) The arrival rate (Number of packets per second) is calculated based upon the link capacity.
3) Arrival packets are based on poisson distribution

$$A(P) = \frac{e^{-\lambda t} (\lambda T)^n}{n!}$$

λ- Arrival rate T-Time duration
t- Time interval n-Number of packets

b) Service Model (μ)

Assumptions:

Service rate is based upon the exponential distribution.

$$S(N) = 1-e^{-\mu s}$$

μ-Service rate s-Number of services
N-Number of packets

4. SIMULATION RESULTS

a) Network

The performance in Windows adjustments is compared with HSTCP and BICTCP. The simulation results of XCP shows a 98% throughput compared with other TCPs. For giving this result the scenario is tested with a dumb-bell topology represented in Fig 4.The simulations are run in NS2.

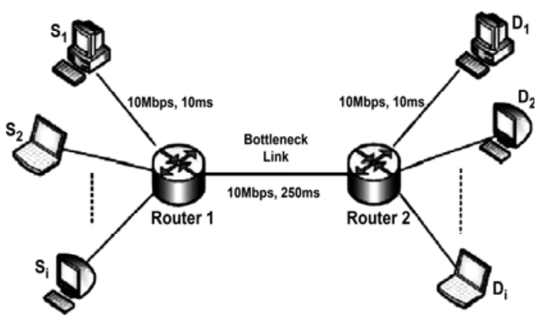

Fig. 4. A simple network configuration for NS-2 Simulation

In this scenario the nodes with 10 Mbps bandwidth and delay of 10 ms is considered in full duplex access link. The router link capacity and delay is 10 Mbps and 250 ms. The parameters taken for comparison are number of packets with time.

b) Window Size

Considering the various success of TCP such as HSTCP, BICTCP which are considered as best in performance, the windows adjustment is achieved to an extent of 90% [14]. The results are best enunciated in the following graphs. Fig .5 depicts the performance of HSTCP. As in the Graph, When Congestion occurs, the entire performance of the network drips down indicating vagaries in performances. In HSTCP, 10,000 packets are transmitted during the time interval 0-200 sec. Then due to the window size adjustment there is drastic decrease and the throughput is minimized and at the same time the utilization of the bandwidth is decreased. The simulation results of HSTCP with respect to time and packets flow is given in Fig 5. So the window size is updated based on the flow.

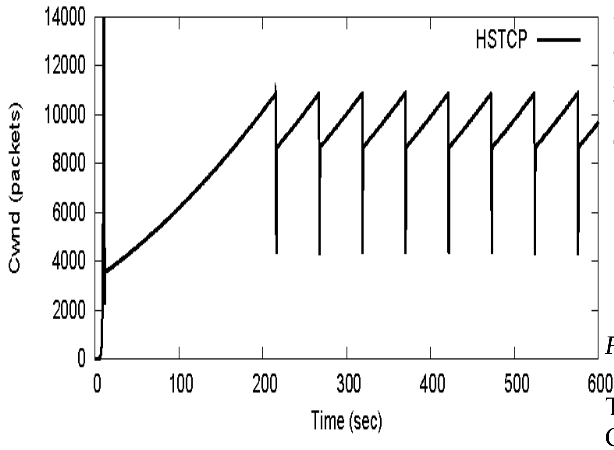

Fig .5. cwnd versus time under the HSTCP scheme

In case of BICTCP, it identifies target window size based on the binary search scheme. Here the pitfalls are reduced, but the time delay due to disruptions caused in Sender rate, produce the following Simulation Results as in Fig 6. The Simulation is more finer than HSTCP.

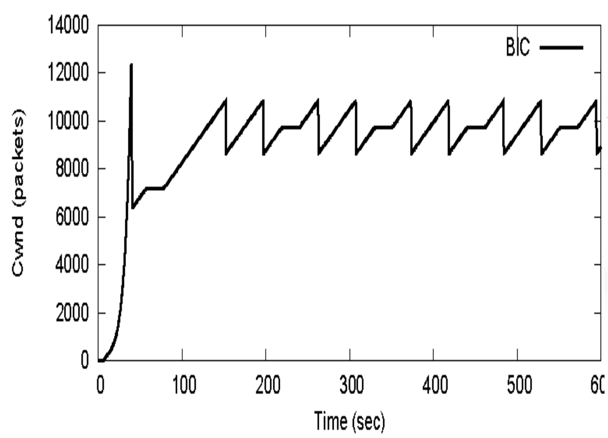

Fig.6. cwnd versus time under the BICTCP scheme

Now comparing the above TCPs with XCP, the Windows Adjustment Procedure gives a result of 98% efficiency. The plot is almost linear. The Traffic is managed Effectively. The vagaries of HSTCP and BICTCP are eradicated in XCP as shown in Fig 7.

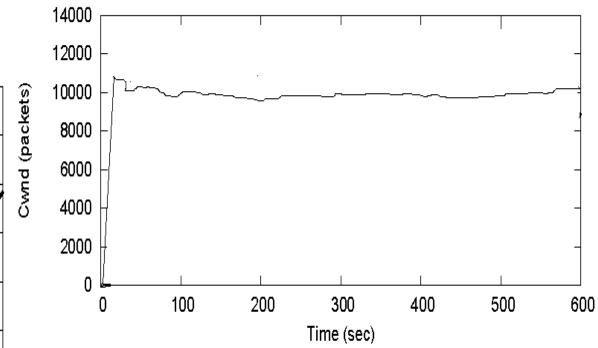

Fig. 7. cwnd versus time under the XCP scheme

The Simulation Results show minimized drips in Cwnd values with increasing time. So it achieves more throughput because more number of packets are transmitted and the flow is normal at the time of congestion. If large number of packets are transmitted within the particular time interval then the utilization of the bandwidth is increased. These results are shown in Fig.8. and it shows that more number of packets are transmitted based on the arrival rate because there is no drastic changes in the window size. So the network utilizes the full bandwidth and it achieves 98% efficiency.

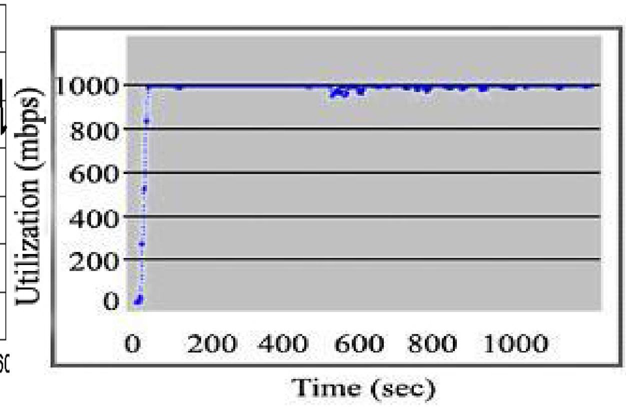

Fig.8.bandwidth utilization versus time Under the XCP scheme.

Hence utilizing XCP, performance of high speed networks can be improved considerably.

5. CONCLUSION

In this paper, the algorithm for Window adjustment Procedure for XCP is proposed which achieves 98% efficiency when compared with High Speed Protocols like HSTCP and BICTCP. The window size is altered drastically based on the time and packet flow and the utilization of the bandwidth is reduced. But in XCP the procedure is based upon the bandwidth and feedback, where the input packets are being regulated by altering the source node and there by reducing the window size in unit step. So the sender can restrict the flow and can avoid congestion thereby resulting in effective Bandwidth utilization. Also the Feedback Mechanism in XCP enables to identify occurrence of congestion effectively. This mechanism is highly useful, particularly in Large Networks wherein many senders transfer continuously at varying data rates.

Hence in comparison to the existing scenarios XCP provides a better mechanism for effective data transfer.

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