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Seamless Flow of Voluminous Data in High Speed Network without Congestion Using Feedback Mechanism

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Abstract**—**Continuously growing needs for Internet applications that transmit massive amount of data have led to the emergence of high speed network. Data transfer must take place without any congestion and hence feedback parameters must be transferred from the receiver end to the sender end so as to restrict the sending rate in order to avoid congestion. Even though TCP tries to avoid congestion by restricting the sending rate and window size, it never announces the sender about the capacity of the data to be sent and also it reduces the window size by half at the time of congestion therefore resulting in the decrease of throughput, low utilization of the bandwidth and maximum delay. In this paper, XCP protocol is used and feedback parameters are calculated based on arrival rate, service rate, traffic rate and queue size and hence the receiver informs the sender about the throughput, capacity of the data to be sent and window size adjustment, resulting in no drastic decrease in window size, better increase in sending rate because of which there is a continuous flow of data without congestion. Therefore as a result of this, there is a maximum increase in throughput, high utilization of the bandwidth and minimum delay. The result of the proposed work is presented as a graph based on throughput, delay and window size. Thus in this paper, XCP protocol is well illustrated and the various parameters are thoroughly analyzed and adequately presented.

Keywords**—**Bandwidth-Delay Product, Congestion Control, Congestion Window, TCP/IP

I. INTRODUCTION

HIGH bandwidth environment is useful for sending large volumes of data within short period of time [1]. 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, 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 control protocols are operating between the network and transport layer. 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. 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 [3][12][14].

Another issue with TCP is the way it allocate bandwidth on networks with high bandwidth delay products and also the Queue size [8][15]. If we have a fast link (eg.Gbps), the TCP's AIMD algorithm is not able to send large volume of data because the sending rate is very low. So automatically limited number of packets are transmitted when we have a high speed environment [6][10]. For example consider a high speed network with Rtt=100 ms and packet size =1.500 bytes. By using of AIMD algorithm the sending rate is 15.00 bytes during the congestion time. So we can transmit only 10 packets/sec. So automatically the performance level degrades because of poor utilization and minimum throughput [9][13] .

But in the proposed work, the new protocol XCP operates between network layer and transport layer. In this protocol, the feedback mechanism is useful and it is to modulate sending rate based on the traffic and service rate of the network in order to avoid congestion. For each flow, the calculations were made and at the same time, sender knows the status of network capacity and the sending rate at the time of congestion. Here the congestion bit value is sent to the sender and the capacity of the network and window size is updated based on the arrival rate, service rate and traffic rate. So the sender is sending the data according to the feedback values in the reverse feedback field by the receiver. Due to the feedback mechanism, maximum number of packets is transmitted and it achieves high utilization, maximum throughout and low delay.

Section II explains the basic concepts of XCP. Section III explains proposed scheme and model. Section IV indicates the Simulation Results. Section V has the concluding remarks.

II. XCP BASICS

A. XCP overview

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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).

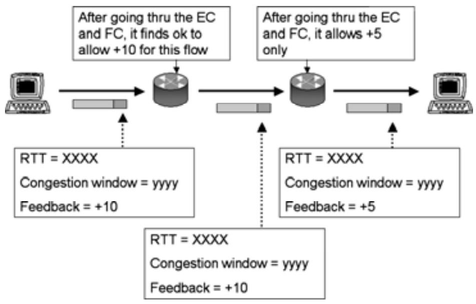

Fig.1 XCP Overview

B. 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][11]. 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. 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 are carried in congestion header and the explicit congestion notification proposal is generalized [4]. 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.

C. 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.

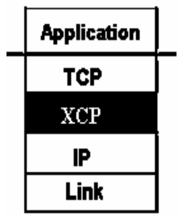

Fig.3 XCP Layer

III. PROPOSED SCHEME

To avoid the congestion in high speed network, feedback mechanism is being used to know the status of the network at the time of data flow. So according to the receiver's feedback, the sender has to resize the window and also the additional parameter values are known by the sender. In the existing system, TCP's window size is changed which results in the control of the transmission rate. But the sender does not know how much amount of data to be transmitted when the congestion occurs and also the buffer is idle even though it has a greater capacity because TCP will gradually increase the window size, but when it detects a loss, the window size(W) is cut to W/2, So TCP is not allowed to send anything more until it has received W/2 acknowledgements.

In the proposed work, XCP's sender will send the data based on the feedback values given by the receiver and hence the sender knows the status of the network and the amount of data to be transmitted at the time of congestion state. As a result of this, the congestion is controlled in the network and there is a continuous flow of data in the high speed network and also the buffer is not idle and therefore there are always some packets in the buffer.

At the time of transferring the voluminous data in the network, the average arrival rate(***λ***) is calculated based on the number of senders data rate and its time interval(t). Also, based on the arrival rate(λ) the service rate(***μ***) and traffic rate(Y) are calculated. For each flow, the calculations were made and at the same time, sender knows the status of network capacity, traffic rate and the sending rate at the time of congestion [16]. Here the congestion bit value is sent to the sender and the capacity of the network and window size is updated based on the arrival rate, service rate and traffic rate. The sender can thus send the data according to the feedback values in the reverse feedback field received by the receiver.

A. Mathematical Model:

a. Arrival Rate: *(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 number of senders, packet size and link capacity.

$$\lambda = \sum \frac{\lambda_i t_i}{n} \tag{1}$$

λ_i - Arrival rate n-Packet Size
t_i- Time interval

b. Service Rate (μ)

Assumptions:

Service rate is based upon the Service time (T_S) router capacity(R) and its utilization factor (U)

$$T_s = n / C \tag{2}$$

T_s – Service Time C - Network Capacity
n - Packet Size

$$U = \lambda * T_s \tag{3}$$

U – Utilization λ – Arrival Rate

$$\mu = U * R \tag{4}$$

R – Router Capacity μ-Service rate

c. Traffic rate:

Traffic rate is based on the transmission ratio σ and the drop probability(p).

$$\sigma = \lambda / C \tag{5}$$

σ – Transmission Ratio
This is equivalent to the offered load for the flows.

$$p = c - \sigma \tag{6}$$

p – Drop Probability

$$Y = (\sigma * 100) / Rtt * \sqrt{p} \tag{7}$$

Rtt – Round Trip Time

Algorithm:
Based on Utilization (U) – Flow rate

In the proposed work , there are three different cases

Case i: If 0.95 ≤ U ≥ 0.99 then normal flow

Case.ii: If the U = 1.0 congestion occur (moderate Congestion)

Case iii: If the 1.01 ≥ U ≤ 1.10, severe congestion occur.

At the time of severe congestion the receiver has to send the feedback to the sender about the queue size, sending rate and window size.

Based on Buffer - Window Size

a) Intialize all the header information, queue size and add the bit value in the Reverse_feedback field.

1. /* queue size */
   If(Qp < Qth)
   then normal flow will occur
   Else
   /* congestion occurred */

2. /* window size */
   If(Qp >= Qth) then
   Cwnd=max(AR*RTT*0.02,MSS)
   Else
   /* Queue is normal */
   Cwnd=max(AR* RTT* 0.05,MSS)

IV. SIMULATION RESULTS

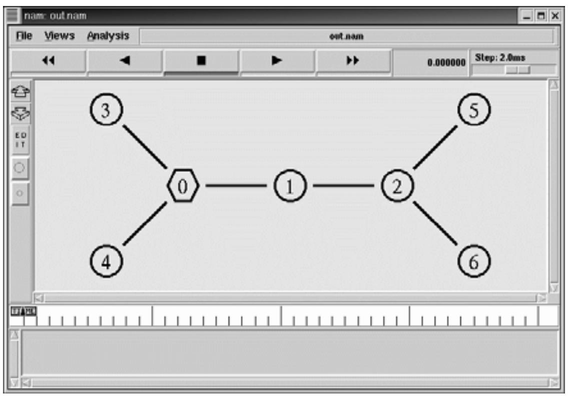

Fig. 4 A simple network configuration for NS-2 Simulation

a) Network

The performance in Windows adjustments is studied based on the dumb-bell topology. 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. This can be extended with different topologies.

In this scenario the capacity of the network is 1 Gbps. The router link capacity is 40 Gbps and Rtt is 100ms. The parameters taken for comparison are number of packets with time.

b) XCP window

Comparing with other High speed protocols such as HSTCP, BICTCP – ie., the TCP family, the XCP provides maximum efficiency and throughput and suffers with delay. In the proposed XCP due to the feed back mechanism and window adjustment procedure followed there is only a minimum delay. When congestion occurs the flow is regulated at the source based on the feedback received from the router and also based on the network traffic. Hence in the proposed scheme, the delay is minimum and the network throughput is high.

Now using the Window Adjustment Procedure a result of 98% efficiency is achieved. The plot is almost linear and the traffic is managed effectively. The resultant study is shown in Fig 5.

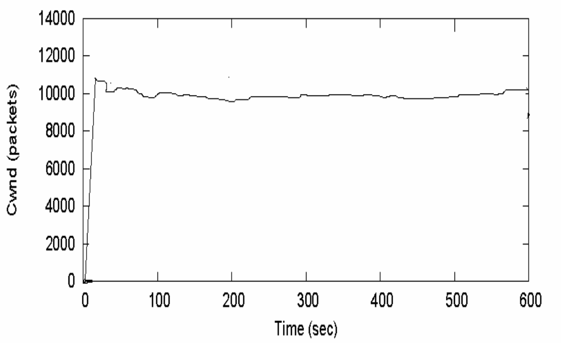

Fig. 5 cwnd versus time under the proposed scheme

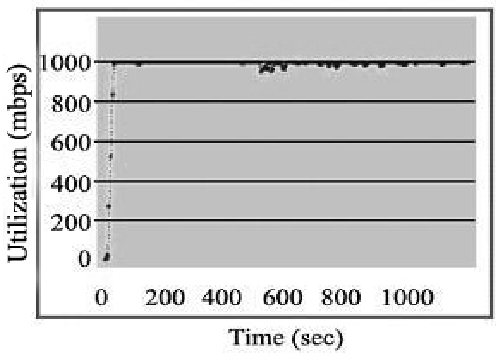

Fig. 6 Bandwidth utilization versus time Under the XCP scheme

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 numbers of packets are transmitted within the particular time interval then the utilization of the bandwidth is increased. These results are shown in Fig.6 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. Hence utilizing XCP, performance of high speed networks can be improved considerably.

C. Queue occupancy of the proposed scheme

The queue size is considered in terms of Mb. The time interval is considered in ms. After this consideration, the following graph is obtained.

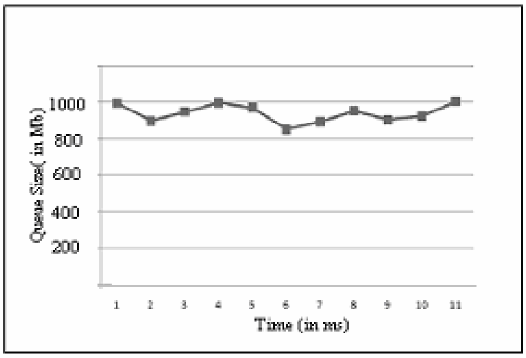

Fig. 7 Queue Size Vs Time graph

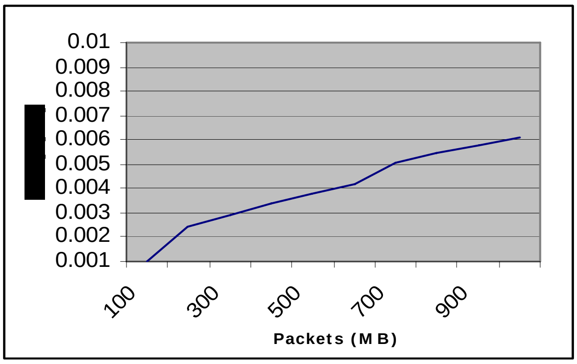

Fig. 8 Packet Vs Delay

The graph shown in Fig.7 illustrates the relation between Queue size and Time. Queue management is adopted whenever Congestion occurs. As shown for various time intervals, based on the traffic the queue size is altered. The graphics response for queue size is almost linear as shown.The delay is considered in ms. The adequate delay at various time intervals is noted with respect to the number of packets and shown in Fig 8.

The graph shown in Fig.8 shows the delay time involved in the network. The delay is very low in high speed networks. The delay is least and varies with time as in Fig 9. From the graph it is concluded that during the maximum packet flow the delay is of 0.0072ms which is a minimum tolerable delay.

The simulation study shows that the proposed protocol calculates the feedback based on arrival rate, service rate, traffic rate and queue size and hence the receiver informs the sender about the throughput, capacity of the data to be sent and window size adjustment, resulting in no drastic decrease in window size, better increase in sending rate because of which there is a continuous flow of data without congestion. Therefore as a result of this, there is a maximum increase in throughput, high utilization of the bandwidth and minimum delay

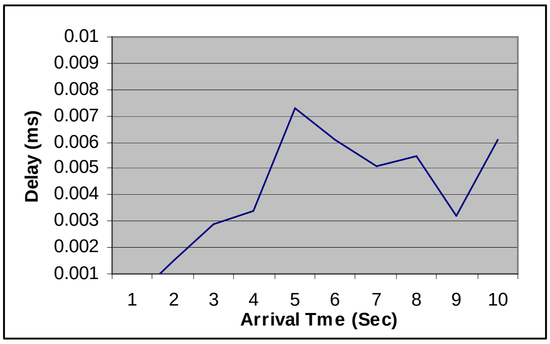

Fig. 9 Arrival Time Vs Delay

V. CONCLUSION

In this paper, the algorithm for Window adjustment Procedure is based on the utilization factor and the flow rate, through which maximum efficiency is achieved when compared with High Speed Protocols. The window size is altered based on the feedback, packet flow and the utilization. Hence the delay is minimum since 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 and minimum delay. 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. Also then by effectively calculating the Queue size and utilization, delay can still be minimized.

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