**Synopsis on**

# AN EFFICIENT EXPLICIT CONGESTION REDUCTION IN HIGH TRAFFIC HIGH SPEED NETWORKS THROUGH AUTOMATED RATE CONTROLLING

*Thesis submitted to Dravidian University for the award of the degree of*

**DOCTOR OF PHILOSOPHY**

in

**COMPUTER SCIENCE**

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**October 2009**

# 1. INTRODUCTION

**Motivation:** With the rapid technological advancement in the field of the computer networks, High Speed Networks supporting the data transfer at the rate of some Giga bits per second (Gbps) has become a possibility. At the same time there is tremendous increase in the network traffic which leads to network congestion resulting in loss of performance. We aimed to increase efficiency and quality of service.

**Background:** The network congestion refers to a situation in which the network resources are overloaded quite often, in other words the total demand for a network resource exceeds its capacity. The current advancement in the technology is adding to the problem congestion for example increase in the buffer capacity increases packet delays and the period of the delay can be so long that by the time packets reach the destination, the sending source might have timed out its timer and retransmitted the copy of the packet thus choking the network with duplicate packets (which ultimately are dropped by the receiver and in the process such duplicate packets occupy considerable amount of network resources during the transmission).

Similarly increased link speed increases the possibility of congestion because of mismatch in link speeds at the point of interconnection of a High Speed Network and a low speed network.

For sending data to a bottleneck link, the sending source uses two rate control techniques for adjusting the data rates namely Open loop & Closed loop. The open loop control technique is useful when the traffic characteristics are defined precisely and the performance requirements are known well in advance, thus the network reserves the available resources for the connections.

The closed loop is used when the network resources cannot be reserved or traffic characteristics are not defined in precise terms. In this case the network resources are shared fairly and efficiently amongst the various users. The performance of the systems using the closed loop technique mainly depends on the feedback delay.

## 1.1 Packet oriented Networks:

In packet oriented networks, like the internet, the data transfer between the end systems occurs in fixed or variable units of packets of limited size. The intermediate nodes, between the end systems, called as routers which are equipped with queues (buffers) used for storing the packets in transition temporarily and then forwarding them in the direction of destination when the link is free.

Since packet-oriented networks have the inherent property that they can get congested locally. So congestion control has to be performed for improving the overall network performance, by controlling the load produced by all the data streams in the network.

Based on the current load conditions of the network, the congestion control is done by adapting efficiently the sending rate of each source of the data streams, thus reducing or even preventing the congestion also allowing a high utilization of the available bandwidth of the network.

## 1.2 Congestion Control in Packet-Oriented Networks:

In packet-oriented networks, two fundamental types of congestion-control mechanisms can be distinguished regarding the role of the network protocol:

(1). In packet oriented networks the network protocols and routers play important roles. The network protocols frequently inform the sending sources about the current load conditions in the network. The sources store current load conditions of the network in congestion control variables which are used for controlling the congestion. This leads to high utilization of Bandwidth and increase in performance [12], [19].

This advantage of such a congestion-control mechanism is combined with two disadvantages.

**First**, the congestion-control information transferred by the network protocol requires some additional overhead. And there is a trade-off between the frequency / overhead and the benefit that can be expected if such a congestion-control mechanism is performed.

**Second**, the upper-layer protocols working on top of the network protocol are limited in their flexibility, as they have to evaluate and react on the congestion-control information supported by the network protocol.

(1) Congestion control can be excluded from and not supported by the network protocol and the routers of the network. Then, protocols working on top of the network protocol are responsible for the congestion control in the network.

(2). In this case, each source has to collect network information frequently and store them in its congestion-control variables, also perform congestion control locally based on values of these variables.

One main problem of this approach is that the network information collected by a sender does not reflect very well the current network conditions. The result is a sub-optimal congestion control in terms of network utilization and data stream performance [7].

Another problem of this approach is that the source of each new data stream entering the network does not know anything about the current load conditions in the network. Therefore, such a source starts sending its data very conservatively using a small sending rate, estimates and probes the current network-load conditions by continuously increasing its sending rate [3].

After a while, the TCP [1], [2], [6] & [8] sender raises its local knowledge about the current network load little by little, so that it is able to perform a more accurate congestion control based on the network information collected.

In the meantime, the congestion control of this data stream might be also far from optimality.

Besides being fair, efficient, responsive and stable; a congestion control technique must be robust against the loss of information also it must scale well with the increase in the speed of the link, the distances and the users.

## 2.0 Review of literature

Many congestion Control algorithms have been designed namely [1], [3], [9], [11], [13], [14], [17], [18], [20 - 24], [26] & [27]:

Random Early Detection (RED), DECbit

Back Pressure Technique

Choke packet Technique

Implicit Congestion Signaling

Additive Increase and Multiplicative Decrease (AIMD)

Explicit Congestion Notification in TCP/IP (ECN)

Binary Congestion Notification (BCN)

**RED:** The gateway detects incipient congestion by computing the average queue size. The gateway could notify connections of congestion either by dropping packets arriving at the gateway or by setting a bit in packet headers.

When the average queue size exceeds a preset threshold, the gateway drops or marks each arriving packet with a certain probability, where the exact probability is a function of the average queue size.

RED gateways keep the average queue size low while allowing occasional bursts of packets in the queue. During congestion, the probability that the gateway notifies a particular connection to reduce its window is roughly proportional to that connection's share of the bandwidth through the gateway.

The DECbit congestion avoidance scheme is an early example of congestion detection at the gateway; in this scheme the congested gateway uses a congestion-indication bit in packet headers to provide feedback about congestion.

When the average queue length exceeds one, the gateway sets congestion-indication bit in the header of arriving packet. The sources use the window based flow control mechanism. They update their windows of data packets once every two round trip times.

If at least half of the packets in the last window had the congestion-indication bit set, then the window size is decreased exponentially, otherwise it is increased linearly.

The main disadvantages of this scheme are averaging queue size for fairly short periods of time and no difference between congestion detection and indication.

**Back Pressure Technique:** If a node becomes congested then it slows down or stops receiving the packets from the preceding node from which it is receiving packets. If this restriction persists for long then packet sending nodes themselves become congested which in turn propagate the restriction on their preceding nodes. But this method is of limited utility as it can be used for the connection oriented networks supporting Hop by Hop flow control.

**Choke packet Technique:** A choke packet is a control packet generated at the congested node & this packet is transmitted back to the source node to restrict the traffic flow. As the source receives the Choke packet it has to reduce its transmission rate till it stops receiving the choke packets. But this method is crude method as a choke packet does not indicate to the sending source, the status of delivery (receipt / non-receipt) of the packets.

**Implicit Congestion Signaling:** In this method the sending source comes to know of congestion at a node if the propagation delays of packets are detected that is the delay is longer than fixed propagation delay and it may ultimately lead to discarding of packets. But the sending node should have a mechanism to detect increased delays and packet discards.

**Explicit Congestion Notification in TCP/IP (ECN):** The purpose of this method is to react to congestion in a controlled & in a fair manner. It especially operates over connection oriented networks. In this method the network alerts the end systems about the growing congestion within the network & the end systems.

ECN allows routers to set the Congestion Experienced (CE) bit in the IP packet header as an indication of congestion to the end nodes as an alternative to dropping the packet. There are two types of ECN namely Forward Explicit congestion (FECN) and Backward Explicit congestion (BECN).

ECN's cannot be relied upon completely to eliminate packet losses as an indication of congestion, and therefore would not allow the end nodes to interpret packet losses as indications of corruption instead of congestion. Similarly, ECN does not eliminate the need for Fast Retransmit and Retransmit

Timeout mechanisms to detect dropped packets, and therefore does not eliminate the need for the Limited Transmit procedure.

**Binary Congestion Notification (BCN):** In TCP/IP based networks congestion is indicated by dropping packets at congested routers. Packets are dropped when the queue of the router reaches its limit (drop tail scheme).

To handle congestion situations before packets actually get dropped several proposals for using binary congestion control have been made. With such an approach, routers that have the capability of detecting incipient congestion can just mark the arriving packets as congested instead of discarding them.

The destination copies the value of the congestion bit of the received packets into the acknowledgement packets sent back to the source. The source then changes its transmission window in accordance with the value of the congestion bit.

# 3. Approach / Method

**Network Traffic Classification:**

**3. 1 Traffic from Behaving sources:**

All the Sender nodes that

- transmit the packets as per the agreed terms of Quality of Service (QoS),
- also during congestion, on receiving the choke packets from a congested node, reduce their current sending rates accordingly

are called the Behaving sources.

**3.2 Traffic from Non-Behaving sources:**

All the Sender nodes that do NOT transmit the packets as per the agreed terms of QoS [16] even after receiving the RM or Choke packets from the congested node for reducing their current sending rate are called the non-Behaving sources.

Such non-behaving nodes keep on sending (pumping in) more and more packets which may lead to worsening of network congestion due to high percentage of queue occupancy and bandwidth requirements [5] thus not allowing the genuine users to get connected to the Network.

**3.3 Research Objective:** The objective of the present study is to propose an algorithm for "An Efficient Explicit Congestion Reduction in High Traffic High Speed Networks through Automated Rate Controlling" for overcoming the limitations associated with the current Congestion Control techniques [25] and test the algorithm through a network simulation tool namely NS 2.28 [15] and study the behavior of the algorithm in case of low, medium and heavy congestion of high-speed, high traffic network.

- Study Throughput [10] for the Behaving and Non-Behaving sources under Congestion situation also when there is No Congestion.

- Meet the QoS demands of the Network Traffic during Congestion situation also when there is No Congestion.

- Fairness of the proposed algorithm in comparison to the conventional TCP [31 – 34].

- Scalability of the proposed algorithm in comparison to the conventional TCP [34].

- Manage the network bandwidth utilization using Dynamic programming (from Operations Research) [33 – 34].

## 4. Chapter outline and Thesis Breakdown

**Chapter I:**

In this chapter, a study of the following topics are covered along with necessary definitions; High Speeds Networks, types of equipments that are required for building such High Speed Networks, the congestion control mechanisms that are used in these special equipments [28 – 30].

**Chapter II:**

In this chapter, a study of the following topics are covered along with necessary definitions Study the nature of traffic congestion in High Speed Limited / Private Networks, the Protocols that are adopted in these High speed networks to control the congestion, the present inefficiencies in the traffic control for such networks [29 – 30].

**Chapter III:**

In this chapter, a new refined model namely "newTCP" has been proposed [31 – 34] to overcome the following four inefficiencies viz. Throughput, Bandwidth utilization, Scalability and fairness property of the existing models (as discussed in Chapter II) has been presented.

**Chapter IV:**

In this chapter, a set of algorithms for the commercial private networks and various assumptions about the nature of Traffic amongst them has been presented for the new model [31 – 34] suggested in chapter III.

**Chapter V:**

In this chapter, based on the model proposed in Chapter III and the Algorithms presented in Chapter IV, findings of the simulations under various assumptions and network traffic conditions have been presented [34].

**Chapter VI:**

Finally the conclusion & future scope of research for the work will be presented.

## LIST OF PUBLICATIONS OF THE AUTHOR

1. K. Satyanarayan Reddy and Lokanatha C. Reddy, "An Efficient Explicit Congestion Reduction in High Traffic High Speed Networks through Automated Rate Controlling" appeared in the proceedings of the International Conference ICSTAORIT – 2006 – XXVI ISPS CONFERENCE Page no. 125 with Paper Id : IT-45 held at Tirupati during the period 7th January 2007 to 9th January 2007.

2. K. Satyanarayan Reddy and Lokanatha C. Reddy, "A Survey on Congestion Control Mechanisms in High Speed Networks" published in the International Journal of Computer Science and Network Security (IJCSNS) Vol. 8 No. 1, pp. 187 - 195, January 2008.

3. K. Satyanarayan Reddy and Lokanatha C. Reddy, "A Survey on Congestion Control Protocols for High Speed Networks" published in the International Journal of Computer Science and Network Security (IJCSNS) Vol. 8 No. 7, pp. 44 - 53, July 2008.

4. K. Satyanarayan Reddy and Lokanatha C. Reddy, "A Model for an Efficient Explicit Congestion Reduction in High Traffic High Speed Networks through Automated Rate Controlling" published in the International Journal of Computer Science and Network Security (IJCSNS) Vol. 8 No. 11, November 2008, pp. 36 – 43, Journal ISSN: 1738-7906.

5. K. Satyanarayan Reddy and Lokanatha C. Reddy, "A Modified Model for Efficient Explicit Congestion Reduction in High Traffic High Speed Networks through Automated Rate Controlling" has been published in IEEE Explore

Journal pp. 664-669, ISBN: 978-1-4244-2927-1, INSPEC Accession Number: 10520788, Digital Object Identifier : 10.1109 / IADCC.2009.4809091).

6. K. Satyanarayan Reddy and Lokanatha C. Reddy, “A Refined New Model for Efficient Explicit Congestion Reduction in High Traffic High Speed Networks through Automated Rate Controlling” has been accepted for being published in the International Journal of Information Technology and Knowledge Management (IJITKM) in Vol-II, Issue-II of December 2009.

7. K. Satyanarayan Reddy and Lokanatha C. Reddy, “newTCP a Refined New Model for Efficient Explicit Congestion Reduction in High Traffic High Speed Networks through Automated Rate Controlling” has been accepted for being published in the International Journal of Information Technology & Knowledge Management (IJITKM) Vol-III, Issue-I of June 2010.

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