FLoadAutoRED: An Active Queue Management Scheme to Prevent Congestion in a Dynamically Varying Traffic in IP Networks

BY

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CERTIFICATE

This is to certify that the thesis entitled **"FLoadAutoRED: An Active Queue Management Scheme to Prevent Congestion in a Dynamically Varying Traffic in IP Networks"** submitted to the Avinashilingam Institue For Home Science and Higher Education For Women, Coimbatore, for the award of the degree of **Doctor of Philosophy in Computer Science**, is a record of original research work done by **K.CHITRA,** during the period of her study in the Department of Computer Science, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, under my supervision and guidance and the thesis has not formed the basis for the award of any Degree / Diploma / Associateship / Fellowship or similar title to any candidate of any University.

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DECLARATION

I hereby declare that the matter embodied in this thesis entitled **"FLoadAutoRED: An Active Queue Management Scheme to Prevent Congestion in a Dynamically Varying Traffic in IP Networks"** is the result of investigations carried out by me in the Department of Computer Science, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, under the supervision and guidance of **Dr. G. PADMAVATHI, M.Sc., M.Phil., Ph.D.,** Professor and Head, Department of Computer Science, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore and that it has not been submitted for the award of any Degree / Diploma / Associateship / Fellowship or other similar title of any other University or Institute.

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K.CHITRA

DEDICATED

TO MY

SON & PARENTS

ABSTRACT

The development and need of distributed data and multimedia applications are growing rapidly in Internet. Some common examples are Video conferencing, Internet telephony, File transfer, On-line games; Internet based banking, Email distributions, News updates and E- business. High quality delivery of data requires high network bandwidth. Moreover, the best quality of service is required to communicate the desired information across the IP network for these application-oriented operations. The special characteristics of these multimedia and data applications place a number of requirements on the IP network. The requirements are in terms of throughput, packet loss, and delay. Further, the deployment of these applications increases the percentage of dynamic varying traffic in the Internet resulting in congestion and starvation of TCP traffic. Such an effect in Internet results in multiple packet losses, low throughput and low delay leading to a congestion collapse. Internet multimedia and data applications cannot tolerate such performance degradation due to congestion. Congestion has to be handled efficiently that keeps the IP network in a stable state to accommodate varying traffic with high performance. Hence congestion has to be prevented by implementing a proactive approach i.e Congestion Preventive technique that keeps the IP networks in a stable state to accommodate varying traffic.

In IP networks, congestion can be detected and prevented at the network level (i.e.) at the Router level. Each router uses a finite buffer maintained in a queue fashion for the packets to be stored and transmitted. As a result, in case of heavy traffic, router gets congested and further congestion collapse is likely to occur. Packet drops at the routers implicitly indicate congestion to the end sources in the network for it to adjust accordingly the sending rate or window size.

Now-a-days Internet applications with dynamically varying load floods the Internet routers with data that requires efficient Queue management mechanisms. Active Queue Management (AQM) is introduced as a congestion

preventive approach that drops packets before buffer becomes full using congestion indicators like queue length and input rate. These schemes are based on congestion metrics like Queue-length, Load, both Queue and Load and other parameters like Loss rate. Further some of these schemes also use flow information along with various congestion metrics to analyze and control the congestion in routers more accurately. Considering these factors, AQM schemes are categorized based on congestion metrics without flow information and with flow information. The existing AQMs do not achieve all the required QoS of Internet routers that are flooded with dynamically varying traffic. Therefore it is proposed to introduce a method that tries to achieve the required QoS of Internet routers with the flooded data.

This thesis presents an Active Queue Management policy as a Router based mechanism for early detection and prevention of congestion inside the network to steer the overall performance of the dynamically varying traffic in IP Networks. The main objective is to steer Active Queue Management algorithms with respect to high link utilization, restricting disproportionate bandwidth usage, minimum delay and queue loss, stabilized and moderate network queues to achieve a better QoS by preventing congestion in a dynamically varying traffic in IP networks.

The performance of the existing algorithm AutoREDwithRED is improved to handle and provide better QoS for dynamically varying traffic in IP networks. The improvement to the AutoREDwithRED AQM is in terms of fairness in case of TCP and non-TCP flows. The entire contribution is discussed in four phases. The Phase-I uses the flow information to bring fairness. Tracking of this information results in increased in fairness, but does not show high improvement in terms of packet drop rate. The packet drop rate depends on the maximum queue threshold max_{th}. Therefore to control the packet drop rate and remove the parameter tuning problem, the parameter max_{th} is set as dynamic rather than as constant in the subsequent Phase - II.

Further to improve response or adaptability of the AQM to the dynamically varying load, input rate is introduced as a secondary congestion metric. The methodology in Phase-III brings in a better adaptability to AQM to the varying load and stable moderate queue sizes. To show a better performance in terms of link utilization and queuing delay, the load factor is introduced in the subsequent Phase – IV. The methodology adopted in Phase IV updates the packet drop probability. Updating the packet drop probability projected a better link utilization and minimum queuing delay.

The proposed AQM projects a better utilization with an improvement in the range 0.68% – 1.1% with respect to AutoREDwithRED for dynamically varying load. The stability of average queue size steers betterment between 12.99% and 35.74%. The packet drop rate is controlled for varying input around 3.38% to 6.1%. It shows a better fairness in values between 2% and 24% in case of moderate input traffic rate**.**

FLoadAutoRED AQM predicts incipient congestion timely and accurately with the help of two congestion factors, the queue size and input rate with the flow information. It projects smaller queuing delay with a higher utilization. It also has a stable queue size and robustness to variation in traffic load. The proposed scheme periodically monitors the link load and determines the capacity, load factor and queue length to detect the incipient congestion early and calculates the packet drop probability. Finally the proposed scheme guarantees the desired performance of dynamically varying traffic in IP Networks.

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GLOSSARY

S.No.	Abbreviation	Full Form
1	TCP/IP	Transmission Control Protocol / Internet Protocol
2	FTP	File Transfer Protocol
3	QoS	Quality of Service
4	VoIP	Voice over IP
5	ECN	Explicit Congestion Notification
6	TCP	Transmission Control Protocol
7	FIFO	First In First Out
8	RED	Random Early Detection
9	AQM	Active Queue Management
10	AVQ	Adaptive Virtual Queue
11	AIMD	Additive-Increase Multiplicative-Decrease
12	PD-RED	Proportional Derivative – Random Early Detection
13	SHRED	SHort-lived flow friendly RED
14	DS-RED	Double Slope - Random Early Detection
15	MRED	Modified Random Early Detection
16	REM	Random Exponential Marking
17	CHOKe	CHOose and Keep for responsive flows, and CHOose and Kill for unresponsive flows

18	FRED	Fair Random Early Drop
19	SVB	Stabilised Virtual Buffer
20	QCF	Queue Control Function
21	EAVQ	Enhanced Adaptive Virtual Queue
22	SAVQ	Stabilised Adaptive Virtual Queue
23	EWMA	Exponential Weighted Moving Average
24	StoRED	Stochastic RED
25	SFED	Selective Fair Early Detection
26	SFB	Stochastic Fair Blue
27	LUBA	Link Utilization Based AQM
28	UDP	User Datagram Protocol
29	FTP	File Transmission Protocol
30	FABA	Fair Bandwidth Allocation
31	ARED	AdaptiveRED

PERFORMANCE METRICS USED

S. No.	FORMULA
1	$Fairness\ Index = \frac{(\sum_{i=1}^{n} x_i)^2}{n \sum_{i=1}^{n} x_i^2}$ where x_i is the normalized throughput (in Kbps) of the i–th flow and n is the number of connections.
2	$Utilisation = \frac{TotalNo.ofPacketsReceived}{SimulationTime} \times \frac{8}{1000 \times Bandwidth}\ \%$
3	$Packet\ Drop\ Rate = \frac{DroppedPackets}{TransmittedPackets} \times 100$
4	$Throughput = \frac{TotalPacketsReceived}{SimulationTime} \times \frac{8}{1000}\ Mbps$
5	$AverageQueueSize = \frac{Sum\ of\ Instantaneous\ Queue\ Size}{No.ofInstantaneousQueueSize}\ packets$
6	$StdDev.AvgQueueSize = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(QSize_i - AvgQSize)^2\ packets}$