

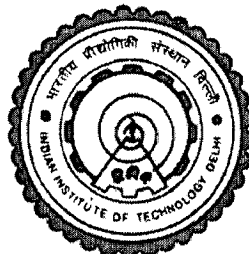
**RATE ESTIMATION AND FLOW CONTROL
OF BEST EFFORT TRAFFIC
IN HETEROGENEOUS NETWORKS**

by

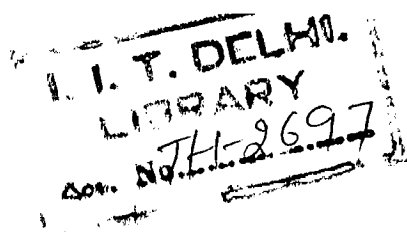
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**DEPARTMENT OF COMPUTER SCIENCE AND
ENGINEERING**

Submitted
in fulfillment of the requirements of the degree of Doctor of Philosophy

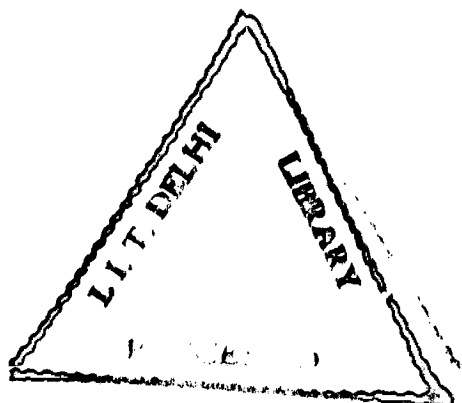
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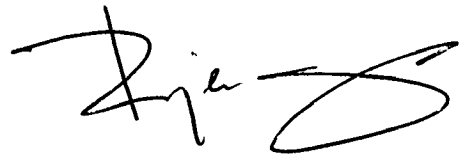


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Certificate

This is to certify that the thesis titled “Rate Estimation and Flow Control of Best Effort Traffic in Heterogeneous Networks” being submitted by R. N. Moorthy to the Indian Institute of Technology, Delhi, for the award of the Degree of Doctor of Philosophy, is a record of bonafide research carried out by him under my guidance and supervision. The results obtained in this thesis have not been submitted to any other University or Institute for the award of any other degree or diploma.

A handwritten signature in black ink, appearing to read 'Bijendra N. Jain', with a stylized flourish at the end.

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R.N. Moorthy

Abstract

We show that in a BE connection, the mean inter-packet arrival time at the destination is a monotonically increasing function of mean inter-packet departure time at the source. Also, we define a most important parameter of the connection, denoted by τ^b , as the smallest value of inter-packet departure time for which the mean inter-packet arrival time equals that of the inter-packet departure time.

The characterization of a connection may be used to estimate τ^b and control the sending rate of the connection. We present an implicit end-to-end rate based flow control policy based on this characterization, for best effort connections in heterogeneous network which is an interconnected set of networks that use traditional packet switching or implement ATM like protocols. The intermediate switches may use a FCFS or a rate allocating packet scheduling discipline such as Fair Queuing. Although our scheme is presented in the context of a connection oriented network it is also applicable in a datagram network, such as the Internet (assuming routing changes take place over time scales significantly larger than a few round-trip times).

An important characteristic of the proposed scheme is that it assumes no support from the underlying network and lower layers to indicate or control congestion, but instead uses the mean spread of sets of uniformly spaced packets to measure the available bandwidth at the bottleneck server (switch/router) along the path of a connection. This estimate of available bandwidth is then fed to a controller which adjusts the sending rate so as to maintain a certain number of packets buffered at the bottleneck server.

The proposed Rate Estimation and Control scheme is studied extensively using simulations. Results obtained from simulation experiments show that the scheme can adapt quickly to changes in bandwidth available to best effort traffic and

consequently utilizes the resources at the servers better and loses fewer packets than TCP, the classical end-to-end control scheme. Our simulation results show that in the case of multiple competing connections using the proposed scheme, the available bandwidth is distributed equitably.

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