SCHEDULING AND MANAGEMENT OF REAL-TIME COMMUNICATION IN POINT-TO-POINT WIDE AREA NETWORKS

By

Cheryl Lynn Pope

2002

A THESIS SUBMITTED FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN THE DEPARTMENT OF COMPUTER SCIENCE

UNIVERSITY OF ADELAIDE

2002

Abstract

Applications with timing requirements, such as multimedia and live multi-user interaction, are becoming more prevalent in wide area networks. The desire to provide more predictable performance for such applications in packet switched wide area networks is evident in the channel management provided by Asynchronous Transfer Mode (ATM) networks and in the extensions to the Internet protocols proposed by the Internet Engineering Task Force (IETF) working groups on integrated and differentiated service. The ability to provide guarantees on the performance of traffic flows, such as packet delay and loss characteristics, relies on an accurate model of the traffic arrival and service at each node in the network.

This thesis surveys the work in bounding packet delay based on various proposed queuing disciplines and proposes a method for more accurately defining the traffic arrival and worst case backlog experienced by packets. The methods are applied to the first in first out (FIFO) queuing discipline to define equations for determining the worst case backlog and queuing delay in multihop networks. Simulation results show a significant improvement in the accuracy of the delay bounds over existing bounds published in the literature. An improvement of two orders of magnitude can be realised for a ten hop path and the improvement increases exponentially with the length of the path for variable rate network traffic. The equations derived in the thesis also take into consideration the effect of jitter on delay, thereby removing the requirement for rate controllers or traffic shaping within the network.

In addition to providing more accurate delay bounds, the problem of providing fault tolerance to channels with guaranteed quality of service (QoS) is also explored. This thesis introduces a method for interleaving resource requirements of backup channels to reduce the overall resource reservations that are required to provide guaranteed fault recovery with the same QoS as the original failed channel. An algorithm for selecting recovery paths that can meet a channel's QoS requirements during recovery is also introduced.

Declaration

This is to certify that this thesis contains no material which has previously been accepted for the award of any degree or diploma in any University. To the best of my knowledge and belief it contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

If this thesis is accepted for the award of the degree, permission is granted for it to be made available for loan and photocopying.

Cheryl Pope

2002

Acknowledgements

I may never have undertaken this PhD without the enthusiastic encouragement of the person who became my advisor, Dr. Jay Yantchev. He often steered me in the right direction when I wasn't certain which path to investigate and I acknowledge his significant contribution to my PhD studies.

Prof. Chris Barter deserves special mention, not only for providing excellent facilities as Head of the Computer Science department; but also for providing the opportunity for me to spend part of my early candidature at Oxford University. It was during this time that I was able to visit the University of York's real-time computing group and define my research problem.

Spouses are often acknowledged for their significant support and tolerance during PhDs. Few people are as fortunate as I am, however, to have a spouse who has offered not only emotional support but intellectual support as well. For his infinite patience, system administration and LaTex skills, giving me priority on our home computer, being a sounding board for my ideas, not being afraid to actually read and understand the "hairy equations", as well as giving me encouragement when I needed it, I acknowledge my husband, Dr. Michael Pope. I'm very lucky to have him.

Finally I would like to acknowledge my parents for encouraging my interest in maths and science and for the many sacrifices they have made for my studies. I would also like to thank Erika for having some long naps while I was making amendments to this thesis. This thesis is dedicated to her. May she find the world a peaceful place full of discoveries to be made.

Contents

List of Tables

List of Figures