Resource Management in Broadband Multimedia Networks

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DECLARATION

No part of the work referred to in this thesis has been submitted in support of an application for the award of another degree or qualification of this or any other university or other institution of learning.

PUBLICATIONS RELATED TO THE WORK PRESENTED IN THIS THESIS

Seminar Presentations

- Prasit Jiyapanichkul, "A Multimedia Network Model for Optimal Resource Management", Technical Presentation, Telstra Research Laboratories, Melbourne, May 1996.
- [2] Prasit Jiyapanichkul, "Optimising Traffic Management in Broadband Networks", Internal Seminar, Swinburne University of Technology, May 1996.
- [3] Prasit Jiyapanichkul, "A Broadband Multimedia Network Model for Optimal Resource/Traffic Management", Technical Presentation, The University of the Thai Chamber of Commerce, Bangkok, Thailand, June 1996.
- [4] Prasit Jiyapanichkul, "An Internet Model for Optimal Resource Management", Technical Presentation, Telstra Research Laboratories, Melbourne, September 1996.
- [5] Prasit Jiyapanichkul, "Optimising Resource/Traffic Management in the Internet", Internal Seminar, Swinburne University of Technology, October 1997.

Papers

- P. Jiyapanichkul and J. Lambert, "A Model for Optimal Resource Management in Broadband Multimedia Networks", *Australian Telecommunication Networks & Applications Conference (ATNAC'96)*, Melbourne, December 1996.
- [2] P. Jiyapanichkul and J. Lambert, "Connection Acceptance Approach to Optimal Resource Management in the Internet", *International Conference on Telecommunications (ICT'97)*, Melbourne, April 1997.

[3] P. Jiyapanichkul and J. Lambert, "Optimal Resource Management with Dynamic Virtual Paths in ATM Networks", *IEEE International Conference on Communications (ICC'98)*, Atlanta, June 1998.

TABLE OF CONTENTS

ACKNOWLEDGMENT DECLARATION PUBLICATIONS RELATED TO THE WORK PRESENTED IN THIS THESIS LIST OF ILLUSTRATIONS ABSTRACT

Chapter 1. INTRODUCTION

Chapter 2.	TOWARD BROADBAND MULTIMEDIA NETWORKS	3
	2.1 Introduction	3
	2.2 Nature of ATM Networks	5
	2.2.1 Connection admission control and	
	virtual path management	5
	2.2.2 Virtual path management	7
	2.2.2.1 VPC capacity allocation	8
	2.2.2.2 VPC configuration	9
	2.2.2.3 VP pool management	9
	2.2.3 Proposed solution	10
	2.3 Nature of the Internet	10
	2.3.1 The Internet and the problem of poor performance	10
	2.3.2 Proposed solutions to the problem	13
	2.4 Conclusions	16

Chapter 3. DEVELOPMENT OF AN OPTIMISATION MODEL FOR ASYNCHRONOUS TRANSFER MODE (ATM) NETWORKS

3.1 Introduction	17
3.2 Graphical Representation of Network Traffic and Resources	18
3.3 Model Implementation	22
3.3.1 Flow constraint implementation	26
3.3.2 Link constraint implementation	27
3.3.3 Node constraint implementation	28
3.3.4 Objective function implementation	29
3.3.5 Summary of broadband multimedia model	30
3.4 Application Example	31
3.4.1 Sample specification and basic solution	32
3.4.2 Effect of a link failure	33
3.4.3 Discussion of the sample problem	34
3.5 Conclusions	34

Chapter 4. APPLICATION TO VIRTUAL PATH MANAGEMENT IN ATM NETWORKS

4.1 Introduction	36
4.2 Modification of the Broadband Multimedia Model	38
4.2.1 Modification of flow constraint	41
4.2.2 Modification of link constraint	41
4.2.3 Modification of node constraint	41
4.2.4 Modification of objective function	41
4.3 Development of DVPM Traffic Management System	42
4.3.1 Sample problem	43
4.3.2 Sample results	44
4.4 Conclusions	47

36

Chapter 5. STATE DEPENDENT VIRTUAL PATH MANAGEMENT IN ATM NETWORKS

5.1 Introduction	51
5.2 Improvement of Virtual Path Management Model	
5.2.1 Flow constraint	53
5.2.2 Link constraint	53
5.2.3 Node constraint	53
5.2.4 Virtual connection state constraint implementation	53
5.2.4.1 Upper bound	54
5.2.4.2 Lower bound	54
5.2.5 Objective function implementation	54
5.2.6 Summary of State Dependent Virtual Path	
Management (SDVPM) model	55
5.3 Performance Evaluation of State Dependent Virtual Path	
Management Model	56
5.3.1 Sample problem	56
5.3.2 Sample results	57
5.3.3 Main features	58
5.4 Conclusions	60

Chapter 6. DEVELOPMENT OF AN OPTIMISATION MODEL FOR THE INTERNET

6.1 Introduction	
6.1.1 Connection-oriented versus connectionless networks	63
6.1.2 TCP/IP versus resource reservation for	
QoS guarantees	64
6.1.3 For whom should we optimise?	64
6.1.4 A model for Web browsing	65

63

6.1.5 A model for resource-reserved services and	
QoS guarantees	67
6.1.6 A unified model for Web browsing and	
QoS guaranteed services	67
6.2 Model Implementation	68
6.2.1 User demand constraint implementation	70
6.2.2 Link constraint implementation	70
6.2.3 Router constraint implementation	71
6.2.4 Server constraint implementation	71
6.2.5 Objective function implementation	72
6.2.6 Summary of the Internet model	72
6.3 Application Example	73
6.3.1 Sample specification and basic solution	73
6.3.2 Effect of transferring server capacity to a mirror site	75
6.4 Conclusions	76

Chapter 7. APPLICATION TO INTERNET TRAFFIC MANAGEMENT 77

7.1 Introduction	77
7.2 Optimal Revenue Example	
7.2.1 Sample network without proxy server	78
7.2.2 Effect of substituting a proxy server	80
7.3 Implementation of Real-Time Traffic Control	
7.3.1 Sample problem	83
7.3.2 Sample results	84
7.3.3 Main features	85
7.4 Conclusions	

Chapter 8. CONCLUSIONS

8.1 Summary of Conclusions	93
8.2 Original Contributions	95
8.3 Suggestions for Future Work	96

APPENDIX I BIRTH-DEATH PROCESS98

APPENDIX II MIRROR SITE AND PROXY SERVER CONCEPT	102
AII.1 Mirror Site Concept	102
AII.2 Proxy Server Concept	103

APPENDIX III NOTE ON SIMULATION PROGRAM	105
	100

BIBLIOGRAPHY

106

LIST OF ILLUSTRATIONS

List of Figures

- Figure 2.1: The growth of wcarchive.
- Figure 2.2: Effect of access policy on number of satisfied users in an overloaded network.
- Figure 3.1: Graphical representation of broadband network elements...
- Figure 3.2: Broadband Network Connection Flow Diagram for LP Model.
- Figure 3.3: Broadband Network Connection Flow Diagram for LP Model (showing mathematical relationships).
- Figure 3.4: Sample 6 Node Network with Gateway.
- Figure 3.5: Sample Network with Link Failure.

Figure 4.1: Sample 6 Node Network.

- Figure 4.2: Total Bandwidth Allocation and Total Bandwidth Usage.
- Figure 4.3: Mean Offered Rate and Mean Blocking Rate.
- Figure 4.4: Ideal Revenue Rate & Event-by-Event Revenue Rate.

Figure 5.1: Sample 6 Node Network.

- Figure 5.2: Ideal and Event-by-Event Revenue Rate from DVPM and SDVPM models.
- Figure 5.3: Total Bandwidth Allocation and Total Bandwidth Usage from SDVPM.

Figure 5.4: Mean Offered Rate and Mean Blocking Rate from SDVPM.

Figure 6.1: Traffic Flow.

Figure 6.2: Network Topology: (logical or physical).

Finger 6.3: Sample network.

Finger 6.4: Sample network with mirror site.

Figure 7.1: Sample network.

Finger 7.2: Sample network with proxy server.

Figure 7.3: LP Result & Simulated Bandwidth Usage.

Figure 7.4: Mean Offered Rate and Mean Blocking Rate.

Figure 7.5: Total LP Result & Total Simulated Bandwidth Usage for Each Service.

Figure 7.6: Total Mean Offered Rate & Total Mean Blocking Rate for Each Service.

Figure 7.7: Optimum Revenue Rate & Event-by-Event Revenue Rate.

Figure AII.1: The relationship between a Primary Server, Mirror Site and Proxy Server.

List of Tables

Table 2.1: List of features for unlimited access and limited access.

Table 3.1: Traffic Parameters for Sample Network.

 Table 4.1: Tariff Rate and VCC Attempt Rate.

Table 4.2: Revenue Comparisons.

Table 5.1: Tariff Rate and VCC Attempt Rate.Table 5.2: The mean event-by-event revenue rate.

Table 6.1: Network Resources.

Table 6.2: Offered user demand.

Table 7.1: Offered user demand.

Table 7.2: Different Control Algorithms for Proxy System.

Table 7.3: The revenue at steady state.

ABSTRACT

This research deals with optimal resource management in an overloaded broadband multimedia network. Optimisation is with respect to user satisfaction, where user satisfaction reflects both the quality of service experienced by connected users and the dissatisfaction of users blocked from access to the network.

The research focuses on Asynchronous Transfer Mode (ATM) networks and the Internet, because these are the dominant emerging broadband networks which present some fundamental unsolved problems, related to the sharing of resources between mixed traffic types. ATM networks use conservative admission control, which protects network resources and ensures a high level of service for those admitted to the network, but results in low network efficiency because of low utilisation of resources due to blocking of many potential users. The Internet does not use admission control, with the result that performance degrades progressively as load increases. This causes frustration among users, and lowers the network efficiency due to high levels of congestion.

We propose an optimisation model for each network (ATM networks and the Internet) which is intended to represent the distribution and consumption of key network resources by different traffic types. The model is aimed at maximising performance such that users admitted to the network are offered no less than some minimum acceptable level of quality of service (QoS). The solution is a set of traffic flow rates on each path which results in maximising an objective function value (revenue based on network operator interest or throughput based on customer interest) for a given network configuration with given user demand. As an example using the ATM network model, we illustrate the application of the model to an ATM network carrying both connection oriented and connectionless traffic. We explore the optimal response to a link failure which in turn causes node overload. As an example using the Internet model, we consider an overloaded network with link bottlenecks and an overloaded Web server, and explore the effect of transferring some server capacity to a mirror site and a proxy server.

For real-time traffic control, the optimisation model is used to assign quotas for bandwidth or connections to selected paths. A control algorithm is implemented to provide maximum performance by admitting requests within the quotas which are obtained from the optimisation model. In an ATM network simulation, the algorithm is used to manage the virtual path (VP) pool in a network which suffers a link failure. A comparison is made between fixed virtual path management (FVPM) and dynamic virtual path management (DVPM), comparing the revenue achieved by each. This illustrates how DVPM adapts the VP pool in a robust fashion to achieve maximum revenue in the face of a link failure. However, the transient response suggests that benefit could be obtained using non-steady-state solutions. The model is extended by taking network state and traffic parameters into account to control changes in the VP pool to recognise limits to the rate at which traffic can be moved (through the natural birth-death processes). This scheme is called state dependent virtual path management (SDVPM). Performance evaluation of the new model shows that SDVPM achieves higher revenue than DVPM when the network suffers a link failure that requires a major change to the VP pool. In an Internet simulation, two algorithms are compared for control of access to a proxy server and a set of primary servers. An algorithm based on optimal flow solutions provides substantially better network performance than a localised heuristic algorithm. In each simulation case (ATM and Internet examples), the performance using a control system based on the steady state optimum flow model is close to the ideal optimal result.