UNIVERSITI PUTRA MALAYSIA

ANALYSIS AND DECENTRALISED OPTIMAL FLOW CONTROL OF HETEROGENEOUS COMPUTER COMMUNICATION NETWORK MODELS

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By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CPU	:	Central Processing Unit
FCFS	:	First-Come-First-Served
GE	:	Generalised Exponential
H_2	:	Two Phase Hyperexponential
I/O	:	Input/Output
ME	:	Maximum Entropy
N-ME	:	Norton-Maximum Entropy
PME	:	Principle of Maximum Entropy
S	:	Simulation

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Chairman : Assoc. Prof. Dr. Abu Talib Othman

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General closed queueing networks are used to model the local flow control in multiclass computer communication networks with single and multiple transmission links. The problem of analysing multiclass general closed queueing network models with single server and multiserver is presented followed by the problem of decentralised optimal local flow control of multiclass general computer communication networks with single and multiple transmission links. The generalised exponential (GE) distributional model with known first two moments has been used to represent general interarrival and transmission time distributions as various users have various traffic characteristics.

A new method of general model reduction using the Norton's theorem for general queueing networks in conjunction with the universal maximum entropy algorithm is proposed for the analysis of

large general closed queueing networks. This extension to Norton's theorem has an advantage over the direct application of the universal maximum entropy approach whereby the study of a subset of queueing centres of interest can be done without repeatedly solving the entire network.

The principle of maximum entropy is used to derive new approximate solutions for the joint queue length distributions of multiclass general queueing network models with single server and multiserver and favourable comparisons with other methods are made. The decentralised optimal local flow control of the multiclass computer communication networks with single and multiple transmission links is shown to be a state dependent window type mechanism that has been traditionally used in practice. The maximum number of packets in transit within the system corresponding to a maximum throughput and can be determined from a preassigned upper bound on the mean time delay, the average allowed load and the parameters of the underlying systems. The direct dependence of the maximum throughput on the mean time delay is also determined. The optimal local flow control with global objectives results in a team decision that does not favour any individual user, and depends only on the relative order of their packet generation rates.

Numerical examples provide useful informations on how critically system behaviour is affected by (i) the distributional form of the interarrival and transmission patterns, (ii) the maximum input rate. The analytic results described in this thesis suggest that (i) analytical analysis for general closed queueing networks which are used to model computer communication networks can be analysed using the principle of maximum entropy, (ii) congestion problems in computer communication networks with non-exponential data flows should be examined in terms of maximum throughput under a time delay constraint where the offered load appears only as a parameter.

Abstrak dissertasi yang dikemukakan kepada Senat Universiti Pertanian Malaysia bagi memenuhi syarat untuk ijazah Doktor Falsafah

ANALISIS DAN KAWALAN ALIRAN OPTIMA NYAHPUSAT BAGI MODEL-MODEL RANGKAIAN KOMUNIKASI KOMPUTER HETEROGEN

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Rangkaian-rangkaian giliran umum tertutup digunakan untuk memodel kawalan aliran setempat dalam rangkaian komunikasi komputer multi-kelas dan satu atau beberapa pautan transmisi. Masalah bagi menganalisis model-model rangkaian giliran tertutup multi-kelas dengan satu-pelayan dan multi-pelayan diperkenalkan diikuti oleh masalah kawalan aliran optima nyahpusat setempat untuk rangkaian-rangkaian komunikasi komputer umum multi-kelas dengan satu dan beberapa pautan transmisi. Model taburan eksponen teritlak (GE) dengan mengetahui dua momen pertama digunakan untuk mewakili taburan-taburan masa antara ketibaan dan transmisi di mana setiap pengguna mempunyai ciri-ciri trafik yang berbagai.

Satu kaedah baru penurunan model umum menggunakan teorem Norton untuk rangkaian giliran umum dan algoritma entropi maksimum umum dicadangkan bagi menganalisis rangkaian-rangkaian giliran tertutup yang besar. Lanjutan kepada teorem Norton ini mempunyai satu kelebihan

dari penggunaan terus entropi maksimum umum yang mana kajian berparameter bagi satu subset pusat giliran yang diminati boleh dilakukan tanpa mengulang menyelesaikan keseluruhan rangkaian.

Prinsip entropi maksimum diguna untuk menerbitkan penyelesaian anggaran baru taburan-taburan gabungan panjang giliran untuk rangkaian giliran umum tertutup multi-kelas dengan satu-pelayan dan multi-pelayan dan perbandingan yang baik dengan kaedah-kaedah lain dibuat. Kawalan aliran optima nyahpusat setempat untuk rangkaian komunikasi komputer multi-kelas dengan satu atau beberapa pautan transmisi adalah mekanisma jenis tingkap bersandar kepada keadaan yang digunakan secara tradisi. Bilangan maksimum paket dalam transit sistem berpadanan dengan perolehan maksimum dan boleh ditentukan dari batas atas yang diberi untuk min masa lewat, purata beban dan parameter-parameter sistem. Persandaran terus perolehan maksimum ke atas min masa lewat juga ditentukan. Kawalan aliran optima setempat dengan objektif sejagat menghasilkan keputusan kumpulan yang tidak mengambil kira setiap pengguna dan sebaliknya bergantung pada giliran relatif pengeluaran paket.

Contoh-contoh numerik memberi maklumat penting tentang bagaimana kritikal perilaku sistem dipengaruhi oleh (i) bentuk taburan antara ketibaan dan corak transmisi (ii) kadar maksimum input. Keputusan analitik dalam tesis ini mencadangkan (i) analisis analitik untuk rangkaian giliran tertutup umum yang digunakan untuk memodel rangkaian-rangkaian komunikasi komputer boleh dianalisis dengan menggunakan prinsip entropi maksimum (ii) masalah kesesakan dalam rangkaian komunikasi komputer dengan aliran data bukan eksponen patut dikaji dalam sebutan perolehan maksimum di bawah kekangan masa lewat di mana beban yang diberi merupakan satu parameter sahaja.

CHAPTER I

INTRODUCTION

The interest in computer communication networks has grown enormously in the last thirty years. The growth in the need for data communications comes from a large number of varied application areas. The finance industry including banking and insurance firms, has a growing need for remote data processing (i.e. electronic fund transfers etc.). In the field of medicine and health, there is a need for large information banks with remote access. Educational computing needs currently emphasizes interactive use as opposed to routine data entry, retrieval and acquisition. Large government agencies have vast data exchange requirements. Tactical military computer communication needs are perhaps the largest and most demanding (i.e. secure, rapid, reliable). Application such as these and many others that are providing the manpower, time and money behind the enormous growth of the information processing industry. As the result, computer systems and computer communication networks become highly complicated and complex in term of data management where different classes of users have their own characteristic and quality of service (QOS) requirements such as throughput, time delay, cost and error rate. In this context, a computer network can be viewed as a facility that makes possible communication between computers and other devices. Major components of the network include the connecting links, the interface between devices and the network, and protocols, which are rules for managing the network resources.