UNIVERSITI PUTRA MALAYSIA

PERFORMANCE MODELLING FOR MOBILE CELLULAR NETWORK USING QUEUEING SYSTEM

HUSSEIN MUZAHIM AZIZ BASI

FSKTM 1999 13

PERFORMANCE MODELLING FOR MOBILE CELLULAR NETWORK USING QUEUEING SYSTEM

HUSSEIN MUZAHIM AZIZ BASI

MASTER OF SCIENCE
UNIVERSITI PUTRA MALAYSIA

1999

PERFORMANCE MODELLING FOR MOBILE CELLULAR NETWORK USING QUEUEING SYSTEM

By

HUSSEIN MUZAHIM AZIZ BASI

Thesis Submitted in Fulfilment of the Requirements for the
Degree of Master of Science in the
Faculty of Computer Science and Information Technology,
Universiti Putra Malaysia

March 1999

In the name of Allah, Most Gracious, Most Merciful

Proclaim! (or read) in the name of thy Lord and Cherisher, who created (1), Created man, out of a (mere) clot of congealed blood (2) Proclaim! And thy Lord Most Bountiful (3), He Who taught (the use of) the pen (4), Taught man that which he knew not.

Surat Al-Alaq (The Clot)

To my Family ……

ACKNOWLEDGEMENTS

In the Name of Allah, Most Gracious, Most Merciful

It is my pleasure to take this opportunity to convey my sincere thanks and sincere gratitude to my supervisor Associate Professor Dr. A. K. Ramani who introduce me to the field of computer networks. I am also grateful to my co-supervisors Dr. Md. Yazid Mohd. and Ms. Shyamala Doraisamy for their kind support, help and guidance. I am really touched by Dr. Ramani and indeed grateful to him for having taken so much of his valuable time for studying, correcting and restructuring my work.

I would like to convey my sincere appreciation to the staff members of Faculty of Computer Science and Information Technology, the University Library, the Graduate School Office, and the Laboratories Technicians.

I'm grateful to Elok Robert Tee for his generosity in letting me share his office and resources in doing my work. Thank you to all my friends who have directly or indirectly given me the encouragement to complete this work.

Finally, I would like to express my most sincere and warmest gratitude to my father Professor Dr. Muzahim A. Basi, mother Md. Basi, brothers; Firas, Azwer, and my sister Hala. For their prayers, love, generous moral and financial support during my study.

Date: February 1999 *Hussein Basi*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

LIST OF ABBREVIATIONS

AC	Authentication center
BS	Base station
CGSA	Cellular geographic serving areas
DCA	Dynamic channel allocation
ESN	Electronic serial number
EIR	Equipment identity register
FCA	Fixed channel allocation
FCFS	First come first served
FIFO	First in first out
FOCC	Forward set-up channel
FCC	Federal communications commission
FDMA	Frequency division multiple access
GOS	Grade of service
HLR	Home location register
HCA	Hybrid channel assignment
MAC	Media access control
MSC	Mobile switching center
MS	Mobile station
MIN	Mobile identification number

PSTN	Public switched telephone network
RBS	Radio base station
SAT	Supervisory audio tone
SID	Home system identity
SS	Subscriber station
TDMA	Time division multiple access
TIA	Telecommunications Industry Association
VLR	Visitor location register

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science.

PERFORMANCE MODELLING FOR MOBILE CELLULAR NETWORK USING QUEUEING SYSTEM

By

HUSSEIN MUZAHIM AZIZ BASI

March 1999

Chairman : Associate Professor Ashwani K. Ramani, Ph. D.

Faculty : Computer Science and Information Technology

Mobile networking technology has been in existence for more than twenty years, but only in the past decade has it become commercially popular. With computers however increasingly portable and networks more accessible, users are coming demanding to the same network services from mobile network as they have been accustomed to obtaining from stationary wireline networks. Mobile communication can be defined as any communications network in which at least one of the constituent entities (users, switches, or a combination of both) change location, relative one to another.

One of the most important problems in the design of a cellular system is deciding on the optimal configuration of it. The designers must evaluate the possible configurations of the system components and their characteristics in order to develop a system with greater efficiency. The parameters useful to measure

different parts performance of the system are: voice quality, frequency spectrum efficiency and grade of service (GOS).

The grade of service (GOS) gives a form to measure a system's performance, and with it the proportion of non-served calls can be known. GOS in cellular systems is effected not only by the systems traffic but also by cochannel interference (outage).

In this thesis, the analytical study of the grade of service (GOS) degradation in presence of outage for the mobile communication with queueing system is wanted.

Two analytical models are proposed, the first model is with fixed outage rate, while the second model is the traffic dependent outage, where the outage is often dependent on the number of channels in use. Thus, the number of channels in outage can be considered as an indicator of the traffic load variations in the system.

The performance parameters considered for the study from the above models are queue length, waiting time and probability of delay. The analytical results can show the benefit for considering the queueing in the cellular network, and can be used by designers in choosing appropriate design parameters to meet requirements.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PEMODELAN PRESTASI BAGI RANGKAIAN BERSEL BIMBIT DENGAN SISTEM BERGILIR

Oleh

HUSSEIN MUZAHIM AZIZ BASI

Mac 1999

Penyelia : Prof. Madya Ashwani. K. Ramani, Ph. D.

Fakulti : Sains Komputer dan Teknologi Maklumat

Teknologi rangkaian bimbit telah wujud lebih dari dua puluh tahun, tetapi hanya pada dekad yang lepas ia telah menjadi popular secara kormesial. Dengan komputer menjadi semakin mudahalih dan rangkaian lebih senang dicapai, pengguna-pengguna mula menuntut perkhidmatan dari rangkaian bimbit sebagaimana yang mereka telah biasa perolehi dari rangkaian tetap. Komunikasi perhubungan boleh ditakrif sebagai mana-mana rangkaian perhubungan di mana sekurang-kurangnya satu daripada entiti-entiti terangkum (pengguna, suis, atau komunikasi kedua-duanya) berubah lokasi, relatif kepada satu dengan lain:

Satu daripada masalah yang paling penting dalam rekabentuk sistem bersel ialah dalam penentuan konfigurasi optimanya. Perekabentuk perlu menilai semua konfigurasi yang mungkin bagi komponen-komponen sistem dan ciri-cirinya bagi membangunkan sistem dengan kecekapan yang lebih tinggi. Parameter-parameter

yang berguna bagi mengukur prestasi bahagian-bahagian sistem ialah : mutu suara, kecekapan spektrum frekuensi dan gred perkhidmatan (GP).

GP memberi satu kaedah bagi mengukur prestasi sistem, dan dengannya bilangan panggilan tak dilayan dapat diketahui. Bukan sahaja kesesakan sistem malah gangguan saluran bersebelahan (outej) juga memberi kesan kepada GP sistem bersel. Di dalam tesis ini, kajian beranalitik bagi kemelesetan GP dengan kehadiran outej bagi perhubungan bimbit dijalankan mengguna sistem berbaris gilr. Dua model analitikal dicadang, yang pertama dengan kadar outej tetap, manakala model yang kedua ialah outej bergantung kepada kesesakan, di mana outej kerapkali bergantung kepada bilapan saluran dalam penggunaan. Maka, bilangan saluran dalam outej boleh dipertimbangkan sebagai satu petanda bagi perubahan muatan kesesakan dalam sistem.

Parameter-parameter prestasi yang dipertimbangkan dalam kajian dengan model-model di atas ialah panjang giliran, masa penungguan dan kebarangkalian kelewatan. Keputusan analitikal boleh memberikan satu nilai kuantitatif untuk kelebihan bagi mempertimbangkan giliran dalam rangkaian bersel, dan boleh diguna oleh pereka bentuk dalam memilih rekabentuk parameter-parameter yang bersesuaian bagi memenuhi keperluan.

CHAPTER I

INTRODUCTION

Personal Communications System

James Clerk Maxwell, a professor of physics at Cambridge University, established the possibility of radio communications in 1864. Maxwell showed theoretically that an electrical disturbance, propagating at the speed of light, could produce an effect at a distance. Hertz, who demonstrated spark-gap communications over distances of several feet in the 1880s, first put theory into practice (Garry, 1993). Marconi, who by 1901 succeeded in transmitting Morse code across the Atlantic oceans, rapidly extended the distance. The vacuum tube made speed transmissions practical and by 1915 the American Telephone and Telegraph Company had sent speech transmissions from Washington, D.C., to Paris and Honolulu (Brailean, 1991). The first practical mobile communications occurred in 1928 when the Detroit Police Department finally succeeded in solving the instability and low sensitivity problems that had plagued their mobile receiver designs for seven years.

By 1933, a mobile transmitter had been developed, allowing the first two-way police system operates in Bayonne, New Jersey (Gregory, 1993).

The personal communications has become a hot topic, not because it is so revolutionary, but because growth in mobile telephone demand has reached a dynamic turning point.

In 1991 the policy statement (FCC), recommended that the substantial spectrum should be allocated to personal communications. The service should be defined broadly to include a whole family of related services. For instance, personal communications could include a public two-way voice service, a data service, or wireless (Gregory, 1993). This definition issue has been hotly debated in the telecommunications industry, and the definition any particular party sets forth depends in large part on what that party would do with the spectrum if it were a licensee. Because of the absence of a strong of consensus from industry, the trend has been to provide greater flexibility to licensees to provide different services. This flexibility allows licensees to respond quickly to consumer needs and allows licensees to use spectrum efficiently (Allen, 1993).

As is always true when existing users may have to vacate spectrum, the proposal is quite controversial in the point-to-point microwave community.

A significant factor in the need to move existing users is whether an overlay technology, such as spread spectrum, can coexist in the same spectrum with point-to-point microwave users (Gregory, 1993).

Personal communications was mentioned as one of the first beneficiaries of the new reserve. The reserve is 220 MHz of spectrum in the 1.8 to 2.2 GHz ranges. The existing licensees of this proposed reserve spectrum are mostly private and common carrier point-to-point microwave users.

Users vary from state and local governments, public utilities to cellular carriers and local and long distance telephone companies (William, 1989).

Interest in instituting personal communications has been sparked internationally as well. The visionaries see personal communications as a service, which can be used at, home, at work, etc. . With personal communications, people will call people, not places; building on the foundation set by cellular.

Cellular System

The most relevant history to the development of personal communications lies with the development of cellular service. Cellular was developed in the United States in the 1940s at Bell Laboratories (John, 1990).

There was no significant move to allocate spectrum for mobile telephone until 1968. Much of the reason for this delay was due to a policy battle with broadcasters who sought to retain control over the 800/900 MHz band (Gregory, 1993).

Broadcasters continued to fight the reallocation of spectrum. Private radio and public mobile telephone interests battled for what they viewed as their share of the spectrum. In 1970, the Federal Communications Commission (FCC) allocated 154 MHz of spectrum 806-960 MHz, to cellular and private radio services. Forty MHz of this spectrum was allocated to cellular (Gregory, 1993).

In 1981, the spectrum is split up the 40 MHz into two equal blocks to be allocated to a wireline carrier, or Telephone Company, and a nonwireline carriers in each metropolitan market. Also they felt that a minimum of 20 MHz was required to prove a viable service using frequency reuse techniques (John, 1990).

The cellular spectrum is allocated to the wireline telephone companies, granting a monopoly in any particular market. This proposal was extremely controversial, being challenged by many parties who sought to make open entry a reality. At this time, the demand for cellular service was not known and the technology was untested. At & T, for example, predicted that there would be 105,000 two-way customers nationwide by 1990 (Gregory, 1993).