UNIVERSITI PUTRA MALAYSIA

RESOURCE ALLOCATION AND MOBILITY PREDICTION ALGORITHMS FOR MULTIMEDIA WIRELESS CELLULAR NETWORKS

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By

MAHER ALI AL-SANABANI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Doctor of Philosophy

May 2008

DEDICATION

To the memory of my Parents,
To my Wife and my Kids
To my Brothers and my Sisters

Maher

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

RESOURCE ALLOCATION AND MOBILITY PREDICTION ALGORITHMS FOR MULTIMEDIA WIRELESS CELLULAR NETWORKS

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Chairman: **Shamala Subramaniam, PhD.**

Faculty: **Computer Science and Information Technology**

Among the issues the telecommunication industry is the demand for multimedia applications with Quality of Service (QoS) in wireless/mobile networks. In the face of this increasingly complex traffic mix, where each service imposes different requirements, QoS provisioning and guarantee for multimedia services have become increasingly important. This is partially due to the users' requirements and poses a difficult challenge for network service providers. The tasks are more challenging than those in the wired networks due to the shortage of resources and the mobility present in wireless networks. The mobility factor causes severe fluctuations of resource usage.

In this research, the QoS provisioning and resource utilization for multimedia services in wireless/mobile networks aspects are addressed.

The first proposed scheme is called Adaptive Multi-Class Services Controller scheme (AMCSC). This scheme harnesses the combinations of Call Admission Control (CAC),

an Adaptive Bandwidth Allocation (ABA) algorithm with micro-Acceptable Bandwidth Level (micro-ABL) and the Connection Management Table (CMT). The specific objective in designing the AMCSC Scheme is to reduce the New Connection Blocking Probability (NCBP) and the Handoff Connection Dropping Probability (HCDP) by managing resource allocation to address. The insufficient resource problem is experienced by the MTs. This scheme supports multiple classes of non-adaptive and adaptive multimedia services with diverse QoS requirements.

The second proposed scheme is a bandwidth reservation scheme based on Mobility Prediction Scheme (MPS). Two proposed MPSs are deployed to predict the mobility movement of mobiles. The first MPS obtains the user mobility information by Received Signal Strength (RSS) which also includes the direction of the MT. This is enhanced based also on the position of the MT within a sector and zones of the cell. The second MPS obtains the user mobility information using the road map information of the cell and the integrated RSS and Global Position System (GPS) measurements. The simulation results show that the proposed scheme enhances the estimation of the target cell. This shown by the reduction of the signalling traffic in wireless cellular networks, reduction of the number of terminated ongoing calls of non-real time traffic and reduction of the number of cancelled reservation due to false reservation.

The third proposed framework is an integration of the AMCSC scheme and the bandwidth reservation done based on the MPS. This integration is used to achieve the ideal balance between the users' QoS guarantee of multiple classes of wireless multimedia and maximizing the bandwidth utilization. The performance result of the proposed framework has proven to improve the achieved performance metrics.

The performances analysis in this research is discrete simulation. The proposed schemes have proven to enhance the performance in terms of NCBP and HCDP for each type of traffic, management the resource for multiple traffics with diverse requirement, bandwidth utilization and predicting the target cell in the right time and place.

Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

ALGORITMA PERLOKASIAN SUMBER DAN PERAMALAN MOBILITI BAGI MULTIMEDIA RANGKAIAN SELLULAR TANPA-WAYAR

Oleh

MAHER ALI AL-SANABANI

Mei 2008

Pengerusi: **Shamala Subramaniam, PhD.**

Fakulti: **Sains Komputer dan Teknologi Maklumat**

Salah satu isu terkini dalam industri komunikasi adalah permintaan aplikasi multimedia dengan *Quality of Service* (QoS) untuk rangkaian tanpa wayar/mobil. Berdepan dengan cabaran dalam menghadapi peningkatan trafik yang kompleks, di mana setiap servis mempunyai permintaan yang berlainan, kepentingan untuk pengawasan QoS dan jaminan bagi servis multimedia semakin meningkat. Sebahagian hal ini adalah disebabkan oleh permintaan pengguna dan peranan yang sukar dimainkan oleh penyedia khidmat rangkaian. Cabaran yang perlu dihadapi oleh rangkaian tanpa wayar adalah lebih sukar jika dibandingkan dengan rangkaian berwayar kerana rangkaian tanpa wayar kekurangan dari segi sumber dan kehadiran mobility dalam rangkaian tersebut. Faktor mobiliti mengakibatkan fluktuasi pada sumber yang sedia ada.

Dalam penyelidikan ini, aspek pengawasan QoS dan jaminan terhadap servis multimedia pada rangkaian tanpa wayar/mobil akan diberi lebih penekanan.

Skema pertama iaitu skema adaptasi yang dinamakan sebagai skema *Adaptive Multi-Class Services Controller* (AMCSC). Skema ini menggabungkan Call Admission Control (CAC) dan algoritma Adaptive Bandwidth Allocation (ABA) bersama mikro-Acceptable Bandwidth Level (mikro-ABL) dan Connection Management Table (CMT). Objektif yang lebih spesifik dalam mereka-bentuk Skema AMCSC adalah untuk mengurangkan New Connection Blocking Probability (NCBP) dan Handoff Connection Dropping Probability (HCDP) dengan mengawal penenmpatan sumber kepada alamat. Masalam kekurangan sumber ini dialami oleh MT. Skema ini menyokong beberapa kelas servis multimedia bukan-adaptasi dan multimedia adaptasi dengan pelbagai keperluan QoS.

Skema kedua, iaitu skema penempahan jalur-lebar berasaskan kepada *Mobility Prediction Scheme* (MPS). Dua MPS yang dicadangkan digunakan untuk menjangkakan pergerakan mobil. MPS pertama memiliki informasi pergerakan pengguna melalui *Received Signal Strength* (RSS) termasuk arah pergerakan MT. Asas peningkatan ini juga berlaku ke atas posisi MT dalam jangkauan sektor dan zon sel. MPS kedua memiliki informasi pergerakan penguna yang menggunakan maklumat peta perjalanan sel dan gabungan RSS dan ukuran *Global Position System* (GPS). Keputusan simulasi menunjukkan skema yang dicadang meningkatkan jangkaan terhadap sel sasaran. Ini ditunjukkan melalui pengurangan isyarat trafik di dalam rangkaian sellular tanpa-wayar, pengurangan jumlah panggilan keluar dalam trafik masa sebenar yang dicantas dan pengurangan jumlah penempahan yang dibatalkan berikutan penempahan yang tidak tepat.

Skema ketiga yang dicadangkan adalah integrasi antara skema AMCSC dan penempahan jalur-lebar berdasarkan kepada MPS. Integrasi ini digunakan untuk mencapai keseimbangan antara kepelbagaian kelas multimedia tanpa wayar bagi jaminan QoS pengguna ke atas pelbagai kelas media tanpa-wayar serta memaksimumkan penggunaan jalur-lebar. Keputusan skema yang dicadangkan telah dibuktikan bahawa ia berupaya memperbaiki keputusan metric.

Analisis keputusan penyelidikan ini adalah berdasarkan simulasi berpisa. Skema yang dicadangkan telah membuktikan bahawa ia berupaya memperbaiki keupayaan dalam NCBP dan HCDP untuk pelbagai jenis trafik, mentadbir sumber untuk perlbagai traffic dengan berbagai keperluan, penggunaan jalur lebar dan menjangkakan sel sasaran pada masa dan tempat yang betul.

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I certify that an Examination Committee met on May 30, 2008 to conduct the final examination of Maher Ali Al-Sanabani on his Doctor of Philosophy thesis entitled "Resource Allocation and Mobility Prediction Algorithms for Multimedia Wireless Cellular Networks" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded a relevant degree. Members of the Examination Committee are as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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Date: 14 August 2008.

DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously and is not concurrently submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

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MAHER ALI AL-SANABANI

Date:

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABA	Adaptive Bandwidth Allocation
ABR	Adaptive Bandwidth Reservation
AMCSC	Adaptive Multi-Class Services Controller scheme
AMPS	Advanced Mobile Phone System
ATM	Asynchronous Transfer Mode
BCP	Boundary Cell Point
BS	Base Station
CAC	Call Admission Control
CDMA	Code Division Multiple Access
CMT	Connection Management Table
CP	Complete Partitioning
CS	Complete Sharing
DCA	Dynamic Channel Allocation
FCA	Fixed Channel Allocation
FCFS	First-Come-First-Served
FDMA	Frequency Division Multiple Access
GC	Guard Channel
GPS	Global Positioning System
GSM	Global System for Mobile communications
HCA	Hybrid Channel Allocation
HCDP	Handoff Call Dropping Probability
HPS	Handoff Probable Segment

HZ	Handoff Zone
IP	Internet Protocol
ITU-T	International Telecommunications Union - Telecommunications
Km	Kilometres
LAN	Local Area Network
MAHO	Mobile Assisted HandOff
MCHO	Mobile Controlled HandOff
micro-ABL	micro Acceptable Bandwidth Level
MLC	Most Likely Cluster
MPS	Mobility Prediction Scheme
MSC	Mobile Switching Centre
MT	Mobile Terminal
NCBP	New Call Blocking Probability
NCHO	Network Controlled HandOff
NRZ	Non-Reservation-Zone
nrt-UBR	non-real time-Unspecified Bit Rate
PCS	Personal Communications System
PDA	Personal Digital Assistant
PDC	Personal Digital Cellular
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RD	Reservation Deadline
RRM	Radio Resource Management
RSS	Received Signal Strength
RTB	Road Topology Based

RTI	Road Topology Information
rt-CBR	real time-Constant Bit Rate
rt-VBR	real time – Variable Bit Rate
RZ	Reservation Zone
TD	Threshold Distance
TDMA	Time Division Multiple Access
WAN	Wide Area Network
UMTS	Universal Mobile Telecommunications System
WCNS	Wireless Cellular Network Simulator
1G	First Generations
2G	Second Generations
3G	Third Generations
4G	Fourth Generations

CHAPTER 1

INTRODUCTION

Wireless communication is, by any measure, the fastest growing segment of the communications industry (Anderea, 2005). As such, it has captured the attention of the media and the imagination of the public. Wireless cellular networks system has experienced exponential growth over the last decades and there were 2 billion users in 2005 as compared to the 10 million users in 2000. It is predicted to reach 3 billion users by the end of 2010 (Audrey, 2006). Nowadays, cellular phones have become a critical business tool and this form important aspect of daily life. This popularity of wireless communication systems is due to its advantages as compared to wireline systems. Among the main advantages is the mobility and cost savings. Complementary to the fast growing Internet technology, wireless communication systems offer an easy and convenient way to share information around the world (Nicopolitidis *et al.*, 2003).

1.1 Overview of Wireless Cellular Network Systems

A wireless cellular network comprises of two levels, a fixed level and a movable level. There are three key constituent elements in wireless cellular network: a Mobile Terminal (MT) which is at the movable level, Base Station (BS) and Mobile Switching Centre (MSC) which are at the fixed level. The MT can be any handheld device, such as a mobile phone, portable computer, Personal Digital Assistant (PDA), car communication systems, notebook, or any other device capable of communicating via omni-directional radio waves within a given frequency band