



**UNIVERSITI PUTRA MALAYSIA**

**LOCATION MANAGEMENT COST REDUCTION USING ADAPTIVE  
VELOCITY-MOVEMENT BASED SCHEME IN PERSONAL CELLULAR  
NETWORKS (PCN)**

**MABRUK SALEM M ELGEMBARI**

**FK 2002 55**

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**By**

**MABRUK SALEM M ELGEMBARI**

**Thesis Submitted to the School of Graduate, Universiti Putra Malaysia  
in Partial Fulfillment of the Requirements for the degree of Master of Science**

**August 2002**



*To God, my Parents, and my Wife*



Abstract of thesis presented to Senate of University Putra Malaysia in partial fulfillment of the requirement for the degree of Master of Science

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**Chairman: Associate Professor Borhanuddin Mohd. Ali, Ph.D.**

**Faculty: Engineering**

Wireless personal communication networks (PCNs) consist of a fixed wireless network with nodes providing wireless coverage area and a large number of mobile terminals (MTs). These terminals are free to travel within the PCN coverage area without service interruption. Each terminal periodically reports its location to the network by a process called location update. When a call arrives for a particular mobile terminal, the network will determine the exact location of the destination terminal by a process called terminal paging. There are many schemes proposed which aim at reducing signaling costs and all these schemes were based on different assumptions and network parameters. Our objective is to study the updating and paging process of the MTs under different dynamic location management schemes, and to develop an adaptive scheme that caters for the ever-changing network parameters. In this thesis, a dynamic paging scheme is



proposed and presented based on the semi-real time velocity information of an individual mobile user. This allows for more accurate prediction of the user location when a call arrives and therefore, reducing the cost of paging. The scheme is based on a basic scheme that was proposed in the open literature. Our new scheme results show that the newly proposed adaptive movement threshold and the adaptive velocity time unit schemes provide significant costs savings, compared to a benchmark system and the basic scheme, under different cell radius sizes and MT velocities broadly classified as high and low mobility systems.



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

**PENGURANGAN KOS PENGURUSAN LOKASI DALAM RANGKAIAN  
SELULAR PERIBADI MENGGUNAKAN SKIM BERASASKAN HALAJU-  
PERGERAKAN BOLEH-SESUAI**

**Oleh**

**MABRUK SALEM M ELGEMBARI**

**Ogos 2002**

**Pengerusi: Professor Madya Borhanuddin Mohd. Ali, Ph.D.**

**Fakulti: Kejuruteraan**

Rangkaian Komunikasi Peribadi wayarles (PCN) mengandungi rangkaian wayarles tetap dengan nod-nod yang menyediakan kawasan liputan wayarles dan sejumlah besar terminal mudahalih (MT). Terminal ini bebas bergerak di dalam kawasan liputan PCN tanpa mengalami gangguan perkhidmatan. Setiap terminal, secara berkala, melaporkan lokasinya kepada rangkaian melalui proses yang dinamakan pengemaskinian lokasi. Apabila sesuatu panggilan tiba dari terminal tertentu, rangkaian akan memastikan destinasi yang tepat melalui proses yang dipanggil pengeluaran terminal. Beberapa skim

telah dicadangkan yang bertujuan untuk mengurangkan kos pengisyaratan. Kesemua skim ini adalah berasaskan kepada andaian dan parameter rangkaian yang berlainan. Di sini, objektif kami adalah untuk mengkaji proses pengemaskinian dan pengeluaran MT di bawah skema pengurusan lokasi dinamik yang berbeza, dan membangunkan skema boleh-ubahsuai yang mengambil-kira parameter rangkaian yang sentiasa berubah. Dalam tesis ini, satu skema pengeluaran dinamik dicadangkan dan dipersembahkan berasaskan maklumat halaju separa-masa benar dari setiap pelanggan mudahalih. Ini membenarkan ramalan lokasi pengguna yang lebih tepat ketika panggilan tiba dan mengakibatkan pengurangan kos pengeluaran. Skim ini berasaskan kepada satu skema asas yang telah dicadangkan dalam literatur terbuka. Keputusan kami menunjukkan bahawa skema ambang pergerakan boleh-ubahsuai dan skema unit masa halajau boleh-ubahsuai yang dicadangkan memberi natijah pengurangan kos, bila dibandingkan dengan satu sistem 'tanda aras' dan skema asas, menggunakan pelbagai saiz jejari dan halaju MT yang diklasifikasikan sebagai sistem kemudahalihan tinggi dan rendah.

## ACKNOWLEDGEMENTS

I would like to express deep gratitude to my advisor and chairman of my supervisory committee Assoc. Prof. Dr. Borhanuddin Mohd Ali, who has helped me very substantially with his guidance, advices, corrections, improvements, and preparation of my thesis.

I am no less grateful to the other committee members Dr V. Prakash and Puan Norkamariah Nordin, who are kind enough to read and comment on my work.

I am also deeply indebted to Dr Mohamed Hadi Habaebi for teaching me MATLAB and support me all the time with his ideas, which helped me to solve a number of problems. Without his suggestions and advices almost every single page of my thesis would have less to offer and would still be far from finished.

I would also like to thank Mr Ashraf Gasim Abdallah, for being helpful and by identifying the research topic.

My additional thanks, to Puan Aishah and my colleagues at the Wireless and Broadband Laboratories, for their kindness and help during my research time.

It is with particular pleasure that I express my affectionate and deeply felt gratitude to my mother, father, brothers, sisters, my wife and the rest of my family members who





always encourage and support me, for without them, my work would have been much more difficult.



This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfillment of the requirements for the degree of Master of Science. The members of the Supervisory Committee are as follows:

**Borhanuddin Mohd Ali, Ph.D.**

Associate Professor,  
Faculty of Engineering,  
Universiti Putra Malaysia  
(Chairman)

**V. Prakash, Ph.D.**

Lecturer  
Faculty of Engineering,  
Universiti Putra Malaysia  
(Member)

**Mohamed Hadi Habaebi, Ph.D.**

Lecturer  
Faculty of Engineering,  
Universiti Putra Malaysia  
(Member)

**Nor Kamariah Noordin, M.Sc.**

Lecturer  
Faculty of Engineering,  
Universiti Putra Malaysia  
(Member)

---

**AINI IDERIS, Ph.D.**

Professor / Dean  
School of Graduate studies,  
Universiti Putra Malaysia

Date



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## LIST OF ABBREVIATIONS

BSC	Base Station Controller
BVP	Basic Velocity Paging
CIC	Cell Identification Code
DCS	Digital Cellular System
DBLU	Direction based Location Update
ETI / TIA	Electronic/Telecommunication Industry Associations
FCC	Federal Communications Commission
GSM	Global System for Mobile Communications
HLR	Home Location Registration
ID	Identifier
LA	Location Area
m	Movement threshold
MT	Mobil Terminal
MSC	Mobile Switching Center
MIN	Mobile identification Number
MC	Mobility Class
NAP	Network Access Point
PACS	Personal Access Communication System
PCN	Personal Cellular Network
RA	Registration Area
STP	Signal Transfer Point



SS7	Signaling System No.7
TLDN	Temporary Local Directory Number
VCI	Velocity Class Index
VLR	Visitor Location Registration
VTU	Velocity Time Unit
MVP	Modified movement velocity paging
MVP_m	Modified movement velocity paging with adaptive movement threshold
MVP_VTU	Modified movement velocity paging with adaptive velocity time unit



## CHAPTER 1

### LOCATION MANAGEMENT IN PERSONAL COMMUNICATION NETWORKS (PCNs)

#### 1.1 Introduction

The Personal Cellular Network coverage area is divided into a large number of smaller areas called cells. Terminals within a cell communicate through the wireless network through a base station (BS) that is installed inside the cell. This base station serves as the network access point (NAP) for all the terminals within the cell. As soon as a terminal enters another cell, its NAP is switched to the base station of the newly entered cell. As the terminal is free to travel from cell to cell, a mechanism is needed to effectively keep track of the location of each terminal. When an incoming call arrives, the wire line networks must be able to determine the residing cell of the called mobile terminal (MT) in a timely fashion without incurring excessive computation and communication costs. Current cellular network partition their coverage area into a number of location areas (LAs). Each LA consists of a group of cells and each terminal reports its location to the



network whenever it enters an LA. This reporting process is called location update. When an incoming call arrives, the network locates the terminal by simultaneously polling all cells within the LA. This polling process is called terminal paging. Both the location update and the terminal paging processes require a certain amount of wireless bandwidth. In addition, the terminal to keep track of its location and to transmit update messages consumes significant power. As a result, the cost is based on the location update and the terminal paging processes. It is clear that if each LA consists of only one cell, the network knows exactly the location of each terminal. In this case the cost of terminal paging is minimal. However, the MT has to report its location whenever it enters a new cell. A trade-off, therefore, exists between the location update cost and the terminal paging policy that can minimize the total cost. In this thesis has been proposed the velocity paging based on the movement registration scheme, that the MT velocity is estimated in terms of velocity classes as opposed to the actual speed. Velocity classes' estimation greatly simplifies the computations and provides important robustness against the change of velocity. At the same time the system shall estimate to which velocity classes each MT belongs to, each time the MT updates its new location. When a MT receives a call, the system checks its velocity classes, estimates how far it could go, and pages the candidate cells.

## **1.2 Background**

Most of the research works performed on paging and registration algorithms can be categorized into two approaches. The first one, called the group mobility approach, builds the paging and registration schemes on top of the system users' collective



mobility pattern. The pattern is typically derived from the summary statistics the system collected over time. A good example of this approach is the location area scheme used in current PCN systems [2]. These algorithms essentially use the mobility information about a group of users to estimate an individual user's movement [3] [4] [5]. It comes as no surprise that these algorithms lack accuracy in their paging prediction and results in rather large paging zones.

The other approach, called the profile approach, recognizes the inherent problem with the group mobility approach and tries to use individual user profile to solve it [6] [7] [8] [9]. This, however, brings significant management overhead into the system, collection of individual user movement statistics, users profile compilation, periodic profile update, and large profile storage. They are fairly complex to implement and put a great burden on system resources and system operators.

### **1.3 Objectives**

The objectives of this thesis are as follows:

To study the mobility management of PCN networks.

To investigate various location management schemes proposed for optimizing location management cost.

To study the dynamic paging scheme for wireless communication system



and examine the velocity-paging scheme that utilizes semi-real time information.

To propose a modified scheme based on the basic velocity-paging scheme proposed in the open literature.

To develop analytical models to evaluate the performance of the velocity paging scheme which utilizes semi-real time technique for reducing signaling costs.

#### **1.4 Contributions of This Thesis**

The contributions of this thesis include:

1. The formulation and the development of a complete analytical model for the newly proposed modified schemes.
2. The formulation and the development of a complete analytical models for the Bench marking systems (i.e., the location area scheme and the basic velocity paging scheme) proposed in the open literature.
3. The performance evaluation of the newly proposed scheme, the adaptive velocity time unit scheme and the adaptive movement threshold scheme, using the quantitative measures presented in the thesis.
4. The proposition of a easy-to-implement simple procedure algorithm based on the above newly proposed schemes to be implemented in the mobile switching center (MSC) part of the fixed network without affecting the operation of the MTs.



## 1.5 Thesis Organization

This thesis is organized as follows: chapter 1 is divided into six sections. The first three sections introduce the location management in personal cellular network systems (PCNs) and describe the motivations and objectives of this thesis. Section four and five describe the contributions and the structure of this thesis respectively.

Chapter 2 consists of eight sections introducing the location registration and call delivery processes as the main part of the location management body. Detailed explanation of how registration and call delivery looks like in PCN networks and what are the existing location management methods in PCN networks are given.

Chapter 3 is divided into six sections describing the concept of the location management cost based on the wireless and wired network and how the velocity paging schemes developed for the velocity classes paging scheme, based on the movement and speed of the mobile terminals.

Section five and six describes the relationship between the velocity time unit, movement ( $m$ ) threshold and the registration time, and the effect of the velocity time unit and movement threshold on the total cost with different velocity classes.

Chapter 4 describes the analysis and evaluation of both schemes, location area and velocity paging models, based on the registration and paging cost, and how the adaptive

