UNIVERSITI PUTRA MALAYSIA

MOBILITY MANAGEMENT SCHEMES BASED ON MULTIPLE CRITERIA FOR OPTIMIZATION OF SEAMLESS HANDOVER IN LONG TERM EVOLUTION NETWORKS

YASEEIN SOUBHI HUSSEIN

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By

YASEEIN SOUBHI HUSSEIN

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

December 2014

DEDICATION

This thesis is dedicated to:

My mum and dad (Saadiya and Soubhi) for their love and endless support,

My lovely wife (Hiba) for her patience and encouragement throughout all my study period,

My beloved brothers and sisters,

Special thanks to my supervisor,

All of my friends,

My beloved first and second country Iraq and Malaysia

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

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December 2014

Chairman: Borhanuddin Mohd Ali, PhD

Faculty: Engineering

The tremendous growth of mobile devices and their attendant applications demand for wireless communication networks supporting high data rates with large capacity. The Long Term Evolution (LTE) network which has been accepted as a 4G network, provides mobile users with a high throughput and low handover latency at high user speeds. The burgeoning growth of real-time applications such as interactive video and voice communications and other media rich contents, places a heavy demand on the network for high data rate and guaranteed quality of service (QoS). To support mobility to a user equipment (UE) it needs to be handed over to a new eNB (evolved node base-station) while still maintaining connectivity with the network at high data rates. This poses a significant challenge that needs to be addressed.

In this thesis we propose a number of schemes to address handover issues such as Handover Failure (HOF), Handover Ping-Pong (HOPP), Outage Probability (OP), Handover Delay (HOD), Packet Loss Ratio (PLR) and Inter Cell Interference (ICI). These schemes extend over all handover phases, namely cell searching, cell selection and handover decision making. First, a scheme called soft frequency reuse and multiple preparations (SFRAMP) is proposed to provide a seamless and fast handover for a UE by way of reducing the handover latency and inter-cell interference which result in high throughput. It is shown that this proposed method significantly reduces the outage probability at various UE speeds. Simulation results using LTE-Sim show that the outage probability and delay are reduced by 24.4% and 11.9% respectively, compared to the hard handover (HHO) method that has been adopted for 4G. The second scheme is cell selection based on multiple criteria decision making (MCDM) approach. The scheme called fuzzy multiple criteria cell selection (FMCCS) considers S-criterion, a method which relies purely on the downlink signal strength, availability of resource blocks (RBs) and uplink SINR using an integrated fuzzy technique for order preference by similarity to ideal solution (TOPSIS). The conventional cell selection in LTE uses S-criterion only,

which is inefficient. It is shown that FMCCS significantly reduces HOPP and HOF with higher throughput. The simulation results show that FMCCS outperforms conventional and cell selection scheme (CSS) methods in HOPP reduction by approximately 27% and 23% and HOF reduction by 19% and 15%, respectively. The throughput shows approximately 11% gain over the conventional scheme.

The third scheme works on the self optimization of handover parameters using fuzzy logic control (FLC) and multiple preparation (MP) called FuzAMP. FLC can automatically optimize HO parameters i.e. Handover Margin (HOM) and Time-To-Trigger (TTT) based on a set of criteria, this is in order to minimize unwanted HOs known as HO Ping Pong (HOPP) and HO failure (HOF). The results demonstrated that our proposed method results in significant reductions of HOF, HOPP and packet loss ratio (PLR) compared to the conventional HHO and enhanced weighted performance HO parameter optimization (EWPHPO) algorithm. The results also show that the reduction of HOF through FuzAMP over conventional HHO algorithm is approximately 60%, 65%, and 66% at 3, 30, and 120 km/h, respectively, and over EWPHPO algorithm is approximately 30%, 46%, and 50% at 3, 30, and 120 km/h, respectively. In HOPP, the results demonstrate that the reduction of HOPP ratio by the FuzAMP algorithm relative to that of the conventional HHO algorithm is approximately 54%, 44%, and 69% at 3, 30, and 120 km/h, respectively, and over EWPHPO algorithm the improvement is approximately 38%, 33%, and 65%, respectively. Moreover, PLR is reduced by approximately 67%, 59%, and 68% at 3, 30, and 120 km/h, respectively, over HHO while over EWPHPO algorithm, the improvements are approximately 52%, 35%, and 48% at 3, 30, and 120 km/h, respectively.

Abstrak tesis ini dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

SKIM PENGURUSAN MOBILITI BERDASARKAN KRITERIA BERBILANG UNTUK PENGOPTIMUMAN PENYERAHAN LANCAR DALAM RANGKAIAN EVOLUSI JANGKA PANJANG

Oleh

YASEEIN SOUBHI HUSSEIN

Disember 2014

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Faculti: Kejuruteraan

Pertumbuhan yang luar biasa peranti bergerak dan aplikasi yang berkaitan memerlukan rangkaian komunikasi wayerles yang menyokong kadar data yang tinggi dengan muatan tinggi. Rangkaian Evolusi Jangka Panjang (LTE) yang telah diterima sebagai rangkaian 4G, menawarkan pengguna bergerak dengan truput yang tinggi dan lengah serahan yang pendek pada kelajuan pengguna yang tinggi. Pertumbuhan mendadak aplikasi masa nyata seperti video interaktif dan komunikasi suara dan media kaya kandungan yang lain, mengenakan permintaan yang berat kepada rangkaian untuk kadar data tinggi dan kualiti perkhidmatan (QoS) yang terjamin. Untuk menyokong pergerakan kepada alatan pengguna (UE) ia perlu diserahkan kepada eNB (nod stesyen tapak evolusi) sementara masih lagi mengekalkan sambungan dengan rangkaian dengan kadar data yang tinggi. Ini menimbulkan cabaran yang besar yang perlu ditangani.

Dalam tesis ini kami mencadangan beberapa skim untuk menangani isu penyerahan seperti kegagalan penyerahan (HOF), penyerahan ping-pong (HOPP), kebarangkalian gangguan (OP), lengah penyerahan (HOD), nisbah kehilangan paket (PLR) and gangguan antara sel (ICI). Skim ini melangkaui ke semua fasa penyerahan, ia itu pencarian sel, pemilihan sel dan membuat keputusan penyerahan. Pertama, suatu skim yang dipanggil penggunaan frekuensi liut dan penyediaan berbilang (SFRAMP) adalah dicadangkan untuk menawarkan penyerahan lancar dan pantas untuk UE dengan mengurangkan lengah penyerahan dan gangguan antara sel yang menghasilkan truput yang tinggi. Adalah ditunjukkan bahawa kaedah yang dicadangkan ini mengurangkan kebarangkalian gangguan pada beberapa kelajuan UE. Hasil keputusan menggunakan LTE-Sim menunjukkan bahawa kebarangkalian gangguan dan lengah dapat dikurangkan dengan 24.4% and 11.9% masing-masing,

berbanding dengan kaedah penyerahan keras (HHO) yang telah diterimapakai oleh 4G.

Skim kedua adalah berasaskan pendekatan pengambilan keputusan berbilang kriteria (MCDM). Skim tersebut yang dinamakan pemilihan sel kriteria berbilang kabur (FMCCS) mengambil kira kriteria S, suatu kaedah yang bergantung sepenuhnya kepada kekuatan isyarat pautan-turun, adanya blok sumber (RB) dan nisbah isyarat ke gangguan dan bisingan (SINR) pautan-atas menggunakan kaedah kabur bersepadu untuk keutamaan susunan berdasarkan kesamaan kepada penyelesaian unggul (TOPSIS). Pemilihan sel konvesional dalam LTE adalah menggunakan kriteria-S semata-mata, ini adalah tidak cekap. Adalah ditunjukkan bahawa FMCCS mengurangkan dengan ketara HOPP dan HOF dengan truput yang lebih tinggi. Hasil keputusan menunjukkan bahawa FMCCS mengatasi kaedah konvensional dan skim pemilihan sel dengan penurunan HOPP sehingga 27% and 23% dan penurunan HOF sehingga 19% and 15%, masing-masing. Truput menunjukkan kelebihan lebih kurang 11% ke atas skim konvensional.

Skim ketiga beroperasi ke atas parameter pengoptimuman kendiri penyerahan menggunakan kawalan logik kabur (FLC) dan penyediaan berbilang (MP) yang dipanggil FuzAMP. FLC mampu untuk mengoptimumkan parameter HO secara automatik, i.e. margin penyerahan (HOM) dan masa untuk mencetus (TTT) berdasarkan satu set kriteria, ini adalah untuk memiminumkan HO yang tak diperlukan yang dikenali sebagai penyerahan Ping Pong (HOPP) dan kegagalan penyerahan (HOF). Hasil keputusan menunjukkan bahawa kaedah cadangan kami menghasilkan penurunan yang ketara bagi HOF, HOPP dan nisbah kehilangan paket (PLR). Hasil keputusan juga menunjukkan penurunan HOF melalui FuzAMP ke atas algoritma HHO konvensional adalah lebih-kurang 60%, 65%, dan 66% pada kelajuan 3, 30, and 120 km/j. Dalam HOPP, hasil keputusan menunjukkan penurunan nisbah HOPP oleh algoritma FuzAMP secara relatif ke atas algoritma HHO konvensional adalah lebih-kurang 54%, 44%, and 69% pada kelajuan 3, 30, and 120 km/j masing-masing, manakala ke atas algoritma EWPHPO penambahbaikan adalah lebihkurang 38%, 33%, and 65%, masing-masing. Lebih-lebih lagi,PLR adalah dikurangkan dengan lebih-kurang 67%, 59%, and 68% pada kelajuan 3, 30, and 120 km/j, masing-masing ke atas HHO manakala ke atas algoritma EWPHPO, penambahbaikan adalah lebih-kurang 52%, 35%, dan 48% pada kelajuan 3, 30, dan 120 km/j, masing-masing.

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I certify that a Thesis Examination Committee has met on 19 December 2014 to conduct the final examination of Yaseein Soubhi Hussein on his thesis entitled "Mobility Management Schemes Based on Multiple Criteria for Optimization of Seamless Handover in Long Term Evolution Networks" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

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

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Declaration by graduate student

I hereby confirm that:

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Declaration by Members of Supervisory Committee

This is to confirm that:

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LIST OF ABBREVIATIONS

3GPP	3rd Generation Partnership Project
4G	fourth generation networks
AHP	analytic hierarchy process
AMC	adaptation modulation and coding
ARQ	automatic repeat request
AS	access stratum
BS	base station
CN	core network
CoMP	coordinated multi-point transmission
CQIs	channel quality indicators
CS	circuit switched
CSS	Cell selection scheme
DCS	dynamic cell selection
DL	downlink
DRX	discontinuous reception
DTX	discontinuous transmission
eICIC	enhanced inter-cell interference coordination
eNB	evolved node base-station
EPC	evolved packet core
EUTRA	Evolved Universal Terrestrial Radio Access
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
EWPHPO	Enhanced Weighted Performance HO Parameter Optimization
FCS	fast cell selection scheme
FDD	frequency division duplex
FFR	fractional frequency reuse
FLC	fuzzy logic control
FMCCS	Fuzzy Multi Criteria Cell Selection
FRF	frequency reuse factor
FTP	file transfer protocol
FuzAMP	Fuzzy Logic Control and Multiple Preparation

GPRS	general packet radio service
HARQ	hybrid automatic repeat request
HHO	hard handover
HII	high interference indicator
HO	handover
HOD	handover delay
HOF	Handover failure
HOM	handover margin
HOPP	Ping-Pong handover
HSDPA	High-Speed Downlink Packet Access
HSS	home subscriber server
ICI	inter-cell interference
ICIC	inter-cell interference coordination
ID	cell identity
IMS	IP multimedia subsystem
IMT-A	International Mobile Telecommunications-Advanced
IP	internet protocol
ITU	International Telecommunication Union
L1	Layer 1
L2	Layer 2
L3	Layer 3
LTE	Long-Term Evolution - proper noun as it's the name of a standard
LTE	Long-Term Evolution
MAC	medium access control
MCDM	multi criteria decision making
MCS	modulation and coding scheme
MIB	master information block
MIMO	Multiple-Input Multiple-Output
MM	mobility management
MME	mobility management entity
MP	multiple preparations
MRO	mobility robustness optimization
MS	mobile station

NAS	non-access stratum
NB	node base station
NCS	neighboring cell search
NGMN	next-generation mobile networks
OFDMA	orthogonal frequency division multiple access
OI	overload indicator
PBCH	physical broadcast channel
PBGT	power budget
PDCCH	physical downlink control channel
PDCP	packet data convergence protocol
PDN	packet data network
PDSCH	physical downlink shared channel
PFR	partial frequency reuse
P-GW	packet data network gateway
PHY	physical layer
PICs	physical cell identities
PLMN	public land mobile network
PLR	packet loss ratio
PRBs	physical resource blocks
PS	packet switched
PSCH	primary synchronization channel
QoE	quality of user experience
QoE	quality of user experience
QoS	Quality of service
RA	random access
RAT	radio access technology
RBs	resource blocks
RE	resource element
RLC	radio link control
RLF	radio link failure
RN	relay node
RNC	radio access control

RNTP	relative narrowband transmit power
RRC	radio resource control
RRM	radio resource management
RS	reference symbol
RSRP	reference signal received power
RSRQ	reference signal received quality
RSSI	received signal strength indicator
SAE	system architecture evolution
SC-FDMA	single carrier frequency division multiple access
SFN	system frame number
SFR	soft frequency reuse
SFRAMP	Soft Frequency Reuse and Multiple Preparation - proper noun as it's the name of their proposed scheme
S-GW	serving gateway
SHO	soft handover
SI	system information (SI)
SIB	system information block
SON	self-organizing networks
SRBs	signaling radio bearers
SSCH	secondary synchronization channel
SSDT	site selection diversity transmission
SSM	sufficient signal metric
SSS	secondary synchronization signal
TA	tracking area
TCP/IP	Transmission Control Protocol/Internet Protocol
TDD	time division duplex
TE	terminal equipment
TOPSIS	technique for order preference by similarity to ideal solution
TTI	transmission time interval
TTT	Time-to-Trigger - proper noun as it's the name of a specific parameter
UE	user equipment
UICC	universal integrated circuit card
UL	uplink

UMTS	universal mobile telephone system
USIM	universal subscriber identity module
VoIP	Voice over IP
W-CDMA	Wideband Code Division Multiple Access
WiMAX	Worldwide Interoperability for Microwave Access
WPHPO	Weighted Performance HO Parameter Optimization

CHAPTER 1

INTRODUCTION

1.1 Background

Over the past decade, there have been great interests in cellular and fixed radio access technologies for providing mobile, nomadic and fixed telecommunication services. The fast pace development of this technology and the challenges it presents due to the increasing number of user equipments (UEs) and the demand to have the service on-the-go have presented new challenges with base stations capability and the handover (HO) techniques. The burgeoning growth of real-time applications such as interactive and streaming video and voice, and media rich applications, place a heavy demand for a high speed network and guarantee of quality of service (QoS).

To cope with these demands and challenges a new network framework called Fourth Generation Networks (4G) has been defined by the ITU-T, and some technologies that meet this specifications such as Long Term Evolution (LTE) has been developed by 3rd Generation Partnership Project (3GPP). LTE provides reduced latency, higher user data rates, improved system capacity and coverage, and reduced costs for the operator. In order to achieve this, an evolution of the radio interface as well as the radio network architecture has been considered [1].

LTE, also called Evolved Universal Terrestrial Radio Access (EUTRA), is capable of providing high data rates of 150 Mbps in downlink direction and 50 Mbps in the uplink, with low latency, flexible bandwidths from 1.4MHz up to 20MHz, as well as support high level mobility and security. Unlike Universal Mobile Telecommunications System (UMTS), LTE is completely Packet Switched (PS) in the core network, whereas UMTS supports both Circuit Switched (CS) and PS in the core networks [2]. 4G technology is based on TCP/IP, the core protocol of the internet. TCP/IP enables wireless networks to deliver higher-level services such as voice over IP, video and streaming media [3].

Unlike WiMAX which is a new built out network, LTE is completely integrated into the existing cellular infrastructure for 2G and 3G networks. This provides seamless handover connectivity between LTE and previous standards. Handover (HO) is an important function that refers to the process of transferring from one base station (called evolved Node B in LTE, eNB) to another while a call is in progress. In general, there are two types of handover: the first type is called intra-RAT or horizontal handover, which is HO within one radio access technology (from one eNB to another within LTE), and the second one is called inter-RAT or vertical handover between different radio access technologies such as LTE and GSM or 3G WCDMA, 3GPP2, WiMAX or even wireless LAN [4].

Intra RAT handover can be further categorised into hard handover (HHO) and soft handover (SHO). HHO is the case when the connection with a previous eNB is severed before being handed over to the next eNB (also known as break-before-make), is only to be considered in LTE networks. HHO can be optimized using an layer 3 (L-3) filtering, and some handover parameters particularly handover margin (HOM) and Time-to-Trigger (TTT) [5], [6]. HHO procedure is simple but it suffers from high outage probability, long delays and unreliable break-before-make procedures [7]. The other handover method, SHO is the case when the connection to two eNBs is simultaneously maintained before being handed over to the next eNB, also called make-before-break. The SHO is a more reliable technique but comes at the cost of wastage of bandwidth and higher complexity, which is undesirable in LTE networks.

In LTE, HHO procedures can be grouped into two categories; initial access and handover. Initial access phase comprises of cell search, cell selection/re-selection, derived system information (SI) and random access (RA). Handover phase comprises of three sub-phases handover preparation, handover execution and handover completion. The cell search and cell selection process is controlled by the user equipment (UE) when the radio resource control (RRC) is in the "idle state", whereas the handover phase is controlled by the eNB, when the RRC is on "connected state" [8], [9]. During the cell search the UE extracts required information from the system information (SI) for random access. These steps are necessary for the users, like all communication systems, before they can send or receive data as shown in Figure 1.1.

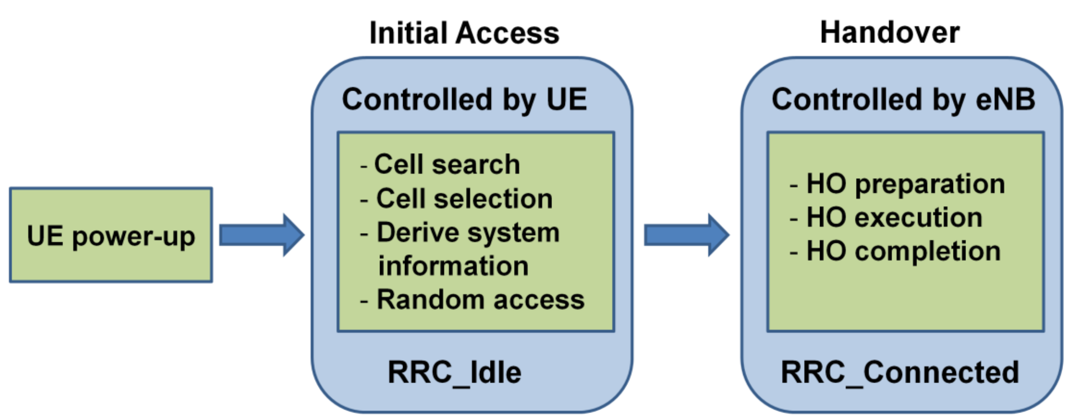

Figure 1.1 LTE handover phases

In this thesis, the focus is on handover management in medium access control (MAC) layer. The parameters in other layers, L1 and L3, may have a significant impact on handover process, such as interference, admission control and radio resource control (RRC) connection in PHY, MAC and network layer, respectively.

The rest of this chapter is organized as follows. In the next section, problem statement is described, followed by the list of objectives, brief methodology and scope of the thesis. Finally, the thesis outline is presented.

1.2 Problem Statement

This thesis bridges the gaps described below. One of the main problems in wireless communication is maintaining the connection at a defined level of QoS while a user is moving around. Fast and seamless handover mechanisms is needed to achieve this target. The fast handover refers to delay and latency, whereas seamless handover is about continuity without loss of packets, handover failures or handed over from one cell to the other, back and forth, called handover ping pong. This thesis investigates on both initial access and handover phases. The three main problems that motivate this research are as follows:

1. In initial and access phases, cell search is the first step that the UE needs to perform in the idle RRC state for HO. The default searching time is normally large and need to be minimized. The search for a target cell is based on highest Reference Signal Received Power (RSRP) according to HHO in LTE. The large delay in HHO may cause high outage probability, packet loss ratio and these will degrade the system performance. In addition, Inter cell interference (ICI) is a common problem in all HO phases that can affect the connection between a UE and a cell. The ICI has more effect on UEs at the cell edge, outward from the cell center. The higher ICI is, the more difficult will be the cell detection and more inefficient bandwidth utilization. Therefore the throughput is significantly degraded.

2. Cell selection, which is an initial access phase, poses an important influence on network performance, and this becomes more critical with user mobility to achieve seamless handover. Although a successful handover is accomplished, it might be into a wrong cell when the selected cell is not an optimal one in terms of signal quality and bandwidth. The conventional cell selection in LTE is based on S-criterion, which is inadequate since it only relies on downlink signal quality. This may cause significant interference to other cells, which causes

handover failure (HOF) or handover ping-pong (HOPP) and consequently degrades cell throughput.

3. The decision to trigger an HO is very crucial to maintain QoS. In LTE the HO triggering is generally based on reference signal received power (RSRP) and reference signal received quality (RSRQ) measurements. To enhance HO decision making, HO parameters have been standardized by 3GPP to improve the performance. The challenge we may face is how to tune HO parameters automatically at various UE speeds taking into consideration the trade-off between HOPP and HOF with a lower packet loss ratio (PLR).

1.3 Aim and objectives

Thus, the aim of this thesis is to design and develop seamless handover schemes with the following objectives:

1- To improve cell searching process and reduce the time required to identify the target cell. This needs to be done at low interference to minimize delay and outage probability.
2- To optimize cell selection scheme to maintain a given QoS by way of reduced handover ping pong, handover failure and at the same time increase the cell throughput.

3- To develop an adaptive handover parameter algorithm for handover decision, so as to reduce the handover ping pong, handover failure and packet loss ratio.

1.4 Brief Methodology

As mentioned above, the objective of this thesis is to come out with a seamless handover mechanism for LTE. In this thesis, we propose three schemes at different handover phases; soft frequency reuse and multiple preparations (SFRAMP), fuzzy multi criteria cell selection (FMCCS) and fuzzy logic control (FLC) and multiple preparation (FuzAMP). In chapter 3, SFRAMP will be described, which is a combination of two techniques, namely soft frequency reuse (SFR) and multiple preparation (MP). In this scheme the MP provides a significant reduction in delay due to minimize search time. In addition, SFR is applied to minimize the ICI during handover, especially at cell edges, and to reduce overhead signaling which may stem from MP. This scheme reduces outage probability significantly and consequently improve cell edge user's throughput.

FMCCS is proposed in chapter 4, to optimize cell selection mechanism for handover. This scheme takes into consideration multiple criteria, resource block (RB) utilization and UE uplink condition in addition to the S-criterion, whereas the conventional cell selection scheme in LTE only considers the S-criterion. FMCCS uses an integrated fuzzy technique for order preference by using similarity to ideal solution (TOPSIS), and it significantly reduces HOPP and HOF. This improvement stems from the highly reliable cell selection technique that leads to increased cell throughput with a successful handover.

In chapter 5, we propose an algorithm based on FLC to optimally set the HO parameters (HOM and TTT) taking into consideration the tradeoff between HOF and HOPP as well as at various UE speeds. In addition, multiple preparation technique is used for extra improvements by enabling further fine-tuning of HO parameters at all UE speeds. This approach achieves low HOPP and HOF associated with MP to reduce PLR.

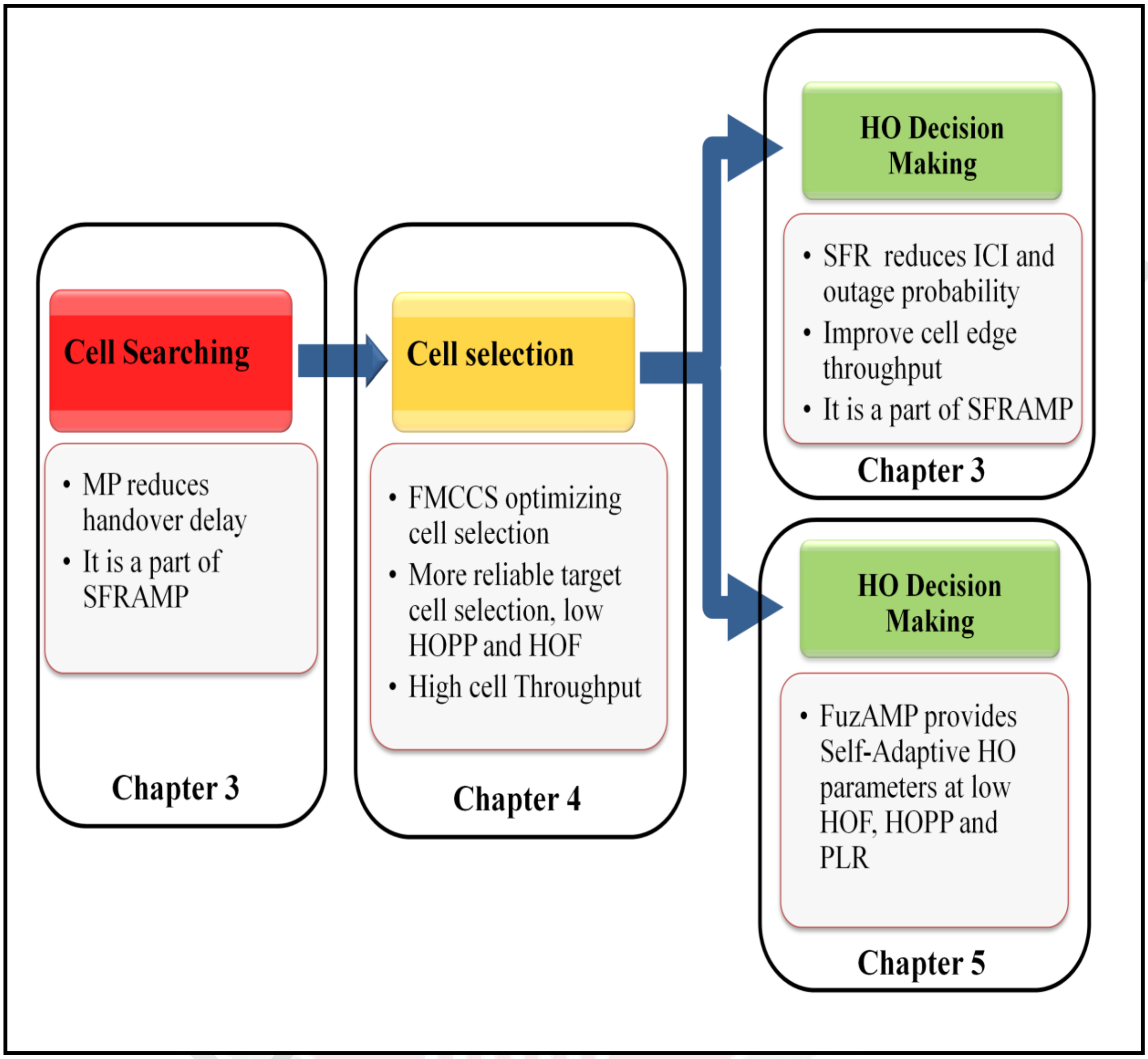

Figure 1.2 Methodology of Thesis

Thus, all the handover phases have been covered by the proposed schemes in this thesis. The enhancements and optimizations takes effect in sequence, i.e. every scheme optimization will optimize the next phase of whole handover procedures. For instance, at the initial stage of handover, when the searching time and ICI are reduced by SFRAMP to speed up and detect the target cell, the cell selection scheme FMCCS will optimize this as well. The more reliable target cell selection by FMCCS in turn will allow the following scheme, FuzAMP, to automatically tune handover parameters as the final optimization stage of handover decision. The seamless handover is achieved with low values of the following parameters, namely delay, ICI, PLR, HOPP and HOF that result in high cell throughput and more reliable procedures. Figure 1.2 outlined the above mentioned methodology.

1.5 Thesis Scope

The schemes proposed in this thesis focuses on Layer 2, which is the most challenging mobility management area. However handover can be managed in several layers, but handover to other than LTE networks is out of the scope of this thesis. Figure 1.3 illustrates the flow of the thesis scope, in which the bold lines with arrows represent the scope followed by the thesis, while the dotted lines shows those that outside the scope of this thesis.

1.6 Contributions

The main contributions of this thesis can be presented as follows:

- Improving cell search time for handover. SFRAMP scheme reduces the handover delay and speed up handover procedures.
- Boosting SINR for UEs at handover region. SFRAMP scheme mitigates inter cell interference, especially at cell edges. This scheme significantly reduces the outage probability for seamless handover.
- Developing cell selection method. FMCCS algorithm is based on multiple criteria decision making which provides an optimal cell selection for a more reliable handover. This algorithm minimizes HOPP and HOF resulting in better cell throughput.
- Optimizing algorithms for self adaptation of handover parameters. FuzAMP algorithm is based on fuzzy logic control which controls self optimization handover. In addition, MP is employed to reduce the delay. This algorithm introduce very low HOPP and HOF ratio, resulting in lower PLR.

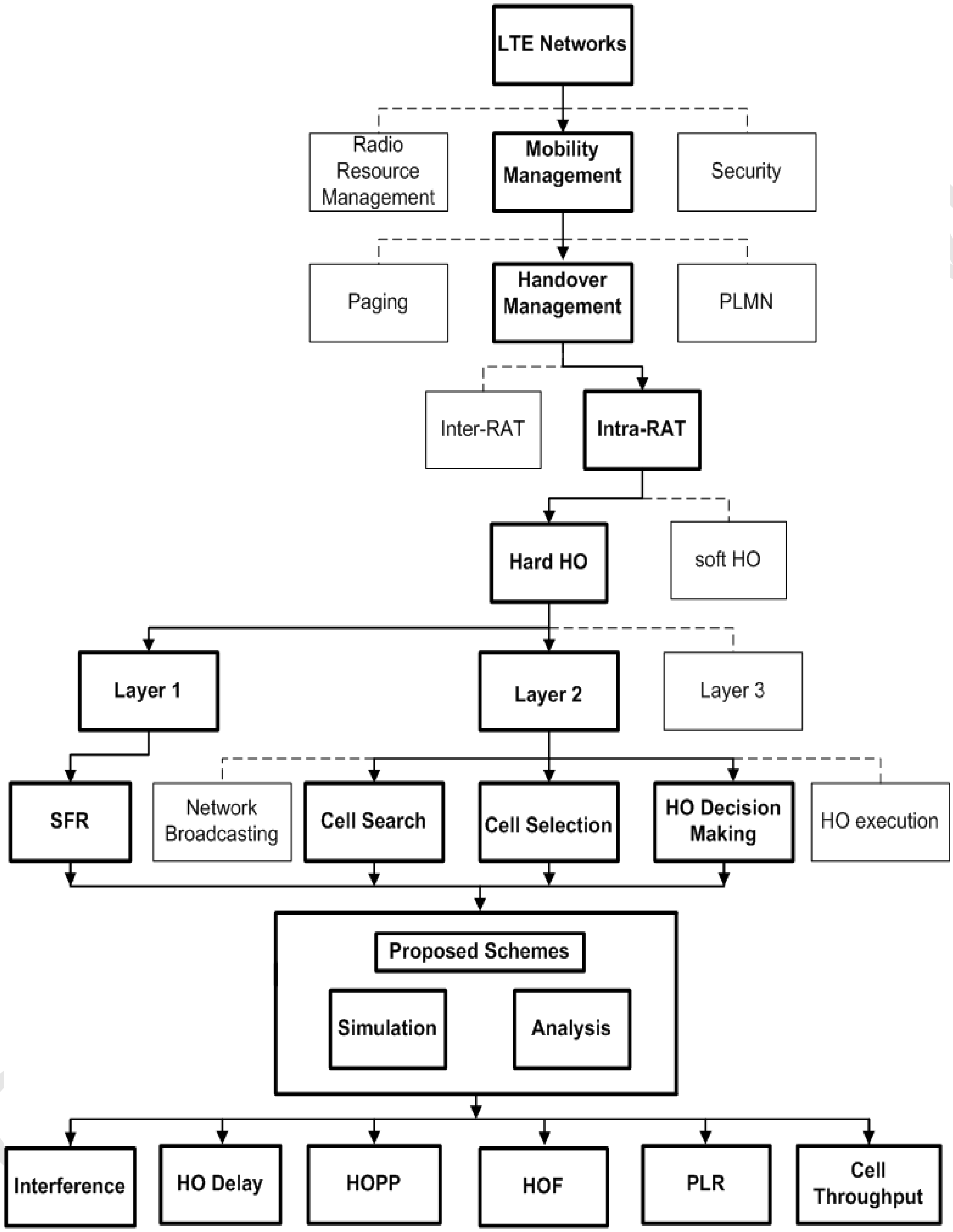

Figure 1.3 Thesis Modules

1.7 Thesis Outline

This thesis presents a new handover mechanism for LTE networks. The thesis is organized as follows:

Chapter 1 provides an introduction of the research topic as a background of mobility and problem statements. The objectives of the thesis and scope are defined here as well.

Chapter 2 presents an overview of the LTE networks. The LTE mobility network architecture is briefly described. Most of the relevant previous works have been critically reviewed.

Chapter 3 introduces in detail the first proposed scheme for seamless and fast handover called soft frequency reuse and multiple preparations (SFRAMP). The performance is evaluated and compared with other works in terms of delay and outage probability.

Chapter 4 describes the scheme to optimize the cell selection for handover, which is based on multiple criteria decision making process named fuzzy multiple criteria cell selection FMCCS. The performance is evaluated and compared with other works in terms of handover ping pong (HOPP), and handover failure (HOF) and throughput.

Chapter 5 presents the third proposed scheme to automatically adapt the handover parameters for seamless handover by using fuzzy controlled based multiple preparation called FuzAMP. The performance evaluation is compared with other works in terms of HOPP, HOF and packet loss ratio (PLR).

Chapter 6 summarizes and concludes the thesis based on the results presented in the thesis. The key features and contributions of all proposed schemes are summarized. This is followed by some suggestion for further investigations in the future.

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