Sudan University of Science and Technology

College of graduate studies

Handover Failure Reduction in LTE

تقليل إخفاق التسليم في التطور الطويل الأمد

Thesis Submitted in Partial fulfillment the Requirements in Telecommunication Engineering for Degree of M.Sc

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قال الله عز و جل

بسم الله الرحمن الرحيم

اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ (1) خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ (2) اقْرَأْ وَرَبُّكَ الْأَكْرَمُ
(3) الَّذِي عَلَّمَ بِالْقَلَمِ (4) عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ(5)

صدق الله العظيم

سورة العلق الآية (1-5)

Dedication

To

my parents,lovely

husband, And my

sweet sons

Acknowledgement

All praise to ALLAH who enabled us to complete this research work successfully. I had extraordinary times during my studies at SUST, and I attribute my good times to the great people who have helped me directly or indirectly, to whom I am grateful for their continuous encouragement, help and trust on us.

First and foremost, i would like to thank my supervisor, Dr. Dr.Ibrahim Khidir. His vision, guidance, sincere help and support have implanted in us gradually, a great interest in scientific research. I want to thank also Dr. Ashraf Gasim Elsid He has been a source of many ideas, enthusiasm and encouragement which inspires me to do well in the research and makes it a reality. Working with them made this research a very rewarding experience both personally and professionally.

A special thanks to my family for encouragement and continuous mental and financial supports, in fact, in every unconditional way, which made this study a success story. It has been a hard journey for me specially with COVID-19 but I am glad I did it.

Abstract

Handover is a very important process in any mobile communication network because it allows the service to be continues and to supply Quality of Service (QoS) to the users. However the handover increases the signaling load and also handover failure affects network performance because Service interruptions can be devastating. The algorithm depend on knowing the current location of the user, and Compare it with the Previous location to determine the angle of direction of the movement. Based on this information the handover decision can be made. This algorithm is tested under two parameter the speed of the mobile and average inter arrival. The simulation results shows that the proposed algorithm has no Handover failure under the speed 60Km/h and no handover failure if average inter arrival under 3min. This algorithm improve the network performance by reducing the number of handover failure. It is really one of the aspirations that this study will encourage further researches and studies in this field. .

المستخلص

يعتبر عملية التسليم عملية مهمة للغاية في أي شبكة اتصالات متنقلة لأنها تتيح استمرار الخدمة وتوفير جودة الخدمة للمستخدمين ومع ذلك ، يزيد التسليم من حمل الإشارات ويؤثر فشل التسليم أيضًا على أداء الشبكة لأن انقطاع الخدمة يمكن أن يكون مدمرًا. تعتمد الخوارزمية على معرفة الموقع الحالي للمستخدم ومقارنته بالموقع السابق لتحديد زاوية اتجاه الحركة. بناءً على هذه المعلومات يتم اتخاذ قرار التسليم. تم اختبار هذه الخوارزمية وفقًا لمعلومتين هما سرعة الهاتف المحمول و معدل زمن الوصول تظهر نتائج المحاكاة أن الخوارزمية المقترحة لا تعاني من فشل في التسليم تحت سرعة 60 كم / ساعة ولا يوجد فشل في التسليم اذا معدل زمن الوصول أقل من 3 دقائق. تعمل هذه الخوارزمية على تحسين أداء الشبكة عن طريق تقليل عدد حالات فشل التسليم. إنها حقًا أحد الطموحات ان هذه الدراسة ستشجع على إجراء المزيد من الأبحاث والدراسات في هذا المجال .

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List of Symbols

$\boldsymbol{K}$	Number of user
$\boldsymbol{\lambda}$	Average number of inter arrival
$\boldsymbol{e}$	Euler's constant 2.71828
$\boldsymbol{dx}$	Distance in x position
$\boldsymbol{dy}$	Distance in y position
$\boldsymbol{d}$	Distance between two eNodeBs
$\boldsymbol{\theta}$	The angel between the current location and position
IeNodeB	The intial distance from eNodeB
DeNodeB	The current distance from eNodeB

List of Abbreviations

A-GNSS	Assisted Global Navigation Satellite Systems
AIAT	Average inter arrival time
AOA	Angle of Arrival
APPS	Average packet per second 258 packet
APS	Average packet size in LTE
BW	Bandwidth
C-RAN	Centralized Radio Access Network
CAC	Call Admission Control
CBP	Call Blocking Probability
CDMA	Code Division Multiple Access
CDP	Call Dropping Probability
CF	Connection fail
CR	Core network
CRLB	Cramer-Rao lower bound
CQI	Channel Quality Index
DCM	Database Correlation Method
E-CID	Enhanced Cell ID
E-UTRAN	Evolved Universal Terrestrial Radio Access
ECGI	Enhanced Cell Global Identity
EDGE	Enhanced Data Services for GSM Evolution
ENB	eNodeB
EPC	Evolved Packet Core
FAP	Femto cell Access Point
G	Generation
GN	Gauss-Newton
GPRS	General Packet Radio Service

GSM	Global system mobile
HD	Handover distance
HO	Handover
HOF	Handover Failure
HOR	Handover Requests Rate
HOS	Handover successes
HSPA	High Speed Packet Access
HSS	Home Subscriber Server
ITU	International Telecommunications Union
LLS	Linear least squares
LMUs	Location Measurement Units
LTE	Long Term Evolution
LM	Levenberg- Marquardt
LBKHO	Location Based Knowledge Handover Optimization
MDR	Minimum data rate-Maximum data rate
ME	Mobile Equipment
MIMO	Multiple in Multiple out
MLB	Mobility load balancing
MME	Mobility Management Entity
MPS	Maximum packet size
MS	Mobile Station
NCC	Number of channel
OFDM	Orthogonal Frequency Division Multiplexing
OTDOA	Observed Time Difference Of Arrival
P-GW	PDN Gateway
PCCRF	Policy Control and Charging Rules Function
PRS	Positioning Reference Signals
PUSCH	Physical UL Shared Channel
QOS	Quality of Service

RAT	Radio Access Technology
SC-OFDMA	Single-carrier FDMA
RRC	Radio Resource Control
RSSI	Residual Signal-Strength Indicator
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
RST	Reference signal time difference
RTT	Round Trip Time
S-GW	Serving Gateway
SMS	Short Message Service
SNR	Signal to Noise Ratio
SRS	Sounding Reference Signals
SWL	Simulation window length
SWW	Simulation window width
TADV	Timing Advance
TDOA	Time Difference of Arrival
U-TDOA	Uplink Time Difference of Arrival
UE	User equipment
UMTS	Universal Mobile Telecommunications System.
UTRAN	UMTS Terrestrial Radio Access Network
VAVG	Average speed of the mobile

Chapter One

Introduction

Chapter one
Introduction

1.1 Preface

The aim of wireless communication is to provide high quality, reliable communication just like wired communication(optical fibre) and each **new generation** of services represents a big step in that direction. This evolution journey was started in **1979** from 1G and it is still continuing to 5G. Each of the Generations has standards that must be met to officially use the G terminology. Each generation has requirements that specify things like throughput, delay, etc. that need to be met to be considered part of that generation. Each generation built upon the research and development which happened since the last generation. 1G was not used to identify **wireless technology** until 2G, or the second generation, was released..1G is an analog technology and the phones generally had poor battery life and voice quality was large without much security, and would sometimes experience **dropped calls** . The maximum speed of 1G is **2.4 Kbps** .2G networks are **digital** . Main motive of this generation was to provide secure and reliable communication channel. It implemented the concept of **CDMA** and **GSM** . Provided small data service like sms and mms.. 2G capabilities are achieved by allowing multiple users on a single channel via multiplexing. The advance in technology from 1G to 2G introduced many of the fundamental services that we still use today, such as SMS, **internal roaming** , conference calls, call hold and billing based on services e.g. charges based on long distance calls and real time billing. The max speed of 2G with General Packet Radio Service (**GPRS**) is 50 Kbps or 1 Mbps with Enhanced Data Rates for GSM Evolution (**EDGE**). Before making the major leap from 2G to 3G wireless networks, the lesser-known 2.5G and 2.75G was an interim standard that bridged the gap.Web browsing, email, video downloading, picture sharing and other **Smartphone technology** were introduced in the third generation. The 3G standard utilises a new technology called **UMTS** as its core network architecture -

Universal Mobile Telecommunications System.3G increased the efficiency of frequency spectrum by improving how audio is **compressed** during a call, so more simultaneous calls can happen in the same frequency range. The UN's International Telecommunications Union **IMT-2000** standard requires stationary speeds of 2Mbps and mobile speeds of 384kbps for a "true" 3G. The theoretical max speed for **HSPA+** is 21.6 Mbps.4G is a very different technology as compared to **3G** and was made possible practically only because of the advancements in the technology in the last 10 years. Its purpose is to provide **high speed** , high quality and high capacity to users while improving security and lower the cost of voice and data services, multimedia and internet over IP. Potential and current applications include amended mobile web access, **IP telephony** , gaming services, high-definition mobile TV, video conferencing, 3D television, and cloud computing.

The key technologies that have made this possible are **MIMO** (Multiple Input Multiple Output) and **OFDM** (Orthogonal Frequency Division Multiplexing). The max speed of a 4G network when the device is moving is 100 Mbps or **1 Gbps** for low mobility communication like when stationary or walking, latency reduced from around 300ms to less than 100ms, and significantly lower congestion.

1.2 Problem Statement

The handover failure and the increase of handover rate request. Handover reduced clients' satisfaction of the quality of service**.**

1.3 Thesis Objectives

The objective of this thesis is

- To reduce handover failure by knowing the direction of movement and the impact of the average inter arrival and the speed of the user equipment on the result.

1.4 .Methodology

The algorithm depended on knowing the location of the user. By knowing the location it reduced handover request and also reduce the handover failure. This algorithm is tasted by using two parameters different speeds and also different average inter arrival. The simulation program was used to implement the logarithm by using MATLAB.

1.5 Research Outlines

The rest of this thesis include the following chapters . Chapter two, contain a review of the LTE system, handover types and location Knowledge Technique in LTE, along with relevant breakthroughs in major studies, papers and references. In chapter three, the physical and mathematical model is explained . In chapter four, the results and findings is presented and discussed for interdependencies and reliability In chapter five, some conclusions is suggested by the experimental analysis and point out some possible future developments in the thesis in this field.

Chapter Two
Literature Review

Chapter two
Literature Review

2.1 Introduction

LTE did not originally qualify as true 4G. The International Telecommunication Union (ITU) initially defined 4G as a cellular standard that would deliver data rates of 1 Gbps to a stationary user and 100 Mbps to a user on the move. In December 2010, the ITU softened its stance, applying 4G to LTE, as well as several other wireless standards. OFDMA enables the LTE downlink to transmit data from a base station to multiple users at higher data rates than 3G, with improved spectral efficiency. Single-carrier FDMA is used for the uplink signal, which reduces the transmit power required of the mobile terminal.**[16]**

2.2 LTE System Architecture

The Core Network (CN) or Evolved Packet Core (EPC) is responsible for the overall control of the User Equipment (called UE) and establishment of the bearers. As it shown in figure (2.1) It includes the following elements:

2.2.1 PDN Gateway (P-GW) – responsible for

- IP address allocation for the UEs
- Filtering of user DL IP packets into the different QoS bearers
- UL/DL service level charging, gating and rate enforcement according to PCRF rules

2.2.2 Serving Gateway (S-GW) responsible for

- Packet routing and forwarding

2.2.3 Mobility Management Entity (MME) - responsible for

- Processing the signaling between the UE and the CN (Non Access Stratum – NAS)
- Bearer & Connection management
- Security

2.2.4 Home Subscriber Server (HSS) which

- Holds users subscription data such as QoS profiles

- Holds information about the PDNs to which the user can connect
- Holds dynamic information such as the identity of the MME to which the user is attached

2.2.5 Policy Control and Charging Rules Function (PCRF)

- Responsible for policy control decision making
- Provides QoS authorization in accordance with user's subscription profile[17].

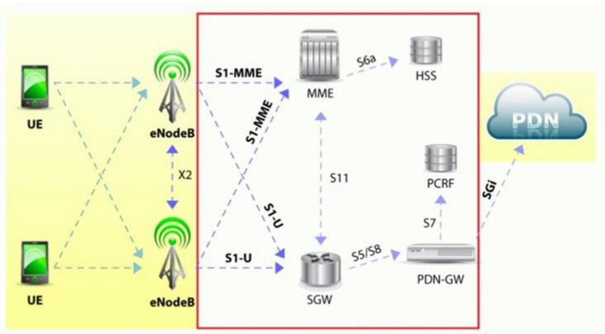

Figure 2.1 LTE System Architecture[17]

2.3 Handover Types in LTE Network

The greatest advantage of a wireless device (mobile device) over a wired one is that its user can travel while using services on it. This mobility has allowed users to conveniently use services in any place, whether at home or on the go, at any time they want. Because of this benefit, wireless users have already outnumbered wired phone users. Mobile subscribers can use services while on the go thanks to the fact that mobile networks support handovers. User Equipment (UE) can switch from one eNodeB/cell to another without losing any incoming or outgoing data, and communicate with the network without interruption during such switch (i.e. by performing a handover). This ensures its user is seamlesslyservedohandover are as seen in this (2.1)

Table (2.1) Handover procedure in LTE

Procedure	Direction or Related Entities	Description
Measurement Configuration	eNB→UE	Specifies measurements to be performed by UE
Measurement Report	UE→eNB	Indicates measurement results
Handover Decision	Source eNB	Makes decision on target cells and handover types (X2 or S1)
Handover Preparation	Varies depending on a handover type	Prepares forwarding path
Handover Execution		Forwards data
Handover Completion		Switches data path

UE has an antenna that can search multiple frequency channels over multiple bands. So, after checking many neighbor cells, it usually accesses the one with the greatest received signal strength (unless no access is allowed due to access restriction or congestion control). Then later when the received signal strength from the UE's current serving cell is getting weak due to the UE's travel, shadowing, etc., and the signal from a neighbor cell is getting strong, a handover is initiated. This allows the UE to access the neighbor cell, and establish a new RRC connection there To this end, when UE establishes an RRC connection with eNB, the eNB informs the UE in which event the received signal strength should be reported, by sending a configuration message (RRC Connection Reconfiguration message). The UE keeps track of the received signal strength of both its serving and neighbor cells. Then when one of the events specified occurs, it reports the received signal strength to the eNB through a Measurement Report message. The eNB, upon receipt of the message, decides whether to initiate a handover or not by reviewing the reported strength information and the overload status of the neighbor cells. Once decided, it performs a handover to a newly selected target cell. A handover can be categorized as one of the three kinds – intra-LTE, inter-LTE and inter-RAT handovers - depending on whether the EPC entities that UE is connected to are changed after the handover or not.[18]

2.3.1 Intra-LTE Handovers

There are different use cases for Intra-LTE handovers. There are primarily three types of Intra-LTE handover can be possible

- **Intra-MME/SGW: Handover using X2 Interface**

X2 is the interface between two eNodeBs, serving eNodeB and target eNodeB in this case. When X2 interface is present then handover is completed without EPC (Evolved Packet Core) involvement. The release of the resources at source eNodeB is triggered by target eNodeB.

- **Intra-MME/SGW: Handover using S1 Interface**

In case when X2 interface is not available and source eNodeB and target eNodeB are part of same MME/SGW then handover is carried out through S1 interface. The S-eNB initiates the handover by sending a Handover required message over the S1-MME reference point. The EPC does not change the decisions taken by the S-eNB.

2.3.2 Inter-LTE Handovers

- **Inter-MME Handover**

In Inter-MME handover two MME are involved in handover, source MME and target MME. The source MME (S-MME) is in charge of the source eNodeB and target MME (T-MME) is in charge of target eNodeB.

Inter-MME handover occurs when UE moves between two different MMEs but connected to same SGW.

- **Inter-MME/SGW Handover**

This is same as Inter-MME but only difference is that here UE need to move from one MME/SGW to another MME/SGW. Source eNodeB is part of one MME/SGW and target eNodeB is in another MME/SGW.

2.3.3 Inter-RAT Handover

Handover from eUTRAN to UTRAN

In case of handover between eUTRAN to UTRAN, the source eNodeB is connected to source MME and SGW and target RNC is connected to Target SGSN and Target SGW.[19]

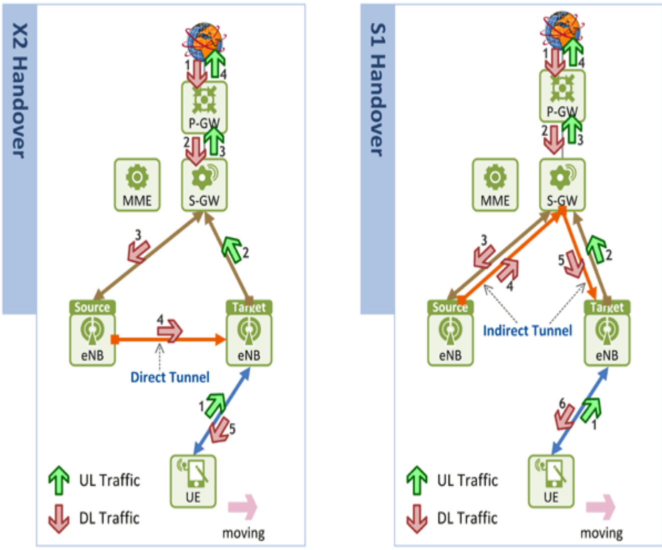

Figure 2.2 the handover types in LTE[19]

2.4 Positioning techniques for mobile devices in LTE

2.4.1 Assisted Global Navigation Satellite Systems (A-GNSS)

A-GNSS (also known as Assisted-GPS or A-GPS) improves the startup performance of a GPS based system. LTE includes support for Assisted Global Navigation Satellite System (AGNSS). The GNSS incorporates multiple satellite positioning systems viz. Galileo,,GPS and modernized GPS,,GLONASS,Quazi-Zenith Satellite System and Space Based Augmentation System (SBAS). With conventional GPS systems, the GPS receiver in the mobile device is solely responsible for receiving satellite signals and computing its location. In a typical A-GPS implementation, the standalone GPS facilities of the phone are augmented by data provided by the network, termed ìAssistance Dataî, which includes information the mobile GPS receiver can use to accelerate the process of satellite signal acquisition. Two types of assistance data are provided to improve the positioning speed and accuracy performance:

- Data assisting the measurements: e.g. reference time, visible satellite list, satellite signal Doppler, code phase, Doppler and code phase search windows;

- Data assisting position calculation: e.g. reference time, reference position, satellite ephemeris, clock corrections.

A-GPS provides excellent accuracy, and as compared with stand-alone GPS, it can reduce the UE GPS start-up and acquisition times, increase the UE GPS sensitivity, allow the UE to consume less power on the handset with the GPS receiver put in Idle mode when it is not needed. Assistance data can be provided by the LTE network for both GPS and GLONASS satellites. The location of the UE has to be known in advance (for example through TDOA). The UE then can find the GPS signals much faster and is sometimes able to get a GPS signal in areas where usually it would not work. In general, AGPS provides the highest accuracy of any network-enabled technique and works well outdoors and in scenarios where a reasonably good view of the sky is available.

2.4.2 Enhanced cell ID

The Cell Id (CID) methods are based on the Cell Of Origin (COO) concept, where a UE is located within the coverage area of its serving eNB (eNodeB), typically to the specific cell/sector within the eNB. Although this method is the least accurate one, it is the easiest to implement, and highly scalable. To improve accuracy, E-CID was introduced in LTE. ECID method has low accuracy (50~1000 m) depending on the size of the cell, but it is easier to implement than other methods, and is generally available across diverse vendor products and networks. In addition to the use of geographical coordinates of the serving eNB, the position of the UE is estimated more accurately by performing measurements on radio signals. UE measurements which can improve the accuracy of the location estimate using this method includes E-UTRAN carrier Received Signal Strength Indicator (RSSI), Reference

Signal Received Power (RSRP) etc. E-UTRAN measurements which can be used in the Cell ID methods include the eNB Round Trip Time (RTT) and the Angle of Arrival (AoA). E-CID can be executed in three ways, using different types of measurements Figure (2.3) show the three cases:

1. E-CID with estimation of the distance from one eNB.
2. E-CID with measuring the distance from three eNBs.
3. E-CID by measuring the Angle-of-Arrival (AoA) from at least two eNBs, better would be to use three eNBs.

In the first two cases the possible measurements can be: RSRP, a standard quality measurement for UEs; or TDOA (Time Difference of Arrival) and the measurement of the Timing Advance (TADV) or Round Trip Time (RTT). In the first case the position accuracy would be just a circle. Method number 2 and 3 provide a position accuracy of a point, while measuring more sources. For case 1 and 2, the measurements are taken by the device, and are therefore UE-assisted. For case number 3 the measurements are taken by the base station and are therefore network assisted. For estimating the distance RTT and TADV can be used. But to measure the direction AoA measurements should be used.

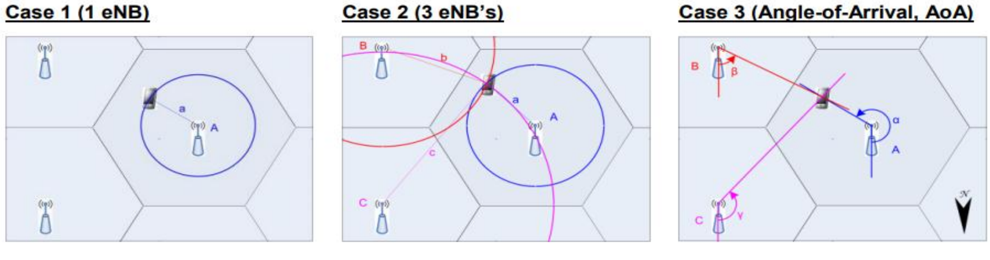

Figure 2.3 The three cases of E-CID

2.4.3 Observed Time Difference Of Arrival†(OTDOA)

OTDOA is a downlink positioning method in LTE, which is based on measuring the difference in the arrival times of downlink radio signals, from multiple base stations Figure (2.4) show The Observed Time Difference Of Arrival. Each LTE cell transmits reference signals and it is the arrival time of the reference signals that the UE compares. The difference in the timing is reported by the UE to the network. Network combines the timing differences with its knowledge of the positions of each cellís antennas, to calculate the UE position. At least four cells need to be measured by the UE.

The measurement conducted between a pair of eNBs is defined as the reference signal time difference (RSTD). This position estimation is based on measuring the Time Different Of Arrival (TDOA) of special reference signals, embedded into the overall downlink signal, received from different eNBs. With 3GPP Release 9, Positioning Reference Signals (PRS) have been introduced as the cell specific reference signals were not sufficient for positioning. The cell specific reference signals cannot guarantee the required high probability of detection, based on simulations, which have shown that the detection is guaranteed in only 70% of cases. That too in an interference free environment, which is not possible in real world implementation. The PRS is periodically transmitted along with the cell specific RS in groups of consecutive downlink sub frames.

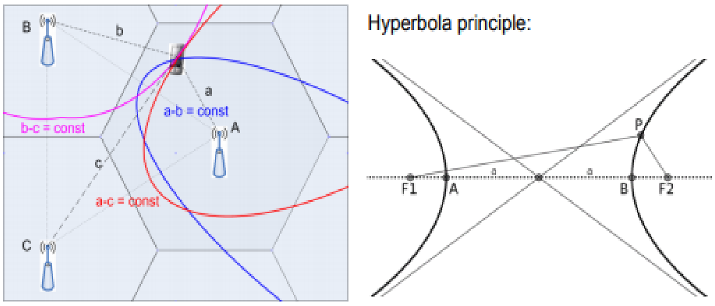

Figure 2.4 The Observed Time Difference Of Arrival

2.4.4 Uplink Time Difference Of Arrival†(UTDOA)

UTDOA utilizes uplink Time Of Arrival (ToA) or TDOA measurements performed at multiple receiving points. Measurements are based on Sounding Reference Signals (SRSs). The advantage is that the UE does not need any additional hardware or software The method uses time difference measurements based on Sounding Reference Signal (SRS), taken by several eNBs, to determine the UEís exact location. The network has to be equipped with exactly time-synchronized Location Receivers/Location Measurement Units (LMUs) and a Location Calculation and Control Center to calculate the position of the handset.

2.4.5 RF Fingerprinting

Fingerprinting (also known as Pattern Matching or Database Correlation Method (DCM)) is a commonly known method which is not explicitly standardized in LTE, but is included in LTE specifications. In this method a UEís position is figured out by using measurements made by the eNB, the UE, or a combination of both, and these measurements are then compared with the already stored fingerprints in a RF map to estimate the position. RF map is typically based on detailed RF predictions or site surveying results.

2.5 Related work

In [3] the author used timing advance(TA) parameters to evaluated the location of the user equipment (UE) in LTE networks in two eNodeBs and four eNodeBs. The maximum timing Advance =0.68millisecond each unit of TA=75.14ms.(TA) occur when Base Station send signal to the mobile station phone in order speed up or delay its data transmission and ensure that each user's data is received in time slot whatever it close or farther from the base station .The points of intersection can be calculated based on the space between the base station and the two radii when the radius circles do overlap. As it shown in figure (2.5) the X coordinate of the intersection can be calculated as the following equation 2.1

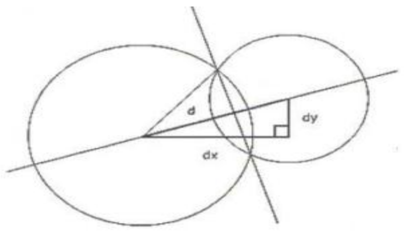

Figure 2.5 The evaluated the location by using timing advance[3]

$$x = \frac{d_x^2 - d_y^2 + d^2}{2d} \qquad 2.1$$

the average distance from the midpoint between the two radius circle intersections to the genuine UE location for each independent run was recorded . It was observed that the most precise location approximation occurs by using two eNodeBs when the two points of intersection get closer to each other. Also, the most accurate prognostic for the location of the subscriber station occurs at 180°. As a conclusion in the cases examined in this research, it can be easily realized that the precise UE location could be done by increasing the number of eNodeBs.

we observe that the most accurate prediction for the location of the subscriber station happens at 180° as shown in Figure (2.6). where the position of the UE construct a direct line with eNodeBs.

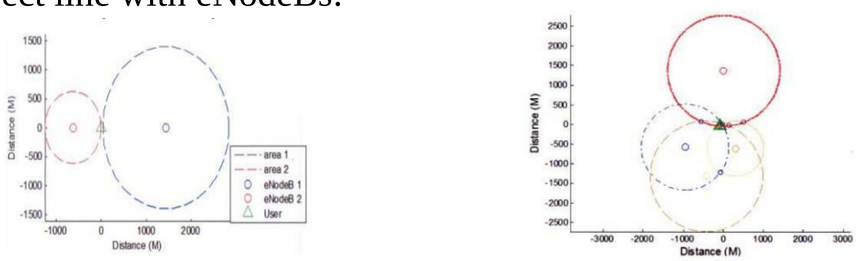

Figure 2.6 the position of the user with 2eNodeB and 4eNodeB[3]

In [4] the author worked on resource block scheduling in LTE system and proposed an algorithm to allocate resource blocks so that user's rate requirement can be fulfilled optimally and throughput of the system can be improved. The overall performance of proposed technique is better and it enhances the network throughput up to 9.5 .The resources allocation is done according to the requirement of users. LTE use OFDM for downlink transmission due to that it divides the bandwidth into multiple narrower sub-carries and data is transmitted on these carries in parallel streams. The bandwidth or user rates allocated to users depend upon the resource blocks allocated to users. The resource blocks have different CQI (Channel Quality Index) value for each user. For the proper distribution of resource blocks such that users can achieve required rate and maximum throughput of system with low latency rate, there is a need of optimal solution. To enhance the overall performance of the network hybrid algorithm is introduced.

In [5] the author proposed a novel Call Admission Control (CAC) scheme as an improvement of Reservation-Based scheme. Approximation method, and the best effort (BE) traffic which reserved bandwidth for the high-level priority call. the BE traffic are not admitted into the network throughout the borrowing period which resulted in the starvation of this traffic. Therefore, the starvation of this traffic leads to increases of handoff Call Blocking Probability (CBP) and Call Dropping Probability (CDP).The scheme dynamically distributes channels for an individual cell or reserved certain quantity of channels from the overall channels in the cell for handoff call using time-varying condition. However, when new calls and handoff calls occur repeatedly then some network resources may be left unutilized and this results in ineffective usage of network resources. CAC mechanism is employed which admits new call and reserves bandwidth for handoff calls, when there is unused bandwidth, while admitted calls are degraded to their lowest level. Otherwise, neither of the calls is admitted. Accordingly, the user call might either be effectively handed off to a new base station or just dropped when it is about to depart the current cell. As we had mentioned above, the handoff calls have priority over new calls since the termination of handoff call in progress is more frustrating, less tolerable and less desirable than blocking a new call. This can be achieved by limiting a new call into the cell when the total number of user calls or the total occupied bandwidth is greater than the threshold value.

It improve the data throughput, reduces CBP, CDP and degradation ratio as compared to the Reservation-Based scheme and other bandwidth degradation schemes

In [6] the author studied the impact of cell size on the handover procedure in a Long Term Evolution (LTE) network. In particular, it highlight the potential problems that may occur when small cell densification is applied. In addition, the impact of the User Equipment (UE) speed is also analyzed.For small cells, both the increased UL interference due to the proximity of neighboring UE and the higher rate of cell border crossings produce a severe handover degradation. For larger cells, the received power from the UE at the cell border is weak thus UL transmissions are impaired due to poor SINR. In addition, we also note a general degradation of the performance as UE speed increases, especially for small cell sizes. However, for large cell sizes we note that very low UE speeds handover failures may rise due to the inability to “escape” from a poor radio condition area.

In [7] the author has examined the soft handover for LTE by considering the threshold and hysteresis margin. By using these two parameters, the highest active set occurs only when the threshold is -115 dBm and hysteresis is 24. At this point, active set reaches 2.082. The highest active set produces lower outage probability. With the proposed model, highest outage happens at 611 m distance from the initial zero position. With maximum outage probability of 2.1x10-7, system performance is excellent As it shown in figure 2.7 .

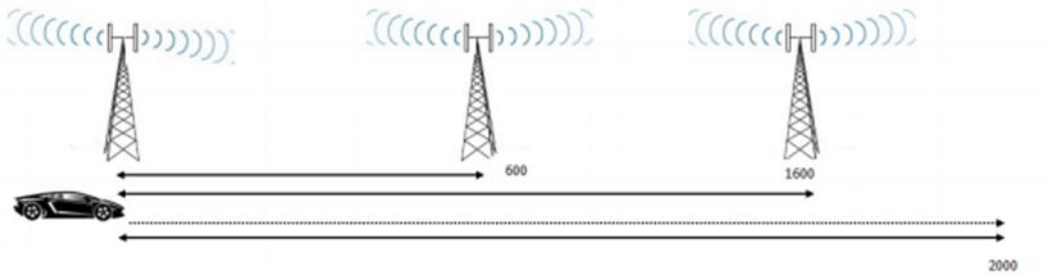

Figure 2.7 The user movement of soft handover for LTE by considering the threshold and hysteresis margin[7].

In [8] the author discussed Location Based Knowledge Handover Optimization algorithm (LBKHO): the location based knowledge is used to improve the network.Figure 2.8 explain the Handover zone that is used between two cells also it illustrates the cells extend by change the geography (increase effective coverage area) when to need it (cell breathing).

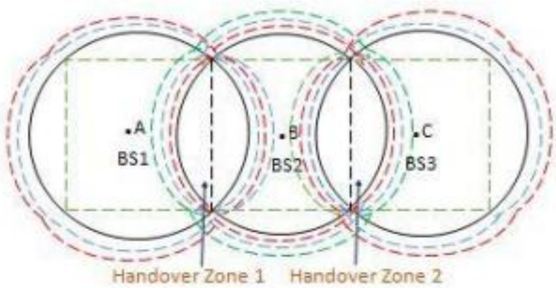

Figure 2.8 The handover zone for LBKHO[8]

Nagwan also discuss in [8] adaptive handover Initialization region algorithm was proposed based on the overlapping region (delta) between cells. Increasing this region (delta) reduce the number of handover failure this reduction is higher for low mobility mobiles terminal. This reduction in the number of handover failure improves the performance of the mobile network.

Actually planning cells are irregular, but for simplicity they used a circular form to represent the cells of the handover process between cells in the model proposed.

In [9] the author discussed the uneven traffic distribution in mobile networks by using Mobility load balancing (MLB). The aim of load balancing is to change network parameters so as to reduce the service area of congested cells and thus steer traffic to neighbor cells with spare resources. In MLB, this is done by decreasing HO margins in highly congested cells, while increasing HO margins in surrounding cells with low congestion rates. Figure (2.9) shows how the service areas of two unbalanced cells are modified by MLB.

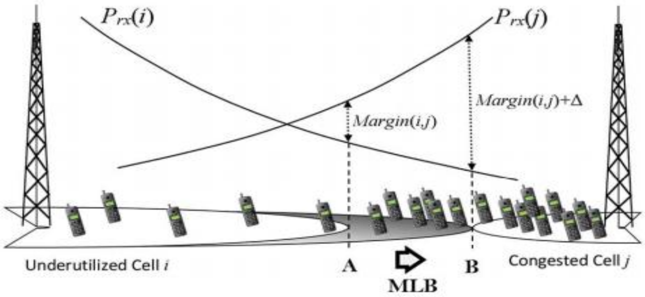

Figure 2.9 The service areas for traffic distribution in mobile networks by using Mobility load balancing[9]

The improvement in call blocking ratio obtained by MLB may not compensate for the deterioration of call dropping and HO failure ratios caused by this technique. Thus, proper monitoring of the latter performance indicators is critical to stop MLB before network connection quality degrades excessively.

In [10] the author evaluated the positioning accuracy of UE is with observed time difference of arrival (OTDoA) technique in LTE networks using dedicated positioning reference signal (PRS) by solving hyperbolic trilateration problem with linear least squares (LLS) and nonlinear GN and LM algorithms and compared it with CRLB computed for RSTD measurements. Performed system-level simulation clarify known results and reveal that simple LLS achieves close to LM positioning accuracy when the number of eNB is 6, while further increasing the number of eNB degrades positioning algorithms accuracy.

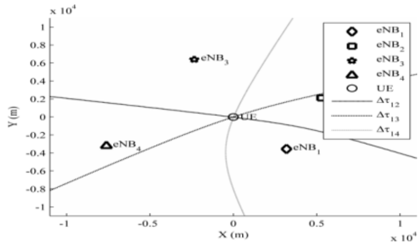

Figure 2.10 The positioning of the user evaluated by (OTDoA)[10]

In [11]the author proposed a new LTE location system in Centralized Radio Access Network (C-RAN), which makes channel and location measurement more available, allocation of baseband processing resources more flexible, and location service capability opening. The location system contains more than two antenna clusters, and each of them gets time-difference-of-arrival (TDOA) of sounding reference signals (SRSs) from different antennas. Then, based on data provided by location measurement units (LMUs), the location information server calculates TDOAs and derives the users' position. Furthermore, a new location algorithm is raised which can achieve distributed antennas collaboration and centralized location computing. And an improved optimized algorithm with the best TDOA selection is proposed. Finally, simulations are given out to verify the efficiency of the proposed algorithm in this LTE location system as it shown in figure (2.11).

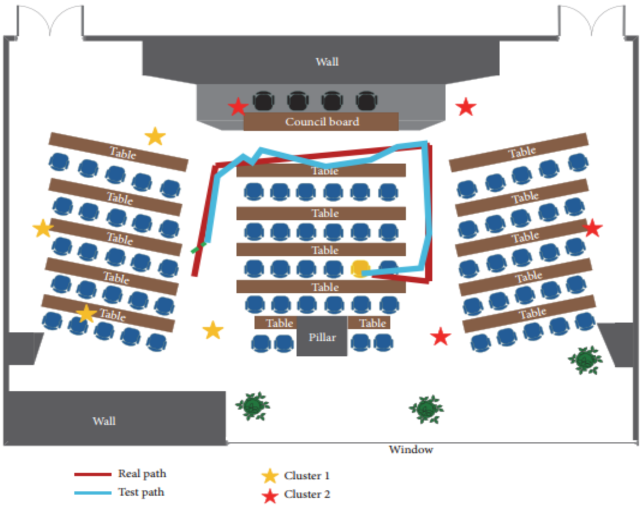

Figure 2.11 LTE location system in (C-RAN)[11]

In [12] the author proposed system shown in figure (2.12), as a homogeneous cellular network consists of many merged indoor target Femtocell Access Point (FAP) and some UE's are moving randomly inside the network. Inside the network, every UE has a unique ID and its neighbors will depend on the serving cell type (corner/edge).

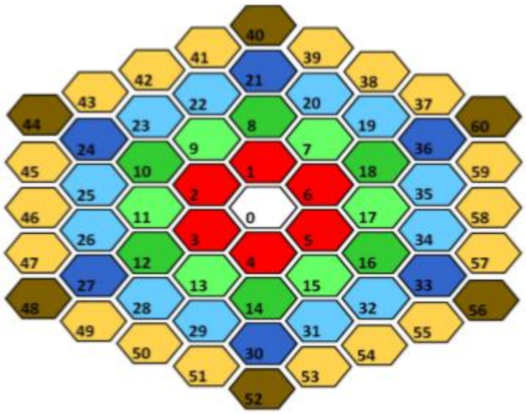

Figure 2.12 the system is modeled by using Markov chain Models[12].

The basis of the proposed HO scheme it to enhance the performance of the LTE FAPs network and optimizing the HO process. Since the number of users in the queue depends on its immediate past state of the queue only, the system can be modeled using Markov chain Models.

2.6 Summary of related researches

In table (2,1) shown the summary of related researches about the previous study it contain the objective of these research and result from it and also explain the suggested idea.

Table (2,1) Describe the summary of related work

No	Title	Objective	Result/Outcome	Method
1	Performance Evaluation of UE Location Techniques in LTE Networks	evaluate the location accuracy of User Equipment (UE) in Long Term Evolution (LTE) networks which depends on the timing advance parameters	In two eNodBs when the two points of intersection get closer to each other. Also, the most accurate prognostic for the location of the subscriber station occurs at 180°. As it can be easily realized that the precise UE location could be done by increasing the number of eNodeBs	Calculating the location of UE by using Timing Timing Advance (TA) in the two eNodeBs and four eNodeBs
2	Enhancement of Proportional Scheduling in LTE Using Resource Allocation Based Proposed Technique	Enhance the overall performance of the LTE network	The users rate requirement can be fulfilled and throughput of the system can be improved	Scheduling resource block in LTE system and proposed An logarithm to allocate resource blocks so that user's rate requirement can be fulfilled optimally and throughput of the system can be improved.
3	An Adaptive Call Admission Control With Bandwidth Reservation for Downlink LTE Networks	Prevent starvation of user traffic and improve the effective usage of network resources in LTE networks	Improvement of data throughput, reduces CBP, CDP and degradation ratio as compared to the Reservation-Based scheme and other bandwidth degradation schemes	A Novel Call Admission Control (CAC) scheme is proposed
4	A simulation study on LTE handover and impact of cell size	Presenting the handover failure in an LTE network when different cell sizes and , the impact of the UE speed	A certain cell size can be found around which any increase or decrease of the cell size brings performance degradations due to different limitations in the uplink	System level simulations are provided using a detailed LTE network simulator accounting for multiple points-of-failure and channel modeling compliant with LTE standards.

5	LTE soft handover based on hysteresis and threshold combination	Examined the soft handover for LTE	The higher the active set value results the lower the outage probability.	Considering the threshold and hysteresis margin.
6	Location-Based Knowledge Handover Optimization (LBKHO) Algorithm for mobile Network	Improve the network performance	The number of handover requests is reduced and the number of failed handovers, and when compared with the model (Adaptive Handover Initialization Region) proposed in a previous study, found that requests for handover in the proposed in our algorithm much less. Which reduces the signaling load in the network so that network performance can be improved	Depending on knowledge of the location of the mobile station at each time update the mobile station location in the network.
7	Analysis of Limitations of Mobility Load Balancing in a Live LTE System	Traffic distribution in mobile networks	Decreasing average Channel Quality Indicator (CQI)in the downlink and increasing Physical UL Shared Channel (PUSCH) interference level in the uplink, especially in cells where handover margins are strongly modified.	Mobility load balancing (MLB)
8	LTE Positioning Accuracy Performance Evaluation	Solvinghyperbolic trilateration problem with linear least squares (LLS) and nonlinear Gauss-Newton (GN) and Levenberg- Marquardt (LM) algorithms and compared it with CRLB computed for Cramer-Rao lower bound (CRLB) measurements	The simple linear least squares (LLS) achieves close to Levenberg- Marquardt (LM) positioning accuracy when the number of eNB is 6, while further increasing the number of eNB degrades positioning algorithms accuracy	Dedicated positioning reference signal (PRS) by means of comprehensive simulation mode

9	A Wireless Location System in LTE Networks	Makes channel and location measurement more available, allocation of baseband processing resources more flexible, and location service capability opening	performance gain and improves the efficiency and accu- racy of the location system in C-RAN architecture.	Uplink SRS is used as monitoring signals. LMUs are responsible for signal detection and TDOA estimation. The location information server calculates the user's position through the proposed algorithms
10	Handover Optimization and User Mobility Prediction in LTE Femtocells Network	Nominate the most proper target femtocell among many candidates and to eliminate the redundant HO in femtocell based cellular networks	Eliminating the unnecessary HO and ensure the load balance of the target Femtocell Access Point (FAP) and the entire network. Also, the serving cell takes into consideration the real capacity of the available survived target FAP.	Novel algorithm based on the Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ) and some User Equipment (UE) parameters like moving direction and the position inside the femtocell used as HO decision criteria.

Chapter Three

Methodology

Chapter Three
Methodology

In this chapter the physical model of the study area is shown. as well as the mathematical model and also flow char of how the mechanism work in details.

3.1 Physical model

The strategy that used in this research first of all the area is divided into four equal square 2×2 Km each. eNodeB1 in cell1 eNodeB2 in cell2 eNodeB3 for cell3 and eNodeB4 for cell4 .The handover distance(hd) is 100m from each side of the cell .The movement direction (Direction) either moving inside or outside the cell. The initial distance from eNodeB1 is (IeNodeB) and the expected distance from eNodeB1 is (deNodeB1) it depended on the direction and the average speed .

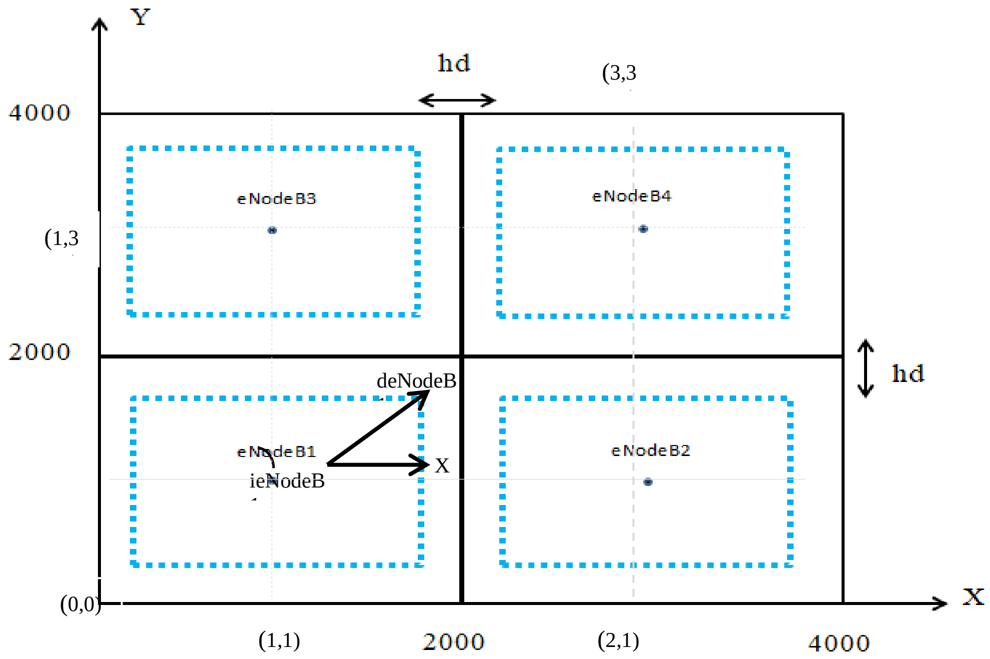

Figure 3.1 the physical model

Algorithm 1

Input: deNB, IeNB, R, t, hd, CF, status, Ch,

Output: Channel Assignment

```
R←1000
hd←100
If deNB<R-hd              %the current  location inside the inner cell radius
     If  Ch>0             %Ch number of available channel
        Then  status←1
      else CF←CF+1        %Connection failed no available channel
                  status←2
  END
```

The movement of each mobile station either stationary or in high or slow mobility and the direction of the movement either it inside or outside the cell. If the mobile station distance less than inner radius of the cell, the channel well be given from inside the cell ,the status of the mobile station is (1) .If there is no channel available the connection will fail(cf), the status will convert to (2).

Algorithm

Input: deNB, IeNB, R, t, hd, CF, status, Ch, Angle

Output: Channel Assignment from handover distance

```
R←1000
hd←100
If deNB<hd            %the current location outside the inner cell radius
If deNB<IeNB          %the user moving Direction inside the serving cell
    If ch>0           %Ch number of available channel
   Then status←1
 else CF←CF+1              %Connection failed no available channel
    Then   status←2
 END
If deNB>IeNB                %the user moving direction outside the serving cell
     Then Angel← abs(asind(deNB/xpos))
      Select the adjacent cell
        If ch>0             %Ch number of available channel
          Then status←1
       else CF←CF+1       %Connection failed no available channel
       status←2
END
```

If the mobile station current location inside the handover distance the direction well be consider by comparing the current distance(deNB) with the initial distance(IeNB)to decide if the user moving inside or outside the cell. If the user moving inside, the channel will assigned to him from the serving cell. If the user moving outside the angle of direction will be calculated to decide which channel will be assigned. As shown in figure(3.2) cell 1 after calculated the angel of direction and distance from eNodeB 1 in the handover distance if the angel is (0-

45°) and (315°-360°) the channel well be assigned from cell 2 the status of the mobile station (1) if there is no channel the connection well fail (cf) the status well be (2) if the angel is (45°-135°)the channel will be assigned from cell3 the status of the mobile is (1) if there is no channel the connection fail (cf) the status well be (2)

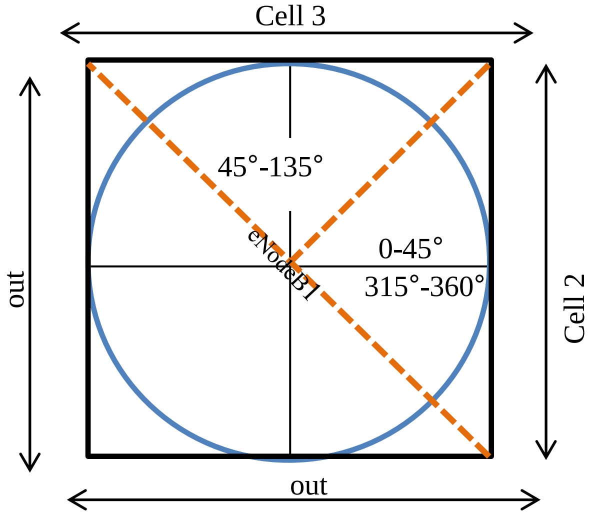

Figure 3.2 description of the movement angle in cell one

As shown in figure(3.3) cell 2 after calculated the angel of direction and distance from eNodeB 2 in the handover distance if the angel is (45°-135°) the channel well be assigned from cell 4 the status of the mobile station (1) if there is no channel the connection well fail (cf) the status well be (2) if the angel is (135°-225°)the channel will be assigned from cell 1 the status of the mobile is (1) if there is no channel the connection fail (cf) the status well be (2) .

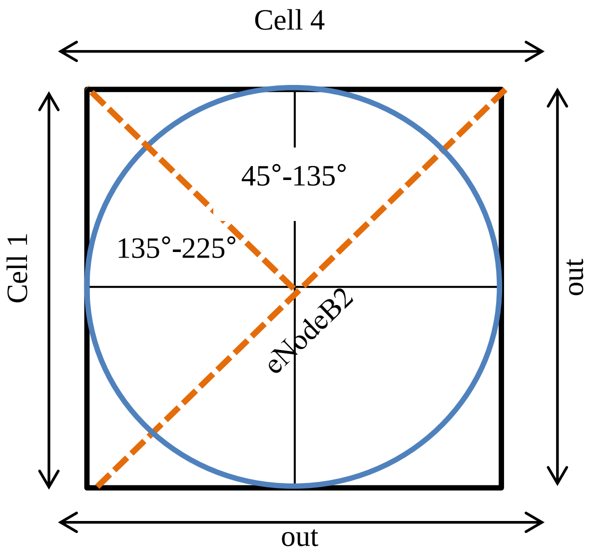

Figure 3.3 description of the movement angle in cell two

As shown in figure(3.4) cell 3 after calculated the angel of direction and distance from eNodeB 3 in the handover distance if the angel is (0-45°) and (315°-360°)the channel well be assigned from cell 4 the status of the mobile station (1) if there is no channel the connection well fail (cf) the status well be (2) if the angel is (225°-315°)the channel will be assigned from cell 1 the status of the mobile is (1) if there is no channel the connection fail (cf) the status well be (2)

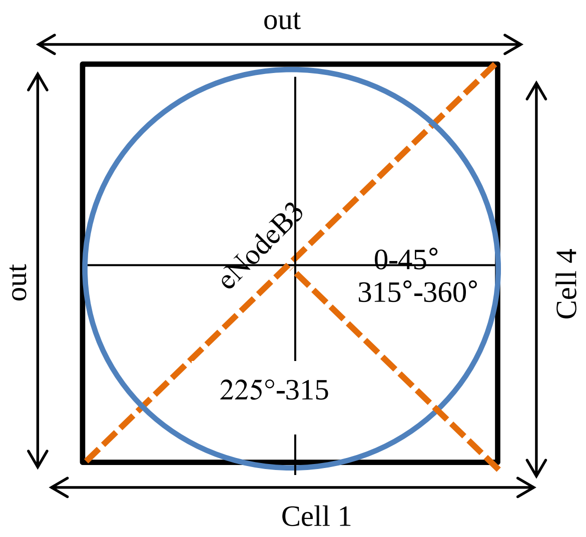

Figure 3.4 description of the movement angle in cell three

As shown in figure(3.5) cell 4 after calculated the angel of direction and distance from eNodeB 4 in the handover distance if the angel is (225°-315°) the channel well be assigned from cell 2 the status of the mobile station (1) if there is no channel the connection well fail (cf) the status well be (2) if the angel is (135°-225°)the channel will be assigned from cell 3 the status of the mobile is (1) if there is no channel the connection fail (cf) the status well be (2)

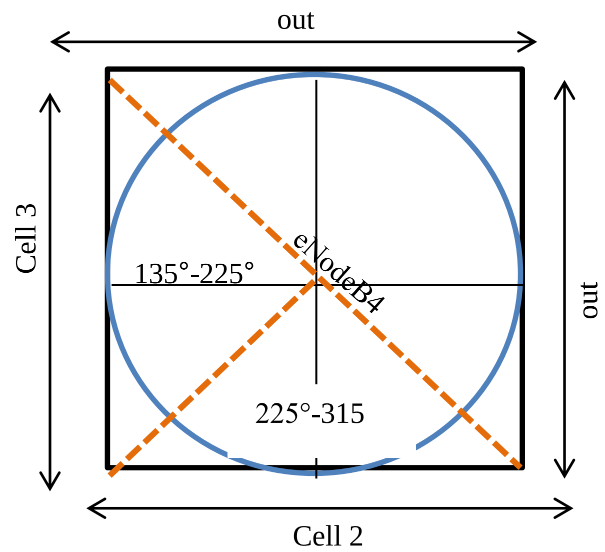

Figure 3.5 description of the movement angle in cell four

Algorithm

Input: deNB, IeNB, R, t, hd, CF, status, Ch, HO, HOF, CCh

Output: Handover decision

```
R←1000
hd←100
If deNB<R-Hd                %the current  location inside the inner cell radius
    If  CCh≠Ch               % the user carry channel from different cell
        If Ch>0
        Then HO←HO+1
         status←3
        else HOF←HOF+1       %Handover failed  if no available channel
              status←4
END
```

When it comes to handover strategy the handover will be executed only if the mobile station carry channel(CCh) from different cell and reach inside the inner radius of another cell . If there is available channel the handover will executed successfully the status will be (3). If there is no channel available the handover will fail the status will be (4) .

3.2 Mathematical model

$$id_{eNB1}=\sqrt{}((X_C-X_{eNB1})^2-(Y_C-Y_{eNB1})^2 \quad 3.1$$

$$id_{eNB2}=\sqrt{}((X_C-X_{eNB2})^2-(Y_C-Y_{eNB2})^2) \quad 3.2$$

$$id_{eNB3}=\sqrt{}((X_C-X_{eNB3})^2-(Y_C-Y_{eNB3})^2) \quad 3.3$$

$$id_{eNB4}=\sqrt{}((X_C-X_{eNB4})^2-(Y_C-Y_{eNB4})^2) \quad 3.4$$

id_{eNB}=initial distance of the user

X_C=the user X coordinate

Y_C= the use Y coordinate

X_{eNB}=the eNB Y coordinate

Y_{eNB}=the eNB X coordinate

First step to find the initial distance for mobile station from each four eNodeB by using the equations (3.1-3.4) the decision about handover will be made after consider the result which obtained from the user movement :

$$d_{eNB1}=\sqrt{}(((X_C+(D \times vavg)) - X_{eNB1})^2-((Y_C+(D \times vavg)) - Y_{eNB1})^2 \quad 3.5$$

$$d_{eNB2}=\sqrt{}(((X_C+(D \times vavg)) - X_{eNB2})^2-((Y_C+(D \times vavg)) - Y_{eNB2})^2) \quad 3.6$$

$$d_{eNB3}=\sqrt{}(((X_C+(D \times vavg)) - X_{eNB3})^2-((Y_C+(D \times vavg)) - Y_{eNB3})^2) \quad 3.7$$

$$d_{eNB4}=\sqrt{}(((X_C+(D \times vavg)) - X_{eNB4})^2-((Y_C+(D \times vavg)) - Y_{eNB4})^2) \quad 3.8$$

d_{eNB1}=the current distance of the user

D=the direction of movement

Vavg=average speed

,If the (D) is +1 that mean that the user is moving away from the serve eNodeB if the (D)is -1 than mean that the user moving close to the eNodeB the current location can be calculated at any time and at any speed by using the equation (3.5-3.8) .Vavg is the user speed it is virtual it can be stationary or slow movement like walking or high speed movement like vehicle speed and also the direction is random after knowing the location exactly from each eNodeB.

Table (3,1) Describe parameter and values

Parameter	Value
Number of cells	Four cells
Cell size	2×2Km
Number of users	500
Simulation time	300s
Handover Distance	100m
Average speed	30-60-200 Km/h
Average inter arrival	1-2-3-4min
Minimum data rate	100Mbps
Maximum data rate	1Gbps
Maximum Packet size	1387×8
Average Packet size	762×8
Average Packet size per second	117
Maximum Bandwidth	18MHz
Number of subcarriers	12
Subcarriers Bandwidth	15KHz
Number of channels	100×4

Number of resource blocks:

Maximum Bandwidth=100 PRBs or 18 MHz.

12 subcarriers*15khz=180KHZ

18Mhz/180khz=100RBs=number of channels

100*4=400 channels

The number of channel or resource block can be calculated in each cell by dividing the maximum Bandwidth 18MHZ with 2MHZ guard channel on 12 subcarrier each 15 kHZ channel bandwidth so the number of channel or resource block equal 100 channel or resource block . The total number is 400 channels because the number of cell is 4.

$$\text{Inter arrival} = P(X=k) = \frac{\lambda^k \ e^{-\lambda}}{k!} \qquad 3.10$$

Where

K= number of user

λ = average number of inter arrival

e = Euler's constant 2.71828

Inter arrival is a random time between the resent connection and the next one it depends on the population in the area

$$CR=(mDR(MDR–mDR)) \qquad 3.11$$

Where

CR=Connection rate

mDR=Minimum data rate

MDR=Maximum data rate

Connection rate is the speed of send and receive this data in time unit for the signal user.

$$HT=(MPS * APS / CR) \qquad 3.12$$

HT=Holding time

APS=Average Packet size per second

CR=Connection rate

Holding time(HT) is the time of using amount of data or traffic On average LTE is sending more bytes in a single packet. Furthermore, the average packet size(APS)of

LTE; 762 Bytes as well as the average packets per second 117 packets are much greater than the average packet size of UMTS; 730 Bytes and the average packets per second 89 packets[7]. LTE in effect was labeled 3.9G and the motivation behind the design of this network was to provide low latency and very high data rates starting from 100 Mbps and reaching more than 1 Gbps at the downlink[8] it explain in Eq 3.12.

$$\Theta = sin^{-1}\frac{(deNB)}{Xpos} \qquad 3.13$$

To calculate the angel of movement in Eq 3.13 it is the angel between the X position and the distance from deNodeB.

3.3 Computer model

This logarithm is used for standard square area of 4X4 km² the study area will fall under the handover distance and will provide more accurate results in terms of the handover fail and successful and connection block rates between the four cell geographical areas. First of all the movement of the mobile station is randomly also the direction. The distance from the mobile station and eNodeBs is calculated also the displacement and the direction if the mobile station moving inside or outside the cell or in the Handover distance. The channel is Assigned when the user current location less than inner cell radius if there is no channel the connection fail (cf). If the mobile station in the handover distance The channel is assigned from adjustment cell after calculate the angel to decide which cell if there is no channels the connection fail (cf). the angel is between the two lines the line that connect the initial distance and the current distance and the Xposition . The handover is designed to take place only if the user arrive inner cell radius when he carry channel from other cells if there is no channel the handover fail (HOF)

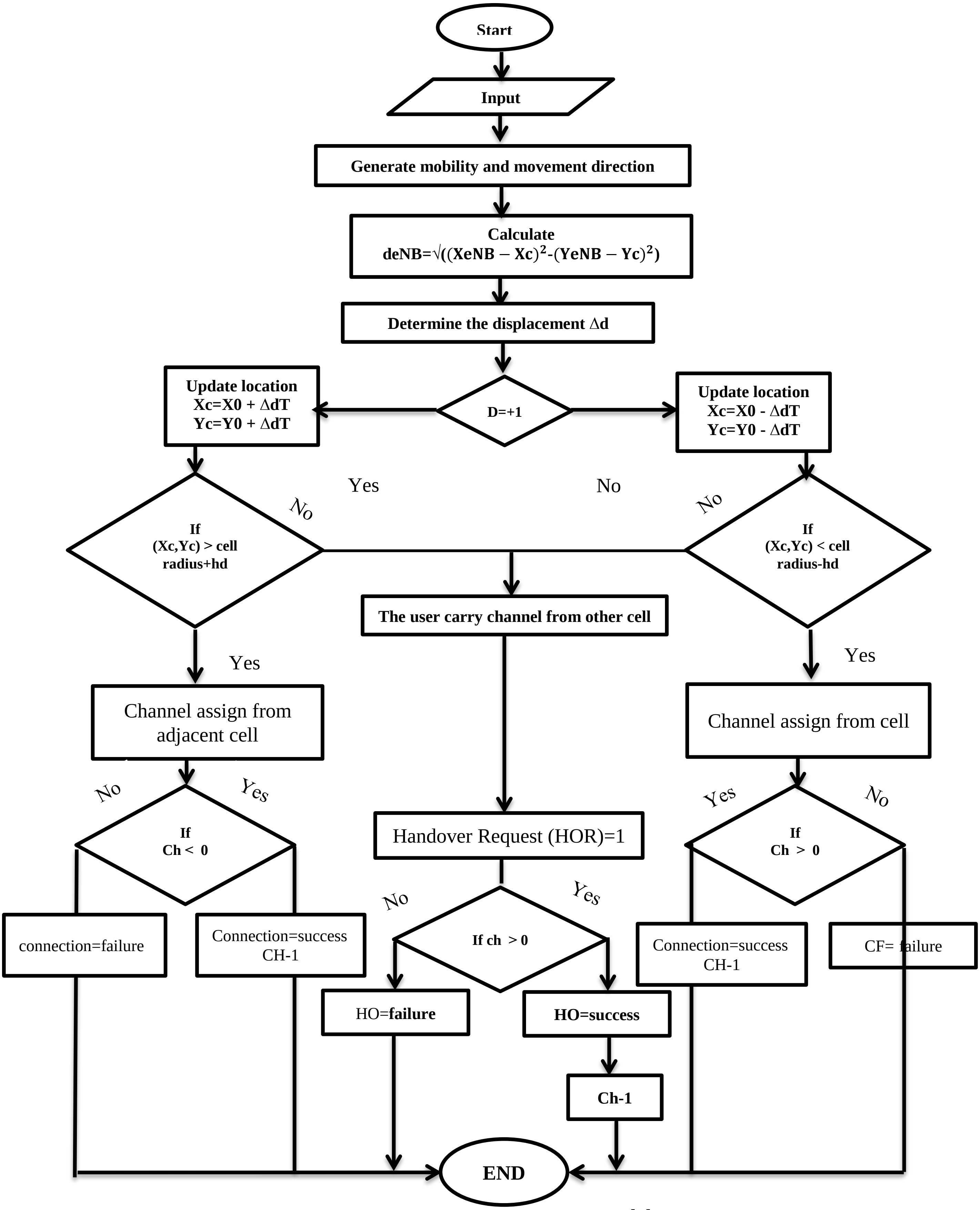

Figure 3.6 Computer model

Chapter Four

Simulation Results

&Discussions

Chapter Four
Simulation and Results

4.1 The simulation Description

In chapter three the physical model is described also the mathematical model is clarified in details. The simulation algorithm is written using MATLAB coding instructions . 500 user is distributed randomly in 4 cells with dimension 2×2 Km for each cell. The simulation time is 3 minutes. The minimum data rate in LTE is 100Mbps and the maximum data rate is 1 Gbps. Different speed is tested in this logarithm (30Km/h,60Km/h,200Km/h). The number of resource block is 100 for each cell. The handover distance is 100m. Different average inter arrival is tested to see the result in this algorithm from 1 minute to 4 minutes .The holding time is calculated from maximum packet size in LTE (1387*8) and average Packet size per second (117) and connection rate .Connection rate is calculated from minimum data rate and maximum data rate. By using matlab simulation the location and the movement will be studied according to this studies the channel will be assigned from the serving cell if the user moves inside the inner radius of the cell. If the user moving inside the Handover distance area so the direction of the movement will be consider by comparing the current location with previous one. If the current location lees than the previous one that mean that the user moving inside so the channel will assigned to the user from the serving cell. If it not according to the angle of movement the channel will be assigned to the user from the adjacent cell. The handover will take a place only when the user carry a channel from a cell and reach inside the inner radius of another cell. This algorithm is tested by using two parameters the speed of the user and the average inter arrival .To see the effect of these two parameter on the connection failure (CF) the handover successes(HO)and the handover failure (HOF).

4.2 Simulation Results and Discussions

The figure 4.1, present the assumed position for users and their distribution in the simulation area under study area which contain 4 cell each 2×2Km .Handover distance surround each cell it is 100m from each side.eNB at the center of each cell.

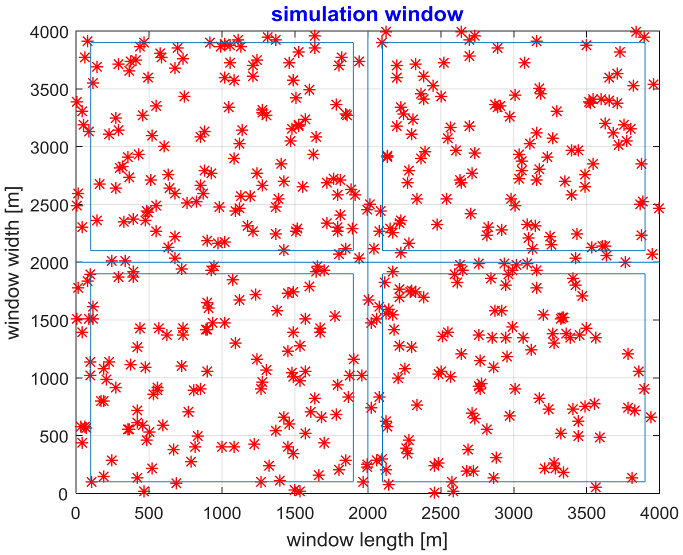

figure 4.1 the user distribution

500 users location by measuring the distance from every eNBs The figure(4.2) presents the distance from the 500 users and eNB1Some user are close and some of them are far away.

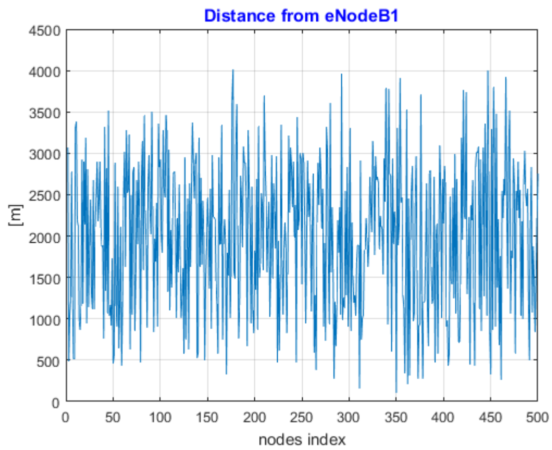

figure 4.2 location user form eNodeB 1

The figure 4.3 presents the500 users location by measuring the distance from eNodeB2

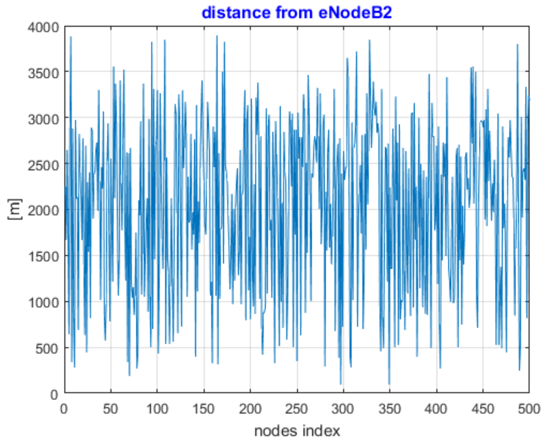

figure 4.3 location user form eNodeB 2

The figure 4.4 presents the 500 users location by measuring the distance from eNodeB3

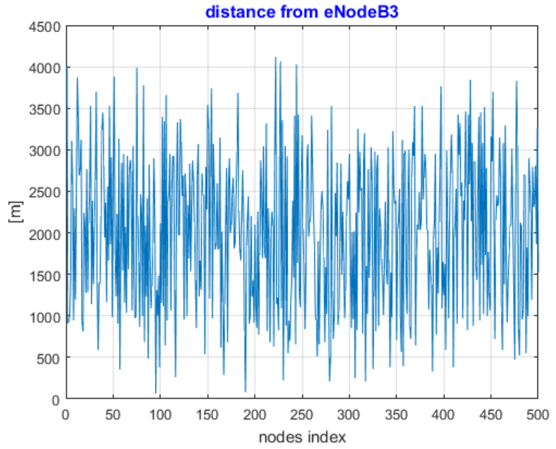

figure 4.4 location user form eNodeB 3

The figure 4.5 presents the 500 users location by measuring the distance from eNodeB4

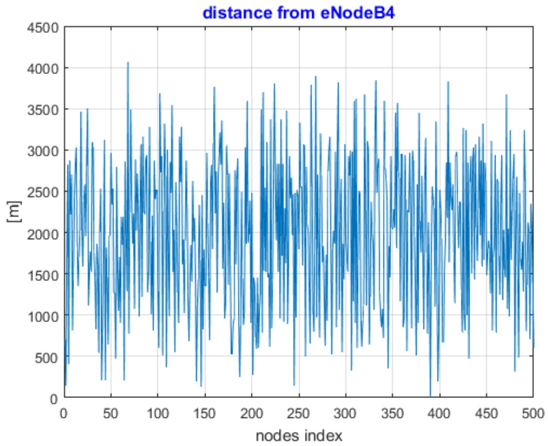

figure 4.5 location user form eNodeB 4

During simulation time of 180 seconds with handover zone of 100 meters, with different speeds the number of successful handovers ,failure handover and connection were recorded for the proposed method in tables 4.1

Table 4.1**:** The handover requests block and handover success connection fail (speed is 30Km/h)

Cell name	**Proposed method**		
	Connection fail	**Handover fail**	**Handover success**
Cell (1)	**1**	**0**	**0**
Cell (2)	**0**	**0**	**1**
Cell (3)	**1**	**0**	**0**
Cell (4)	**0**	**0**	**0**

As in the result of speed 30Km/h there is no handover fail and there is connection fail and one Handover success what if the speed increase up to 30 to 60km/h as in table 4.2

Table 4.2**:** The handover requests block and handover success connection fail (speed 60Km/h)

Cell name	**Cases**		
	Connection fail	**Handover fail**	**Handover success**
Cell (1)	**0**	**0**	**0**
Cell (2)	**1**	**0**	**3**
Cell (3)	**1**	**0**	**0**
Cell (4)	**0**	**0**	**0**

The result shows the increase of the handover and no handover fail in the speed of 60Km/h what if the speed increase to 200Km/h as shown in table 4.3

Table 4.3**:** The handover requests block and handover success connection fail (speed 200Km/h)

Cell name	**cases**		
	Connection fail	**Handover fail**	**Handover success**
Cell (1)	**3**	**0**	**0**

Cell (2)	**0**	**2**	**4**
Cell (3)	**1**	**0**	**0**
Cell (4)	**4**	**0**	**0**

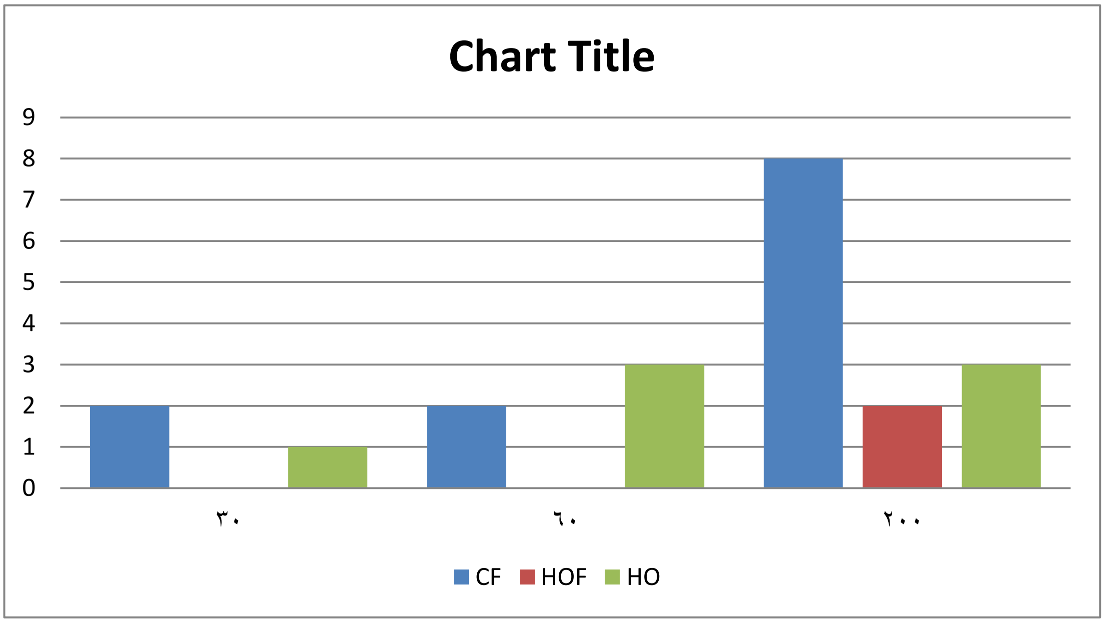

figure 4.6 the relationship between the speed and (cf,HOF,HO)

As shown in the result the speed effect on the algorithm. By changing the average inter arrival (ava) time for (1, 2, 3,4) minutes the number of active mobile station will increase that mean the traffic will increase that effect the connection failure(cf) and handover failure (HOF) the speed of mobile station is 60Km/h that is the average speed in many countries

Table 4.3: The handover requests block and handover success connection fail (ava= 1 min)

Cell name	**cases**		
	Connection fail	**Handover fail**	**Handover success**
Cell (1)	**0**	**0**	**0**
Cell (2)	**0**	**0**	**2**
Cell (3)	**2**	**0**	**0**
Cell (4)	**0**	**0**	**0**

There is no handover failure when the ava is one minuet and also two minuet as it shown in table 4.4

Table 4.4: The handover requests block and handover success connection fail (ava= 2 min)

Cell name	cases		
	Connection fail	Handover fail	Handover success
Cell (1)	0	0	0
Cell (2)	0	0	1
Cell (3)	0	0	0
Cell (4)	2	0	0

When it became to three minutes it observed one handover failure and increment of connection failure is shown in table 4.5

Table 4.5: The handover requests block and handover success connection fail (ava=3 min)

Cell name	cases		
	Connection fail	Handover fail	Handover success
Cell (1)	0	0	0
Cell (2)	0	1	1
Cell (3)	0	0	0
Cell (4)	5	0	0

By increasing the ava to four minutes the handover failure and the connection failure also increases. It has found from the result that if the ava increase into above three minutes the handover failure increase and also the connection failure

Table 4.5: The handover requests block and handover success connection fail (ava=4 min)

Cell name	cases		
	Connection fail	Handover fail	Handover success
Cell (1)	4	0	0
Cell (2)	3	2	0
Cell (3)	0	0	0

Cell (4)	0	0	0

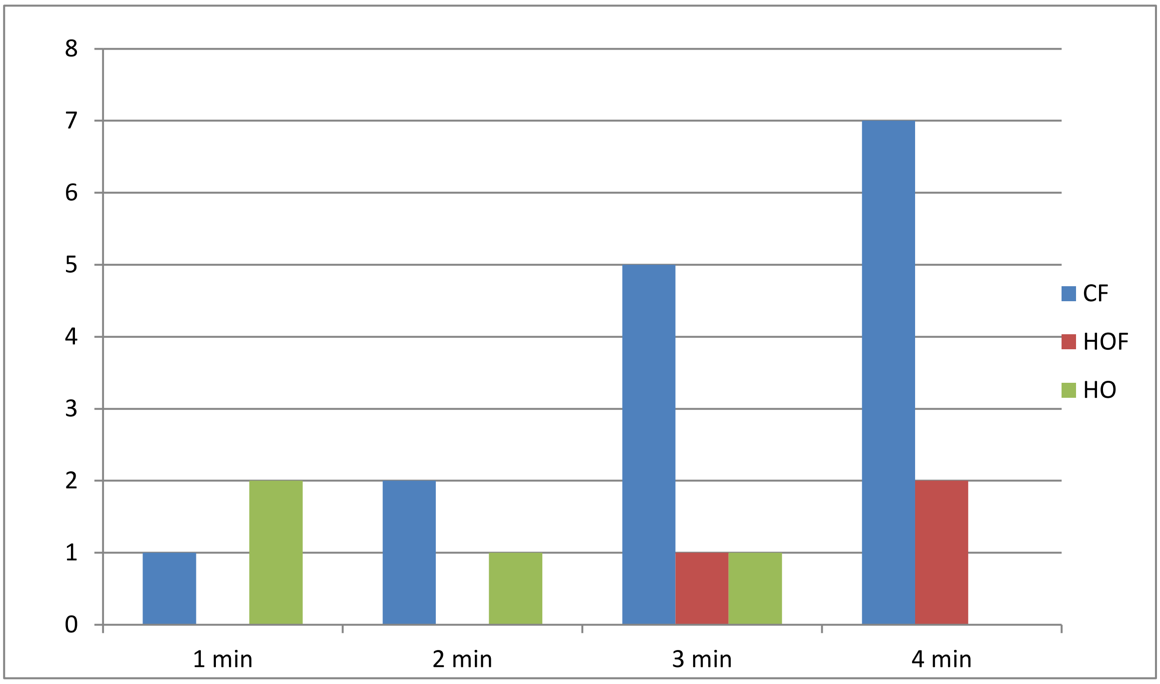

figure 4.7 the relationship between the average inter arrival and (CF,HO,HOF)

Chapter five
Conclusion and Recommendations

Chapter five
Conclusion and Recommendations

5.1 Conclusion

In this thesis, the proposed algorithm is depend on knowing the location of the mobile station and knowing the angel of direction and also the distance from each eNodeB. The main objective is to reduce handover failure by knowing the direction of movement and the impact of the average inter arrival and the speed of the user equipment on the result .As it shown in the result the impact of two cases the speed of the mobile station and the average inter arrival. It has observed that if the mobile station is moving faster than the average speed, the number of (cf) is increase also the (HO) increase and there is no (HOF) below average speed which is 60km/h .The second case is average inter arrival it has found that if the average inter arrival increase the number of (HOF) will increase and the (cf) also increase the number of (HO) will decrease. And there will be no (HO) if the average inter arrival above 3 minutes. In this thesis the idea is to decrease the handover failure.

5.2 Recommendations

For future work different parameter should be tasted to see the effectiveness of this logarithm in telecommunication network like signal strength. Also can use different type of channel assignment like dynamic channel assignment to give more efficiency to the network. Also this algorithm can be tested in different speed

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APPENDIX

APPENDIX

Simulation Program

```
%********************
% Marwa PROGRAM MASTER
%********************
close all
clear
% INPUT VARIABLS
%----------------
ww=4000; %ww is the simulation window width
wl=4000;% wl is the simulstuin window Lengths
user=500;
hd=100; %hd is handover distance
vavg=16;% avrage speed 60 km/h
sim_time=300;%Simulation time in second
avg_interarrival=180; %average inter arrival 3 mint
min_data_rate=100000;% min data in downlink of lte [kbp]
max_data_rate=1000000;%max data rate in downlink kbp
max_pac_size= (1387*8);%maximum paket size in LTE.
average_packet_per_second=117;% in LTE average packet per second 117 packet
average_packet_size=(762*8);%average packet size in LTE is 762*8byte
average_session=10;
status=zeros(1,user);
T_BW=18000000; %The total bandwidth ber cell is 180 MHz (1GHz)
C_BW=180000; %channel bandwidth is 180  kHz
cf1=0; % connection fauilar counter in eNodeB1
cf2=0;% connection fauilar counter in eNodeB2
cf3=0; % connection fauilar counter in eNodeB3
cf4=0; % connection fauilar counter in eNodeB4
ch=zeros(1,user);
out=0;
HO1=0
HO2=0
HO3=0
HO4=0
HOF1=0
HOF2=0
HOF3=0
HOF4=0
HOR=0

 out1=0
 out2=0
 out3=0
 out4=0
%*****************
% mobile distribution
%*******************

xpos=wl*rand(1,user);
ypos=ww*rand(1,user);
xpos_eNodeB1=1000;
ypos_eNodeB1=1000;
xpos_eNodeB2=3000;
ypos_eNodeB2=1000;
xpos_eNodeB3=1000;
```

```
ypos_eNodeB3=3000;
xpos_eNodeB4=3000;
ypos_eNodeB4=3000;
cell_radius=1000;
%*************
%Generating trafic
%*************
inter_arrival=poissrnd(avg_interarrival,1,user);
arrival=cumsum(inter_arrival);
con_rate=min_data_rate+round((max_data_rate-min_data_rate)*rand(1,user));


holding_time=(round(max_pac_size*rand(1,1))*poissrnd(average_packet_per_second,
1,user))/con_rate(1,user);
holding_time=holding_time*poissrnd(average_session,1,1);

plot(xpos,ypos,'*r')
grid
line([0 4000],[2000 2000])
line([2000 2000],[0 4000])
line([((2*xpos_eNodeB1)-hd) ((2*xpos_eNodeB1)-hd)],[hd ((2*xpos_eNodeB1)-
hd)])%1
line([hd ((2*xpos_eNodeB1)-hd)],[((2*xpos_eNodeB1)-hd) ((2*xpos_eNodeB1)-
hd)])%1
line([hd hd],[hd ((2*xpos_eNodeB1)-hd)])%1
line([hd ((2*xpos_eNodeB1)-hd)],[hd hd])%1
line([((2*xpos_eNodeB1)+hd) ((2*xpos_eNodeB1)+hd)],[hd ((2*xpos_eNodeB1)-
hd)])%2
line([((2*xpos_eNodeB1)+hd) (4*xpos_eNodeB1)-hd],[((2*xpos_eNodeB1)-hd)
((2*xpos_eNodeB1)-hd)])%2
line([((2*xpos_eNodeB1)+hd) ((4*xpos_eNodeB1)-hd)],[hd hd])%2
line([((4*xpos_eNodeB1)-hd) ((4*xpos_eNodeB1)-hd)],[hd ((2*xpos_eNodeB1)-
hd)])%2
line([hd hd],[((2*xpos_eNodeB1)+hd) ((4*xpos_eNodeB1)-hd)])%3
line([hd ((2*xpos_eNodeB1)-hd)],[((2*xpos_eNodeB1)+hd)
((2*xpos_eNodeB1)+hd)])%3
line([((2*xpos_eNodeB1)-hd) ((2*xpos_eNodeB1)-hd)],[((2*xpos_eNodeB1)+hd)
((4*xpos_eNodeB1)-hd)])%3
line([hd ((2*xpos_eNodeB1)-hd)],[((4*xpos_eNodeB1)-hd) ((4*xpos_eNodeB1)-
hd)])%3
line([((2*xpos_eNodeB1)+hd) ((4*xpos_eNodeB1)-hd)],[((4*xpos_eNodeB1)-hd)
((4*xpos_eNodeB1)-hd)])%4
line([((2*xpos_eNodeB1)+hd) ((2*xpos_eNodeB1)+hd)],[((2*xpos_eNodeB1)+hd)
((4*xpos_eNodeB1)-hd)])%4
line([((2*xpos_eNodeB1)+hd) ((4*xpos_eNodeB1)-hd)],[((2*xpos_eNodeB1)+hd)
((2*xpos_eNodeB1)+hd)])%4
line([((4*xpos_eNodeB1)-hd) ((4*xpos_eNodeB1)-hd)],[((2*xpos_eNodeB1)+hd)
((4*xpos_eNodeB1)-hd)])%4
title('simulation window','fontsize',12,'color','b');
xlabel('window length [m]');
ylabel('window width [m]')
figure%2
plot(holding_time)
grid
title('holding time in second','fontsize',12,'color','b');
xlabel('nodes index');
ylabel('holding time[s]')
figure%2
plot(inter_arrival)
grid
```

```
title('Interrival Distribution','fontsize',12,'color','b');
xlabel('nodes index');
ylabel('Inter Arrival time[s]');
figure%2
plot(arrival)
grid
title('arrival time in second','fontsize',12,'color','b');
xlabel('nodes index');
ylabel('arrival time[s]');
ncc1=T_BW/C_BW;% number of channel cell 1
ncc2=T_BW/C_BW;% number of channel cell 2
ncc3=T_BW/C_BW;% number of channel cell 3
ncc4=T_BW/C_BW;% number of channel cell 4
thita=zeros(1,user)

thitadeg=zeros(1,user)


%*************
%calculat the distans between the BS and each mobile node
%******************
for k=1:user
    deNodeB1(1,k)=sqrt((xpos(1,k)-xpos_eNodeB1)^2+(ypos(1,k)-ypos_eNodeB1)^2);
    ideNodeB1(1,k)=deNodeB1(1,k);
    deNodeB2(1,k)=sqrt((xpos(1,k)-xpos_eNodeB2)^2+(ypos(1,k)-ypos_eNodeB2)^2);
    ideNodeB2(1,k)=deNodeB2(1,k);
    deNodeB3(1,k)=sqrt((xpos(1,k)-xpos_eNodeB3)^2+(ypos(1,k)-ypos_eNodeB3)^2);
    ideNodeB3(1,k)=deNodeB3(1,k);
    deNodeB4(1,k)=sqrt((xpos(1,k)-xpos_eNodeB4)^2+(ypos(1,k)-ypos_eNodeB4)^2);
    ideNodeB4(1,k)=deNodeB4(1,k);

end

     plot(deNodeB1)
     grid
     title('Distance from eNodeB1','fontsize',12,'color','b');
     xlabel('nodes index');
     ylabel('[m]');
     figure%6
      plot(deNodeB2)
     grid
     title('distance from eNodeB2','fontsize',12,'color','b');
     xlabel('nodes index');
     ylabel('[m]');
     figure%7
      plot(deNodeB3)
     grid
     title('distance from eNodeB3','fontsize',12,'color','b');
     xlabel('nodes index');
     ylabel('[m]');
     figure%7
      plot(deNodeB4)
     grid
     title('distance from eNodeB4','fontsize',12,'color','b');
     xlabel('nodes index');
     ylabel('[m]');

  %Main Program
  %============
  status=zeros(1,user);
```

```
  for t=1:sim_time
         out=0;
         for k=1:user
              g=round(rand(1,1));
             if g==0;
                 direction=1;
             else
                 direction=-1;
             end
     deNodeB1(1,k)=sqrt(((xpos(1,k)+(direction*vavg*rand(1,1)))-
xpos_eNodeB1)^2+((ypos(1,k)+(direction*vavg*rand(1,1)))-ypos_eNodeB1)^2);
     deNodeB2(1,k)=sqrt(((xpos(1,k)+(direction*vavg*rand(1,1)))-
xpos_eNodeB2)^2+((ypos(1,k)+(direction*vavg*rand(1,1)))-ypos_eNodeB2)^2);
     deNodeB3(1,k)=sqrt(((xpos(1,k)+(direction*vavg*rand(1,1)))-
xpos_eNodeB3)^2+((ypos(1,k)+(direction*vavg*rand(1,1)))-ypos_eNodeB3)^2);
     deNodeB4(1,k)=sqrt(((xpos(1,k)+(direction*vavg*rand(1,1)))-
xpos_eNodeB4)^2+((ypos(1,k)+(direction*vavg*rand(1,1)))-ypos_eNodeB4)^2);

end

     for k=1:user
     % Assign channel
     %----------------
     if arrival(1,k)>=t
         if status(1,k)==0
         if deNodeB1(1,k)<(cell_radius-hd)
             if ncc1>0
             ncc1=ncc1-1;
             ch(1,k)=1;
             status(1,k)=1;
             else
                 cf1=cf1+1;
                 status(1,k)=2;
             end
         elseif  deNodeB2(1,k)<(cell_radius-hd)
              if ncc2>0
             ncc2=ncc2-1;
             ch(1,k)=2;
plot(deNodeB1,'--r')
             status(1,k)=1;
             else
                 cf2=cf2+1;
                 status(1,k)=2;
              end
         elseif  deNodeB3(1,k)<(cell_radius-hd)
             if ncc3>0
               ncc3=ncc3-1;
             ch(1,k)=3
               status(1,k)=1;
             else
                 cf3=cf3+1;
                 status(1,k)=2;
              end
         elseif deNodeB4(1,k)<(cell_radius-hd)

             if ncc4>0
               ncc4=ncc4-1;
             ch(1,k)=4
             status(1,k)=1;
             else
```

```
            cf4=cf4+1;
            status(1,k)=2;
        end
    %Channel assignment in the cell boarder of cell(1)
    %------------------------------------------------
      elseif deNodeB1(1,k)<cell_radius

        if deNodeB1(1,k)<ideNodeB1(1,k)

            if ncc1>0
          ncc1=ncc1-1;
        ch(1,k)=1
        status(1,k)=1;
            else
              thitadeg(1,k)=abs(asind(deNodeB1(1,k)/xpos(1,k)));
              if (thitadeg(1,k)<45)&&(thitadeg(1,k)>315)
                  if ncc2>0
                      ncc2=ncc2-1;
                      ch(1,k)=1;
                      status(1,k)=1;
                  else
            cf2=cf2+1;
            status(1,k)=2;
                  end
              elseif (thitadeg(1,k)>45)&&(thitadeg(1,k)<135)
                  if ncc3>0
                      ncc3=ncc3-1;
                      ch(1,k)=1;
                      status(1,k)=1;
                  else
            cf3=cf3+1;
            status(1,k)=2;
                  end
                  elseif (thitadeg(1,k)>135)&&(thitadeg(1,k)<315)
                      out=out+1;
              end
            end
        end

%Channel assignment in the cell boarder of cell(2)
    %------------------------------------------------
      elseif deNodeB2(1,k)<cell_radius

        if deNodeB2(1,k)<ideNodeB2(1,k)


            if ncc2>0
          ncc2=ncc2-1;
        ch(1,k)=2
        status(1,k)=1;
            else
              thitadeg(1,k)=abs(asind(deNodeB2(1,k)/xpos(1,k)));
              if (thitadeg(1,k)>45)&&(thitadeg(1,k)<135)
                  if ncc4>0
                      ncc4=ncc4-1;
                      ch(1,k)=4;
                      status(1,k)=1;
                  else
            cf4=cf4+1;
            status(1,k)=2;
```

```
                end
            elseif (thitadeg(1,k)>135)&&(thitadeg(1,k)<225)
                if ncc1>0
                    ncc1=ncc1-1;
                    ch(1,k)=1;
                    status(1,k)=1;
                else
          cf1=cf1+1;
          status(1,k)=2;
                end
                elseif (thitadeg(1,k)>225)||(thitadeg(1,k)<45)
                    out=out+1;
            end
          end
      end

%Channel assignment in the cell boarder of cell(3)
   %-------------------------------------------------
    elseif deNodeB3(1,k)<cell_radius
        if deNodeB3(1,k)<ideNodeB3(1,k)

            if ncc3>0
          ncc3=ncc3-1;
        ch(1,k)=3
        status(1,k)=1;
            else
              thitadeg(1,k)=abs(asind(deNodeB3(1,k)/xpos(1,k)));
              if (thitadeg(1,k)>255)&&(thitadeg(1,k)<315)
                if ncc1>0
                    ncc1=ncc1-1;
                    ch(1,k)=1;
                    status(1,k)=1;
                else
          cf1=cf1+1;
          status(1,k)=2;
                end
              elseif (thitadeg(1,k)>315)||(thitadeg(1,k)<45)
                if ncc4>0
                    ncc4=ncc4-1;
                    ch(1,k)=4;
                    status(1,k)=1;
                else
          cf4=cf4+1;
          status(1,k)=2;
                end
                elseif (thitadeg(1,k)>45)&&(thitadeg(1,k)<225)
                    out=out+1;
              end
            end
        end
      %Channel assignment in the cell boarder of cell(4)
   %-------------------------------------------------
    elseif deNodeB4(1,k)<cell_radius

        if deNodeB4(1,k)<ideNodeB4(1,k)
            if ncc4>0
          ncc4=ncc4-1;
        ch(1,k)=4
        status(1,k)=1;
            else
```

```
                  thitadeg(1,k)=abs(asind(deNodeB4(1,k)/xpos(1,k)));
                  if (thitadeg(1,k)>225)&&(thitadeg(1,k)<315)
                      if ncc2>0
                          ncc2=ncc2-1;
                          ch(1,k)=2;
                          status(1,k)=1;
                      else
                cf2=cf2+1;
                status(1,k)=2;
                      end
                  elseif (thitadeg(1,k)>135)&&(thitadeg(1,k)<225)
                      if ncc3>0
                          ncc3=ncc3-1;
                          ch(1,k)=3;
                          status(1,k)=1;
                      else
                cf3=cf3+1;
                status(1,k)=2;
                      end
                      elseif (thitadeg(1,k)>315)||(thitadeg(1,k)<135)
                          out=out+1;
                  end
                end

             end
      end

%Channel Release after connnection end
%-------------------------------------
con_time(1,k)=arrival(1,k)+holding_time(1,k)
      elseif (status(1,k)==1)
     if con_time(1,k)<=t
         if ch(1,k)==1
             ncc1=ncc1+1;
             status(1,k)=5;
         elseif ch(1,k)==2
             ncc2=ncc2+1;
             status(1,k)=5;
         elseif ch(1,k)==3
             ncc3=ncc3+1;
             status(1,k)=5;
         elseif ch(1,k)==4
             ncc4=ncc4+1;
             status(1,k)=5;
         end
     end

 %Handover request and execution
%-------------------------------
%Handover to cell (1)
%--------------------
    if deNodeB1(1,k)<(cell_radius-hd)
          if ch(1,k)~=1
              if (ch(1,k)==2)&&(ncc1>0)
                ncc1=ncc1-1;
                ncc2=ncc2+1;
                HO1=HO1+1
                ch(1,k)=1;
              elseif (ch(1,k)==3)&&(ncc1>0)
                ncc1=ncc1-1;
```

```
                  ncc3=ncc3+1;
                  HO1=HO1+1
                  ch(1,k)=1;
                   elseif (ch(1,k)==4)&&(ncc1>0)
                  ncc1=ncc1-1;
                  ncc4=ncc4+1;
                  HO1=HO1+1
                  ch(1,k)=1;
                else
                    HOF1=HOF1+1;
                    status(1,k)=3;
                end
            end

      end


   %Handover to cell (2)
  %---------------------
    if deNodeB2(1,k)<(cell_radius-hd)
            if ch(1,k)~=2
                if (ch(1,k)==1)&&(ncc2>0)
                  ncc2=ncc2-1;
                  ncc1=ncc1+1;
                  HO2=HO2+1
                  ch(1,k)=2;
                elseif (ch(1,k)==3)&&(ncc2>0)
                  ncc2=ncc2-1;
                  ncc3=ncc3+1;
                  HO2=HO2+1
                  ch(1,k)=2;
                   elseif (ch(1,k)==4)&&(ncc2>0)
                  ncc2=ncc2-1;
                  ncc4=ncc4+1;
                  HO2=HO2+1
                  ch(1,k)=2;
                else
                    HOF2=HOF2+1;
                    status(1,k)=3;
                end
            end


%Handover to cell (3)
  %---------------------
    if deNodeB3(1,k)<(cell_radius-hd)
            if ch(1,k)~=3
                if (ch(1,k)==1)&&(ncc3>0)
                  ncc3=ncc3-1;
                  ncc1=ncc1+1;
                  HO3=HO3+1
                  ch(1,k)=3;
                elseif (ch(1,k)==2)&&(ncc3>0)
                  ncc3=ncc3-1;
                  ncc2=ncc2+1;
                  HO3=HO3+1
                  ch(1,k)=3;
                   elseif (ch(1,k)==4)&&(ncc3>0)
                  ncc3=ncc3-1;
                  ncc4=ncc4+1;
```

```
                   HO3=HO3+1
                   ch(1,k)=3;
                 else
                     HOF3=HOF3+1;
                     status(1,k)=3;
                 end
             end
    %Handover to cell (4)
    %---------------------
      if deNodeB4(1,k)<(cell_radius-hd)
             if ch(1,k)~=4
                 if  (ch(1,k)==1)&&(ncc4>0)
                   ncc4=ncc4-1;
                   ncc1=ncc1+1;
                   HO4=HO4+1
                   ch(1,k)=4;
                 elseif  (ch(1,k)==3)&&(ncc4>0)
                   ncc4=ncc4-1;
                   ncc3=ncc3+1;
                   HO4=HO4+1
                   ch(1,k)=4;
                    elseif  (ch(1,k)==2)&&(ncc4>0)
                   ncc4=ncc4-1;
                   ncc2=ncc2+1;
                   HO4=HO4+1
                   ch(1,k)=4;
                 else
                     HOF4=HOF4+1;
                     status(1,k)=3;
                 end
             end









    %  status(1,k)=2;

          end
      end
      end
          end
      end
      end
      end
     figure
     plot(thitadeg)



figure
hold on
plot(deNodeB2,'*b')
hold on
plot(deNodeB3)
```

```
figure
hist(ch)
figure
hist(status)
cf=[cf1 cf2 cf3 cf4]
HO=[HO1 HO2 HO3 HO4]
HOF=[HOF1 HOF2 HOF3 HOF4]
figure
plot(HOF)
figure
plot(HO)
out
```