Sudan University of Science and Technology

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Performance Evaluation of Effective Hotspot Cell Management Using Adaptive Handover Time Scheme

A Research Submitted in Partial fulfillment for the Requirements of the Degree of B.Sc. (Honors) in Electronics Engineering (communications)

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DECLARATION

بسم الله الرحمن الرحيم

قال تعالي:

﴿قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيم﴾

صدق الله العظيم

سورة البقره الاىق ﴿32﴾

DEDICATION

All praises to Allah for the strength and his blessing in completing this research. We dedicate this research to beloved people who have meant and continue to mean so much to us. Our dedication is extended also to our caring mothers; who held our hands in the first day of school, and be always there for us giving all the love, supporting, and care, to our fathers; who always be proud of us and for sacrifices they have made to educate us, and to our friends; who always be there when we needed them.

Thanks to all of you

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Also thankful to **Dr. Mohamed Abdelrazig** and **Eng. Mustafa Malik** for assistance that helped in completion of this research.

ABSTRACT

In 4G system there are many services can be offered to the users, and effective resource management will lead to give them a proper quality of services they require. A hotspot cell is an important problem faced the network providers and prevents the users to have the proper service they demand due to the scarcity of the resources caused by the heavy load in the cell. Research is focusing on hotspot cell problem and finds a way through adaptive handover time scheme to reduce the number of the hotspot cells .Adaptive handover time scheme effectively manage the resources in the cells through borrowing the resources from the coldspot to the hotspot cell considering the status of the both the current serving and target cells. The improvement in the system achieved is shown in the simulation using the Matlab. the results are achieved in parameters that improved the system and enhanced the performance comparing to the conventional scheme , including the resource utilization increased by 192.2%, blocking probability reduced by 24.2%,diminish the delay time by 4.7% and also QoS parameters such as data rate ,throughput raised by 139% ,165% respectively , reduction of packet delay and jitter by 27% ,28% respectively .

المستخلص

في نظام الجيل الرابع هنالك العديد من الخدمات التي يمكن تقديمها للمستخدمين, الاداره الفعالة للموارد المتوفره تقود الي اعطاء هؤلاء المستخدمين الخدمات المطلوبه بجوده مناسبة. الخليه الساخنة هي مشكلة مهمه تواجه مقدمي الشبكة و تمنع المستخدمين من الحصول علي الخدمات المناسبة التي يقومون بطلبها نتيجة للنقص في الموارد الناتج عن الحمل الزائد في الخلية. يركز البحث علي مشكلة الخلية الساخنة وايجاد طريقة لتقليل عدد الخلايا التي لها هذه المشكلة عن طريق خوارزمية تكييف زمن التسليم لتقليل عدد الخلايا الساخنة . خوارزمية تكييف زمن التسليم تدير المصادر بطريقة فعالة فتقوم باستلاف الموارد من الخلية الباردة الي الخلية الساخنة بالأخذ في الاعتبار حالتي كل من الخليتين الحالية والمستهدفة. التحسين المحقق في النظام يظهر في المحاكاة باستخدام الماتلاب. النتائج المحققة في المعاملات التي ادت الي تطوير النظام وتحسينه مقارنة بالطريقة التقليدية, مضمنة في المعاملات كاستغلال الموارد التي زادت بنسبة 192.2%, احتمالية الحظر قلت بنسبة24.4%, تقليل زمن التأخير ب 4.7% , وايضا متطلبات جودة الخدمة متمثلة في معدل البيانات ,الطاقة الانتاجية زادتا بنسبتي 139%,165% علي التوالي, تقليل زمن تاخير الحزمة و زمن الوصول بين الحزم ب 27% و28 % علي التوالي.

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R_t	Total resource in system
N	Number of user on state
B	Adaptive factor (0-1)
N_{hold}	Number of user in hold state
N_{HO}	Number of handoff calls
R_h	Total resource in hotspot
R_{th}	Available resource in coldspot and hotspot cell
R_c	Available resources in cols spot cell
D_T	Total time in current cell
D_t	Handover delay in cell
D_c	Delay time in cell
N	Number of cell
H	Average hold time
C	Channel capacity
R	Resources
R_u	Used Resource

R_{th}	Total resource in hotspot
R_{AH}	Available resources in hotspot
R_{tc}	Total resource in coldspot
R_{hc}	Hold resource in coldspot
R_t	Total resource in the system
D_R	Data rate
B	Bandwidth
M	Modulation factor
C	Coding rate
L	Total size of application data
P	Packet number
L	Number of bits in packet
C	Capacity of the link (bit/second)
H	Header size (bit)
J	Jitter continuously calculates for each packet.
D	Different for the packet and the previous packet (i-1)
M	Borrowing resources

LIST OF ABBREVIATION

1G	First generation
2G	Second generations
3G	Third generations
3GPP	Third Generation Partnership Project
4G	Fourth generations
ACS	Adaptive sizing scheme
A-GPS	Assisted GPS
AMC	Adaptive modulation and coding
BPSK	Binary phase shift keying
BS	Base station
CA	Carrier aggregation
CQI	Channel quality indicator
CSI	Channel state information
DeNB	Donor eNB
Ds-CDMA	Direct Sequence Code Division Multiple Access
ECICs	Enhanced inter cell interference coordination
E-CID	Enhanced cell ID

eNB	Evolved Node B
FDD	Frequency division duplex
FDM	Frequency division multiplexing
FDMA	Frequency division multiple access
GoS	Grade of service
GPS	Global positioning system
HetNet	Heterogeneous network
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet protocol
ISI	Intersymbol interference
ITU	International telecommunication union
ITU-IMT	ITU-International mobile telecommunication system
LTE	Long term evolution
MAHO	Mobile assisted handover
MBMS	Multimode broadcast multicast services
MIMO	Multi-input multi-output
MS	Mobile station
MSC	Mobile Switching Centre
MT	Mobile terminal
OFDM	Orthogonal frequency division multiplexing
OFDMA	Orthogonal frequency multiple access
OTDOA	Observed time difference of arrival
PARR	Peak average power ratio
QoS	Quality of services
QPSK	Quadrature Phase Shift Keying

RN	Relay node
RSS	Received signal strength
SC-FDMA	Single carrier FDMA
SINR	Signal to interference plus noise ratio
SNDR	Signal to noise plus distortion ratio
SNR	Signal to noise ratio
SS	Source station
TDD	Time division duplex
TDMA	Time division multiple access
TS	Target station
UE	User equipment
UL	Uplink
QAM	Quadrature amplitude modulation

CHAPTER ONE

INTRODUCTION

1.1. Preface

Everyday there is a growth on the communication systems due to the increasing in the number of users ,and the vendors faced a lot of problems when they want to give the users the best services, one of this problems is the hotspot cell which have heavy load than the adjacent cells , the research solve this problem by trying to perfect utilize the resources of the system .

Resource reservation mechanism should maximize the number of users in cell which in turn minimize the call blocking and call dropping probability, resource reservation is more challenging than in wired network due to the scarcity of bandwidth in wireless links so it's the most important component of resource management process in wireless networks. In mobile network, network resources are shared among multiple services. Resources which are the time and frequency are the fundamental physical and network layer quantities that limit the amount of data that can be transmitted over a communication link [1].

Two important quality of service parameters in wireless networks include; handoff call dropping probability and new call blocking probability. In the handoff call dropping probability the essential bandwidth of this call should be allocated in the new cell to avoid call dropping and to provide quality of service guarantee, whereas the new call blocking probability denotes the probability that an ongoing call is forced to terminate during the handoff process caused by lack of available bandwidth in the new cell [2].

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1.2. Problem Statement

The lack in resources due to hotspot cells problem caused dropped, block call, degradation of service quality, also forced termination and waste of bandwidth in handover process.

1.3. Proposed Solution

Management of hotspot cells problem by using Adaptive handover time algorithm will adaptively control the handoff initiation time according to load status of cells, operation is done by utilizing the resource in both serving and targeted cell it will ensure the handoff process happens fast and smoothly this will reduce the grade of service (GOS) and enabling the network to use its entire resource channel effectively.

1.4. Aim and Objectives

The main aim of this project is to enhance the performance of the system by using adaptive handover time scheme, which increase the amount of resources in hotspot cell.

The objectives of this project are:

- To develop a mathematical model for performance metrics.
- To simulate the performance metrics using Matlab.
- To evaluate the performance of the system considering :

❖ Resource utilization
❖ Data rate
❖ Throughput
❖ Packet delay
❖ Jitter
❖ Delay time
❖ Blocking probability

1.5. Methodology

Studying the basic idea of the adaptive handover time algorithm and Completing the mathematical models that covers and reflect the improvements happened to the system After adding the adaptive handover time algorithm, also compare it with conventional schemes support with figures using Matlab .

1.6. Thesis Outlines

Chapter One:

It's an introduction of the research and it covers the Problem Statement, Proposed Solution and Aim and Objectives.

Chapter Two:

It is a literature review and it gives a Background of the LTE, LTE Advanced, OFDM and general background involved in the research, also discussed the related works in the last decade.

Chapter Three:

Discussed the basic idea of the methodology, represent the procedures of the adaptive handover time algorithm, and considering the mathematical models which represents the performance of the system.

Chapter Four:

Covers the results obtained and discussion of the results.

Chapter Five:

Consist of brief conclusion of the research and the recommendations for the future researches.

CHAPTER TWO

LITREURE REVIEW

2.1. Background

Mobile Communication technologies are often divided into generations ,with 1G being the analog mobile radio system ,2G the first digital mobile systems, and 3G the first mobile systems handling broadband data. The long term evolution LTE is often called 4G [3].

This continuing race of increasing sequence numbers of mobile system generations is in fact just a matter of labels .what important is the actual system capabilities and how they have evolved [3].

2.1.1. General Features of LTE

LTE represents a radical new step forward for the wireless industry, targeting order-of-magnitude increases in bit rates with respect to its predecessors by means of wider bandwidths and improved spectral efficiency. Beyond the improvement in bit rates, LTE aims to provide a highly efficient, low-latency, packet-optimized radio access technology offering enhanced spectrum flexibility [4].

The LTE design presents radical differences at every layer. Like many other communication technologies the physical layer uses OFDM waveforms in order to avoid the inter symbol interference that typically arises in high bandwidth systems. One differentiating aspect of the LTE standard is MIMO [4].

2.1.1.1. Intersymbol Interference ISI

ISI stand for Intersymbol Interference is an interference usually generated when transmitting in a multipath fading channel. In this kind of channel, multiple copies of transmitted signal is received at different time intervals, Which causes interference, In a multipath fading channel, the received signal can be delayed copy of the original signal coming through receive antenna, creates interference thus changing of amplitude and phase [5].

2.1.1.2. OFDM

OFDM stand for Orthogonal Frequency Division Multiplexing is considered as one of the most compromising wireless technique for future generation cellular systems. A special case of multicarrier transmission [6].

Large numbers of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data stream or channels shown in Figure (2.1) [6].

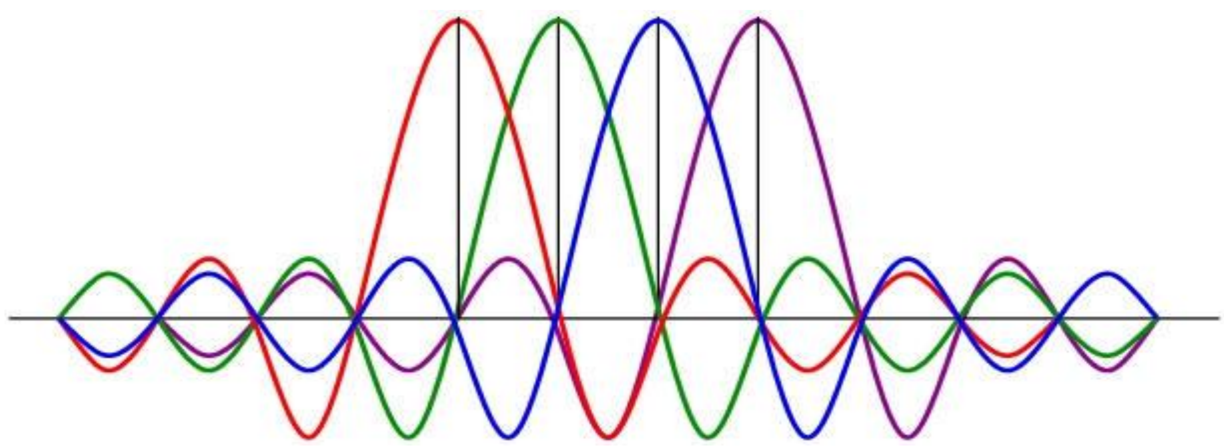


Figure 2.1: Orthogonal Sub-Carriers in OFDM

Multiplexing deals with allocation/accommodation of users in given bandwidth which deals with allocation of available resource. In FDM need guard band between adjacent frequency bands so extra overhead and lower throughput. OFDM support multiple users via TDMA basis. Shown in Figure (2.2) [6].

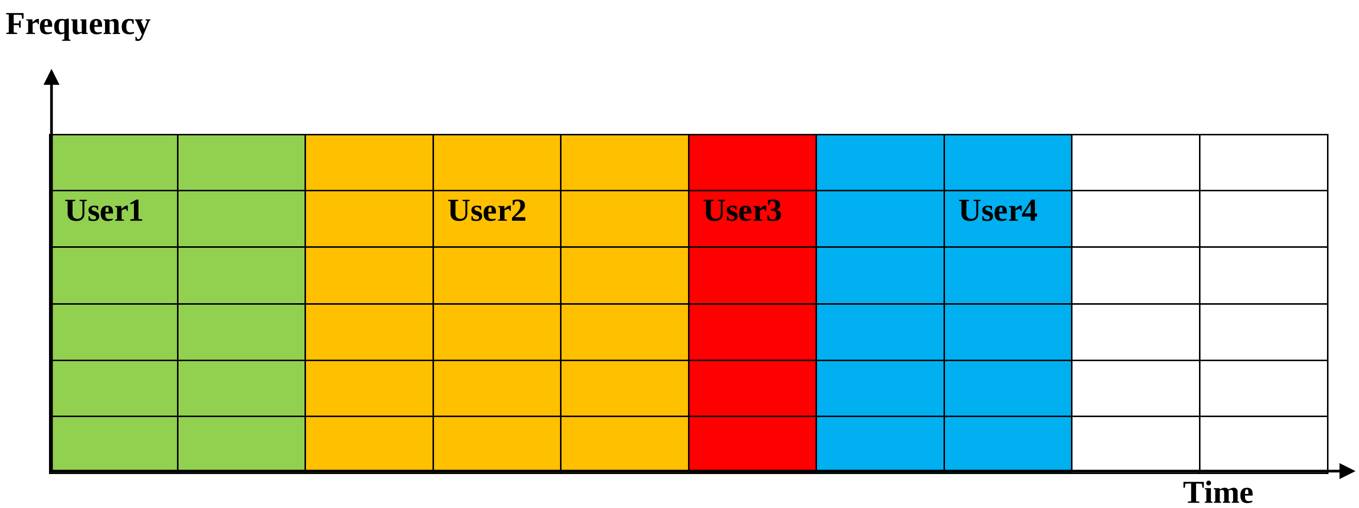


Figure 2.2: OFDM Resources Allocation

OFDM is combination of modulation and multiplexing. Normal modulation is single carrier modulation techniques in which the incoming information is modulated over single carrier [6].

Also is a multicarrier modulation technique which employs several carriers within the allocated bandwidth to convey the information from source to destination. Each carrier may employ one of the several available digital modulation techniques (BPSK) [6].

OFDM is robust against frequency selective fading and narrowband interference; different frequency components of the signal experience different fading [6].

It is very difficult to handle frequency selective fading in the receiver in which case the design of the receiver is hugely complex. Instead of trying to mitigate frequency selective fading as whole (which occurs when huge bandwidth is allocated for the data transmission over frequency selective fading channel). OFDM mitigates the problem by converting the entire frequency selective fading channels [6].

OFDMA support either on TDMA or FDMA basis or both at the same time. Also supports simultaneous low data rate transmission from several users[6].

Further improvement to OFDMA over OFDM robustness to fading and interference since it can assign subset of subcarrier per user by avoiding assigning bad channel or sub-carrier power shown in Figure(2.3)[6].

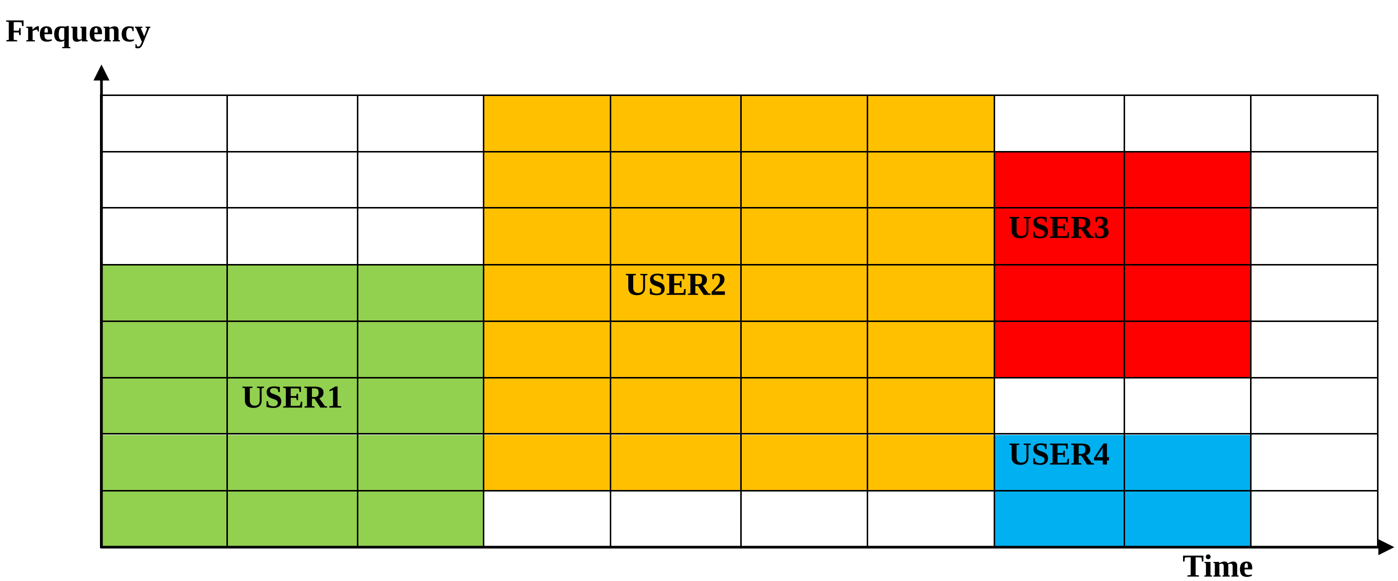


Figure 2.3 Resources Allocation in OFDMA

2.1.1.3. Single Carrier FDMA

In cellular applications, a big advantage of OFDMA is its robustness in the presence of multipath signal propagation. The immunity to multipath derives from the fact that an OFDMA system transmits information on M orthogonal frequency carriers, each operating at M times the bit rate of the information signal. On the other hand, the OFDMA waveform exhibits very pronounced envelope fluctuations resulting in a high peak-to-average power ratio (PAPR). Signals with a high PAPR require highly linear power amplifiers to avoid excessive inter modulation distortion. To achieve this linearity, the amplifiers have to operate with a large back off from their peak power. The result is low power efficiency (measured by the ratio of transmitted power to dc power dissipated).which places a significant burden on portable wireless terminals. Another problem with OFDMA in cellular uplink transmissions derives from the inevitable offset in frequency references among the different terminals that transmit simultaneously. Frequency offset destroys the orthogonality of the transmissions, thus introducing multiple access interference. To overcome these disadvantages, 3GPP is investigating a modified form of OFDMA for uplink transmissions in the “long-term evolution (LTE)” of cellular systems. The modified version of OFDMA, referred to as single carrier FDMA (SC-FDMA).As in OFDMA, the transmitters in an SC-FDMA system use different orthogonal frequencies (subcarriers) to transmit information symbols. However, they transmit the subcarriers sequentially, rather than in parallel. Relative to OFDMA, this arrangement reduces considerably the envelope fluctuations in the transmitted waveform. Therefore, SC-FDMA signals have inherently lower PAPR than OFDMA signals. However, in cellular systems with severe multipath propagation [7].

2.1.1.4. Multi Input Multi Output (MIMO)

MIMO is used to increase the overall bit rate through transmission of two (or more) different data streams on two (or more) different antennas - using the same resources in both frequency and time, separated only through use of different reference signals - to be received by two or more antennas Shown in Figure (2.4) [8].

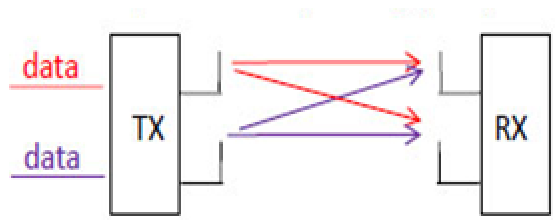


Figure 2.4 Spatial Multiplexing (MIMO) Using 2x2 Antennas

2.1.2. Releases of LTE

2.1.2.1. Release 8 - LTE Introduced

The work on LTE was initiated in late 2004 with the overall aim of providing a new radio access technology focusing on packet switched data only .the first phase of the 3GPP (The 3rd Generation Partnership Project) work on LTE was to define a set of performance and capability targets for LTE. This included targets on peak data rate, user/system throughput, spectral efficiency and control/user latency plane [9].

Once the targets were set, 3GPP studies on the feasibility of different technical solution considered for LTE were followed by development of the detailed specification .the first release of LTE specification, release 8, was completed in the spring of 2008 and commercial network operation began in late 2009 [9].

Release 8 when LTE was introduced for the very first time. All the releases following only enhanced the technology. The following is the main achievements [10]:

- High peak data rates: Up to 300 Mbps in downlink and 75 Mbps in uplink when using 4x4 MIMO and 20 MHz bandwidth [10].
- High spectral efficiency [10].
- Flexible bandwidths: 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz [10].
- Short round trip time: 5 ms latency for IP packets in ideal radio conditions
- Simplified Architecture [10].
- OFDMA in downlink and SC-FDMA (single carrier FDMA) in uplink [10].
- MIMO multiple antenna scheme [10].
- Operation in paired (FDD) and unpaired spectrum (TDD) [10].

2.1.2.2. Release 9 - Enhancement to LTE

The initial enhancements were included to LTE in release 9. These were in fact the improvements which were left behind from release 8 or perhaps provided some minor improvements. These improvements are listed below with brief description [10].

- **Femto Cell:** Femto cell is basically a small cell used in offices or homes and connected to providers' networks through landline broadband connection. 3G Femto cells are deployed around world and in order for LTE users to take advantage of femto cell [10].
- **MIMO Beam forming:** Beam forming is used to increase cell edge throughput by directing beam towards specific UE (user equipment) by position estimation at eNB (evolved node B refer to base station) . In release 8, LTE supported single layer beam forming based on user-specific Reference Symbols. In release 9, single layer beam forming has been extended to multilayer beam forming [10].
- **MBMS:** With Multimedia broadcast Multicast Services (MBMS), operators have capability to broadcast services over LTE network. The idea is not novel to the LTE and has been used in legacy networks as well but for LTE, the MBMS channel has evolved from data rate and capacity perspective. The MBMS was already defined at physical layer in release8 but with release 9, higher layer and network layer aspects were completed [10].
- **LTE Positioning:** Three position methods are specified in LTE release 9 i.e. Assisted GPS (A-GPS), Observed Time difference of arrival (OTDOA) and Enhanced Cell ID (E-CID). The goal is to improve the accuracy of user

locations in case of emergency scenarios where the user itself is unable to disclose his whereabouts [10].

2.1.2.3. Release 10 - LTE Advanced

The LTE-Advanced specifications in release 10 includes significant features and improvements to fulfill ITU IMT-Advanced requirements which sets higher speeds than what UE can achieve from 3GPP release 8 specifications. Some key requirements lay down by IMT-Advanced are as below [10]:

- 1 Gbps DL / 500 Mbps UL throughputs.

- High spectral efficiency.

- Worldwide roaming

Following are some significant improvements in release 10:

- **Enhanced Uplink multiple access:** Release 10 introduces clustered SC-FDMA in uplink. Release 8 SC-FDMA only allowed carriers along contiguous block of spectrum but LTE-Advanced in release 10 allows frequency-selective scheduling in uplink [10].
- **MIMO enhancements:** LTE-Advanced allows up to 8x8 MIMO in downlink and on the UE side it allows 4X4 in uplink direction [9].
- **Relay Nodes:** In order to decrease coverage loop holes, Relay nodes are one of the features proposed in release 10. The relay nodes or low power enbs extending the coverage of main eNB in low coverage environment. The relay nodes are connected to Donor eNB (DeNB) through Un interface [10].

- **Enhanced inter-cell interference coordination (eICIC):** eICIC introduced in 3GPP release 10 to deal with interference issues in Heterogeneous Networks (HetNet). eICIC mitigates interference on traffic and control channels. eICIC uses power, frequency and also time domain to mitigate intra-frequency interference in heterogeneous networks [10].
- **Support for Heterogeneous Networks:** The combination of large macro cells with small cells results in heterogeneous networks. Release 10 intended to layout the detail specification for heterogeneous networks [10].
- **Carrier Aggregation (CA)**: To achieve these very high data rates it is necessary to increase the transmission bandwidths over those that can be supported by a single carrier or channel. The method being proposed is termed carrier aggregation, it is possible to utilize more than one carrier and in this way increase the overall transmission bandwidth [10]. (Shown in Figure 2.5).

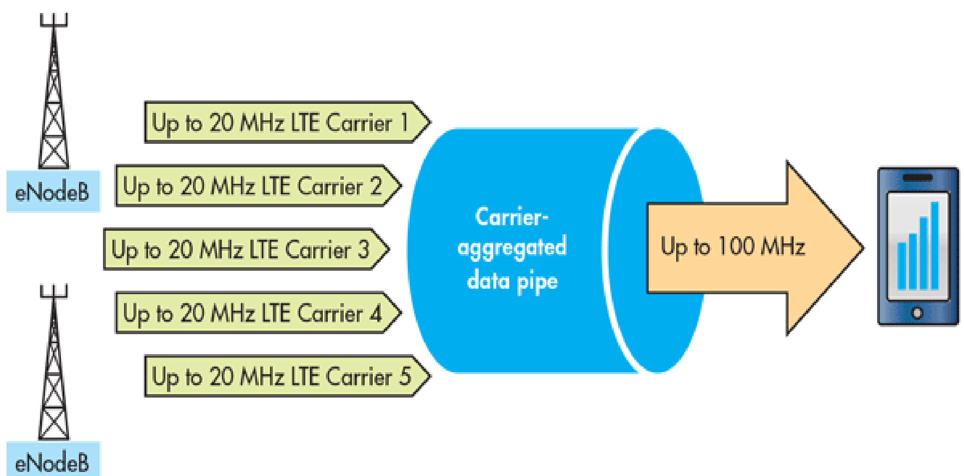


Figure 2.5: Carrier Aggregation

These channels or carriers may be in contiguous elements of the spectrum, or they may be in different bands which illustrate in Figure (2.6) [10].

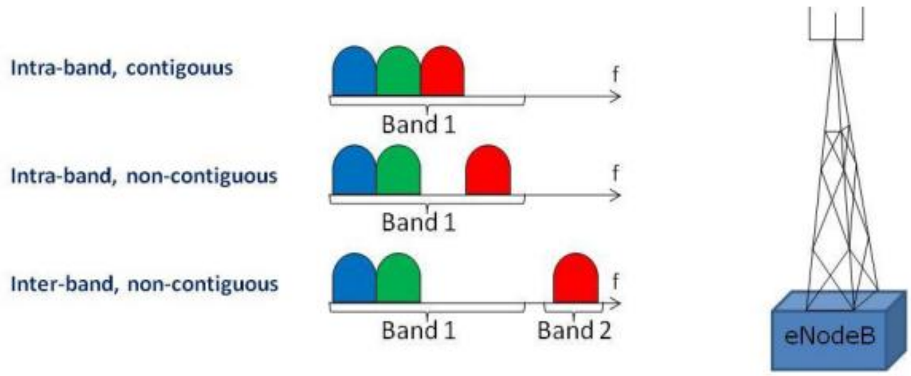


Figure 2.6: Carrier Aggregation; Intra-band and Inter-band Aggregation Alternatives

2.1.3. Overview of LTE-Advanced

The main new functionalities introduced in LTE-Advanced are Carrier Aggregation (CA), (enhanced use of multi-antenna techniques MIMO and support for Relay Nodes (RN) [11].

. LTE-Advanced was required to deliver a peak data rate of 1000 Mbps in the downlink, and 500 Mbps in the uplink. In practice, the system has been designed so that it can eventually deliver peak data rates of 3000 and 1500 Mbps respectively, using a total bandwidth of 100MHz that is made from five separate components of 20MHz each, Higher spectral efficiency, from a maximum of 16bps/Hz in Release 8 to 30 bps/Hz in Release 10 And Increased number of simultaneously active subscribers [4].

2.1.4. Handover Mechanism

Handover or handoff refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another channel. Handoffs are broadly classified into two categories—hard and soft handoffs, the hard handoff can be further divided into two different types intra- and inter cell handoffs. The soft handoff can also be divided into two different types' multi way soft handoffs and softer handoffs [12].

Hard handoff means break before make that is the connection to the source is broken before or 'as' the connection to the target is made. In a hard handoff, the link to the prior BS is terminated before or as the user is transferred to the new cell's BS. That is why hard handoff is also known as break before make [12].

Soft handoff is a "Make before break" handoff. That is, the mobile station (MS) is up on a call and moves from one base station (BS) to another, but the MS starts communicating with a new BS before terminating communications with the old BS [12].

2.1.4.1. MAHO

Mobile Assisted Handoff (MAHO) in this method, the handover is more decentralized. Both the mobile station & the base station supervise the quality of the link. The network asks the MS to measure the signal from the surrounding BSs. But the network makes the handoff decision based on report from the MS [12].

2.2. Related Works

J. jobin , M. faloutsos , S. K. Tripathi and S. V. Krishnamurthy (2004) study and qualify the effective of hotspot in wireless cellular networks and identify some cases for the formation of hotspot and based on them categories hotspot into three different time first capacity base ,second delay based and third preferential mobility based ,also show different effect these types on network performance and develop fluid flow model and analytical model to study hotspot .

Young-ha Hwang and sung-keenoh,woo-jinseok and sang-ha kim(2008)proposed an effective resource management scheme using vertical handoff and fairness concept to prevent hotspot cell and satisfy the various quality of service requirement in 4G wireless network

F. Richard Yu (2008) Proposed a Future wireless networks designed to support adaptive multimedia by controlling individual ongoing flows to increase or decrease their bandwidth in response to change in traffic load .there is growing interest in quality of service (QoS) provisioning under this adaptive multimedia framework., in which a bandwidth adaptation algorithm needs to be used in conjunction with the call admission control algorithm.

Later HalehShahzad Hassan Taheri (2012) proposed resource management approach that integrates a 2-tier structure to future estimation with purpose of avoiding forced termination. This hotspot cell management scheme using adaptive handover time in 4G mobile network was earlier proposed by Dongwookkim ,seunghaklee,hanjin lee and hyunsooyoon(2005).

S. Das,S. sen,RJayaram proposed a dynamic load balancing scheme for the channel assignment problem in cellular mobile, start with a fixed assignment scheme where each cell is initially allocated a set of channels, each to be assigned on demand to a user in the cell.

It is a balancing scheme proposes to mitigate unused channels from unloaded cells to an overloaded one through borrowing a fixed number of channels from cold cells to hot one according to borrowing algorithm.

H.Jeon, S. Hwang and S.kwon proposed a channel assignment scheme in DS-CDMA cellular system which overcomes the handoff interruptions of delay sensitive services by increasing the probability that soft handoff occurs in handoff for them also the priority of using the frequency channels served by all cells is given to delay sensitive services over delay in sensitive ones.

S. Das, S. Senp.Agrawal and R. jayaramproposed a fixed channel assignment scheme for where every cell is initially allocated a set of local channels; each assigned on demand and migrate unused channels from suitable cold cells to the hot ones through a distributed channel borrowing algorithm.

CHAPTER THREE

ADAPTIVE HANDOVER

TIME SCHEME

3.1. Investigation

After investigation and research to solve hotspot cell problem (The hotspot cell problem degrades the service quality which leads to dropping of handover calls or blocking of new calls) Found that Many algorithm been proposed to solve the hotspot cell problem and can be classified by resource allocation scheme which allocate additional resources to the hotspot by borrowing them from neighboring cells by resource management system which controls overall resources, and distribution scheme which is an algorithm that controls the transmitting power to distribute traffic load of hotspot cell [2].

Choosing the adaptive handover algorithm to be under studying because it's not prevent the hotspot cell than the others ,and try to decrease the number of hotspot cells and utilize the resource effectively in the system.

3.2. Adaptive Handover Time Algorithm

The proposed scheme used hard handover mechanism with a network which adopts orthogonal frequency division multiplexing (OFDM) and mobile assisted handover MAHO (mobile phone assisted the cellular base station to transfer a mobile phone to a anew radio channel with stronger signal strength) [17].

Adaptive handoff algorithm is assumes that the cells is connected through the backbone network without any restrains of the structure .also expected not to impose high system complexity because it only adopt hard handover parameters ,hysteresis and absolute threshold without changing the mechanism itself [17].

It control the handover time within the means of two algorithms:

- Slow handover is applied when handover to hotspot cell happens .it delays the handover to hotspot until the target cell obtain available resources [17].
- Fast handover is applied when a handover from a hotspot cell happens. It forces handoff to the nearest target cell to recover its original status and to maintain resources [17].

In adaptive cell sizing scheme (ACS), which is a representative algorithm which base station adjust transmitting power of only those mobiles which are to be handed over to the nearest neighboring cells, hotspot shrink their service area in order to accommodate load they can adequately handle, at this time lightly loaded neighboring cells increase their service areas to pick up the extra traffic which lead to use remained resources in the cells [2].

3.3. The Procedures of Adaptive Handover Time Scheme

In this proposed algorithm we set the threshold value based on traffic load (Traffic load is the rate of channel occupancy in the cell) of cells.

As (shown in Figure3.1); when the current serving cell BS1 receive the report from a mobile which includes signal strength weaker than a specific threshold, Bs1 request the load information of the target cell BS2through the backbone network [2].

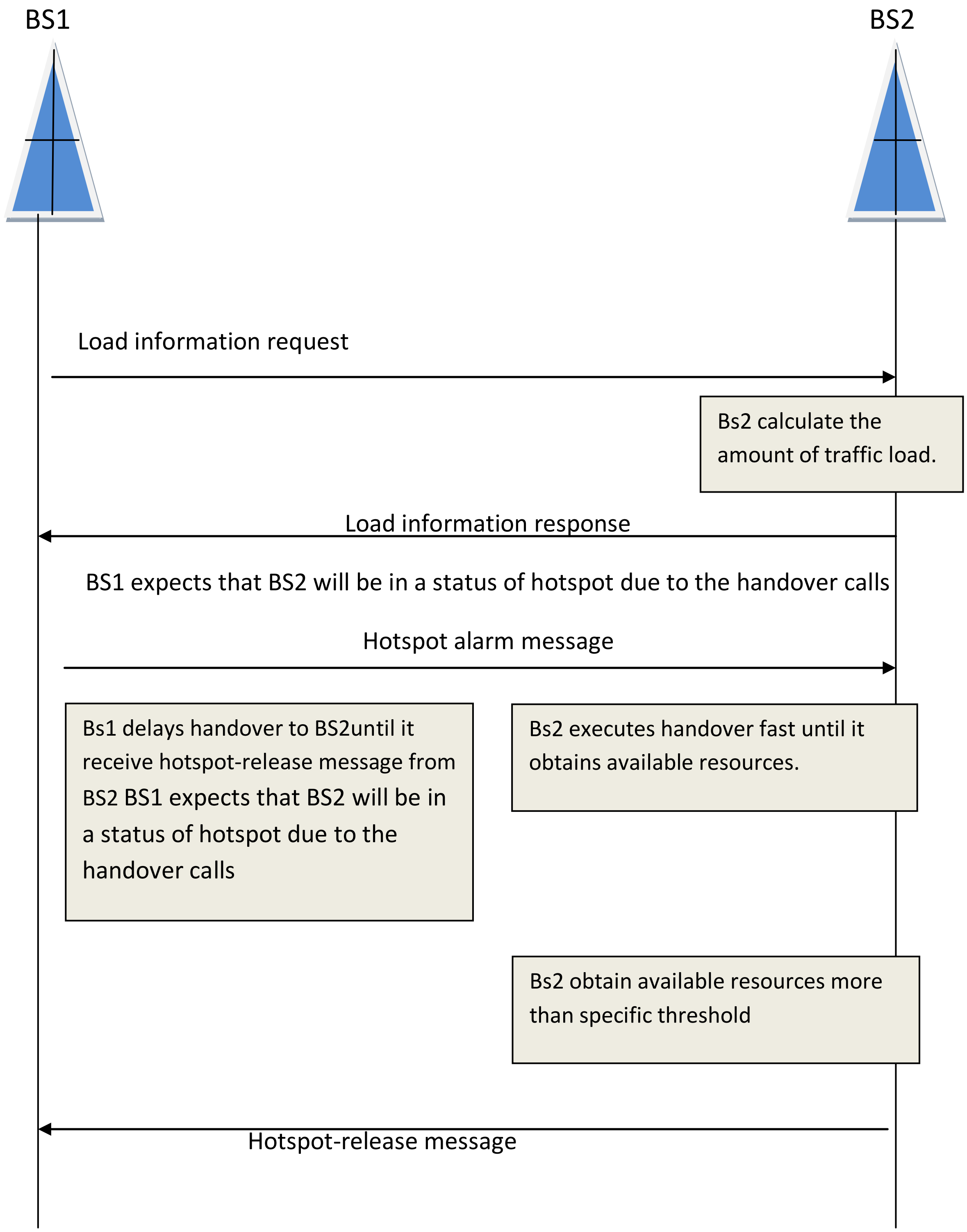


Figure 3.1: Procedures of Adaptive Handover Time Scheme

If cell BS1 determines that the target cell BS2 will become in a status of hotspot due to the increased load caused by the handover calls, It will send a hotspot alarm message and it delays all handover to BS2 [2].

Through this message BS2 realize that its status will become hotspot soon due to additional load caused by handover calls so it will execute all possible handover earlier than schedule in the conventional handover scheme in order to reduce its load .with this fast handover execution BS2 can make resources available and prepare for handover calls which may occur in near future [2].

If BS2 get out of hotspot status with fast handover execution and obtain sufficient amount of resources it send hotspot-release message to BS1 [2].

If both the target and serving cell are on hotspot status this algorithm turns to conventional handover system [2].

3.4. Terms Used In the Algorithm

The threshold value of the received signal strength RSS to initiate the handover process called Thres-serving. Therefore, when the RSS of SS (source station) drops below thres-serving, the Mobile Switching Centre (MSC) registration procedures are initiated for mobile terminal (MT's) handover to target station TS [18]

The minimum value of RSS required for successful communication between an MT and target station TS called Thres-min, the threshold value of RSS from target station for handoff execution is Thres-target [18].

To maintain the quality of service and to make the effective usage of resources, distribution of traffic is needed. The two Active modes are the HOLD and ON state between user and base station. The HOLD state has full downlink and thin uplink channel and ON state has both full downlink and uplink traffic channel. The load added by the handoff calls is defined as handoff. The handoff call is assume to be in the ON state soon after the handoff process is over. The traffic load can be estimated by calculating the number of users in the three modes, Hold, on and Handoff [18].

The value of traffic load is approximated to 0 when the current cell is regarded as the lightly loaded cell and as the number of mobile nodes increase, the traffic load is taken as 1, the current Cell becomes a hotspot. The hd value used in the algorithm is called hotspot threshold. If the ratio of number of available resources by number of total resources is less than hd, then that cell have hotspot status. Figure.3.2 shows the Adaptive RSS algorithm, when the RSS of the serving cell is less than threshold value, it sends the load information request message to the target cell and receive load information response message from the cell. The target cell calculates the amount of traffic load. If the amount of available resources of the target cell is less than the hotspot threshold, hd, the current serving cell sends hotspot alarm message to the target cell .Then, target cell completes all the pending handover request & send hotspot release message to serving station. Now, handover is executed to target station (TS) [18].

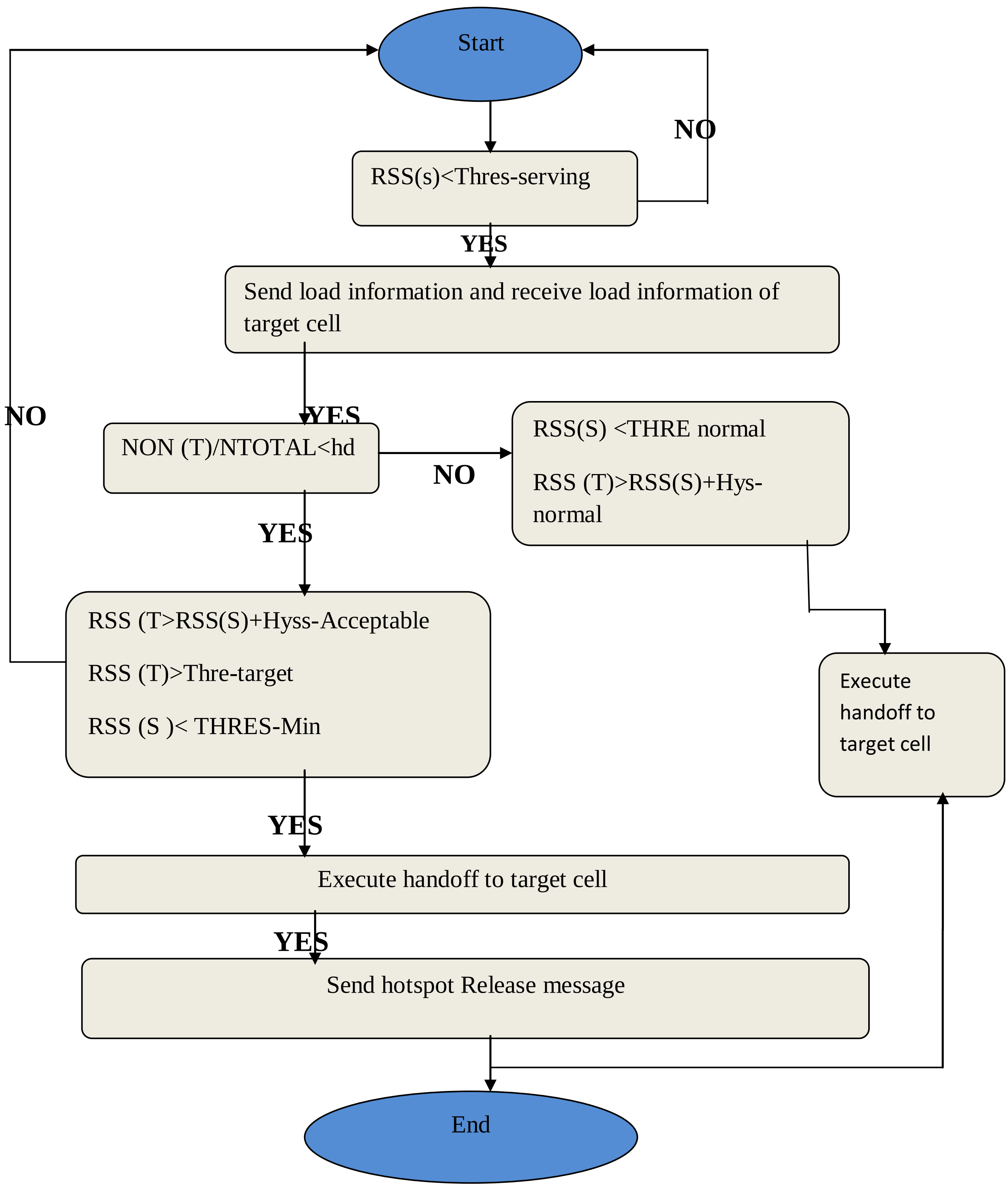


Figure 3.2: The Process of the Adaptive Handover Algorithm

In this proposed algorithm, the proper threshold value should be carefully selected in order not to degrade the service quality of other users. The previous work used fixed RSS to initiate the handoff process. An adaptive RSS threshold is recommended to use so that the mobile has enough time to initiate the handoff process. The algorithm has been modified by applying a mathematical formulation for controlling the handoff time and called as an adaptive RSS threshold (Thres-min) [18].

3.5. Adaptive Modulation and Coding AMC

In cellular communication system the quality of a signal received by a user equipment UE depends on number of factors –the distance between the desired and interfering base stations, path loss exponent, shadowing, short term Rayleigh fading and noise [19].

In order to improve the system capacity, peak data rate and coverage reliability these systems are able to adapt and adjust the transmission parameters based on link quality, the signal transmitted to any particular user is modified to account for the signal quality variation through a process commonly referred method for link adaptation or AMC [19].

AMC raise the overall system capacity in which provides the flexibility to match the modulation coding scheme to the average channel conditions or received signal quality for each user [19].

The implementation of AMC offers several challenges, first AMC is sensitive to measurement and delay in order to select the appropriate modulation, the schedule must aware of the channel quality. Also delay in reporting channel measurement also reduces the reliability of channel quality estimate [19].

The basic idea of link adaptation is to adapt the link efficiently in the actual channel conditions by varying certain transmission parameters. Transmission power, symbol rate, constellation size and coding scheme can be dynamically adapted in response to the time –varying channel. With selection of these transmission parameters, the system makes the most out of a time varying channel, instead of fixing the parameters for worst-case channel. The tradeoff involves minimizing the error probability for robustness and maximizing the instantaneous throughput for bandwidth efficiency [19].

Adaptive modulation and coding (AMC) is one of the adaptive techniques to counteract fading and enhance the performance of wireless system. It selects an optimal combination of modulation and coding scheme (MCS) to maximize bandwidth efficiency. The decision is based on the channel state information (CSI) each MCS is associated with a coding rate and constellation size, which has given bit rate. A quality of service (QoS) constraint on delivery delay is usually imposed [19].

Communication channel quality can have a significant impact on the performance of wireless communication system. Channel with high quality can transfer data at higher rate and lower latency than channel with low quality. Channel quality should therefore be factor that needs to be considered when scheduling message transmissions in communication system [19].

Channel quality indicator (CQI) can be value representing measure of channel quality for given channel .Typically, high value CQI is indicative of channel with high quality and vice versa. CQI for channel can be computed by making use of performance metric, such as signal-to-noise ratio (SNR), signal-to-interference plus noise ratio (SINR), signal-to-noise plus distortion ratio (SNDR), these value can be measured for given channel and then used to compute CQI for the channel. The CQI for given channel can be dependent upon the transmission (modulation) scheme used by the communication system shown in Table 3.1. Other factors that may be taken into account in CQI are performance impairments, such as Doppler shift, channel estimation error, interference [19].

One commonly used technique to compute CQI is to determine a value of metric channel and then use the value to compute the CQI. The CQI for channel can then be used variety of operations involving the channel, such as scheduling transmissions on the channel. In communications system that has plurality of channels, a single CQI can be used for multiple channels as long as they are sufficiently close in frequency to each other. By using single CQI it is not necessary to compute CQI for each channel and hence computation and processing time can be saved [19].

Table 3.1: The Relations between Modulation, Code Rate and Signal to Noise Ratio.

Modulation	**Code rate**	**SNR**
BPSK	½	6.4 - 9.3
QPSK	¾	9.4 -11.1
	¾	11.2 - 16.3
16-QAM	½	16.4 - 18.1
	¾	18.2 - 22.6
64-QAM	2/3	22.7 – 24.3
	¾	>=24.4

3.6. Mathematical Model of Performance Metrics

- **Blocking Probability**

Blocking probability is the fraction of time a trunk request is denied because all channels are busy; it depends on the amount of available resource in the cell. Lack and inefficiency utilize of resources in conventional scheme will raise the blocking probability shown in equation (3.1a). The adaptive handover time scheme raises the amount of the resources which will lead to decrease the blocking probability equation (3.1b).

$$R_t = N + BN_{HOLD} + N_{HO} \tag{3.1}$$

R_t: total resource in system

N: number of user on state

B: adaptive factor (0-1)

N_{hold}: number of user in hold state

N_{HO}: number of handoff calls

With Conventional scheme

$$P_r = \frac{R_t - R_h}{R_t} \qquad (3.1a)$$

R_t: total resource in system

R_h: total resource in hotspot

With Adaptive handover time

$$P_r = \frac{(R_t - R_{th})}{R_t} \qquad (3.1b)$$

$R_{th}=R_h+R_c$

R_h: total resource in hotspot

R_{th}: available resources in hotspot and coldspot cell.

R_{C} : available resource in the coldspot cell

- **Delay Time**

It is the time interval between two events. The delay time in conventional scheme will be larger because the number of cells that will be handed over is equal at least the period time delayed in it's hotspot cell , or equal the period time delayed in it's hotspot cell plus the delay time of all neighboring hotspot cell which is handover to it shown in equation (3.2a).

In adaptive handover time scheme the delay time is just equal to the delay time of a hotspot cell shown in equation (3.2c).

With Conventional scheme

$$D_T = D_C + D_t \times N \tag{3.2a}$$

D_T : total time in current cell

D_t: handover delay in cell

D_c: delay time in cell

N: number of cell

$$Dc = \frac{H}{C - R} \tag{3.2b}$$

H: average hold time

C: channel capacity

R: resources

With Adaptive handover time scheme

$$D_T = D_c \tag{3.2c}$$

- **Resource Utilization**

Resource is the time and frequency that shared among users , because of the heavily loaded cell there is lack in resources in hotspot cell, where there is resources in the coldspot remains unused which mean inefficient resource utilization shown in equation (3.3a), in the adaptive handover time scheme the resource in coldspot is borrowed to the hotspot cell so then the utilization of resources is improved , shown in equation (3.3c) .

With Conventional scheme

$$R_u = \frac{R_{AH}}{R_t} \tag{3.3a}$$

With Adaptive handover time scheme

$$R_{th} = R_{AH} + (R_{tc} - R_{hc}) \tag{3.3b}$$

$$R_u = \frac{R_{th}}{R_t} \quad (3.3c)$$

R_u: used Resource

R_{th}: total resource in hotspot

R_{AH}: available resources in hotspot

R_{tc}: total resource in coldspot

R_{hc}: hold resource in coldspot

R_t: total resource in the system.

- **Quality of Service (QoS)**

❖ **Data Rate**

It is the speed within which data can be transmitted from one device to another. Or it is the amount of data which transmitted in one second. Adaptive handover time scheme increase the amount of resources in a hotspot cell by borrowing it from neighboring cell which increase the bandwidth so the data rate will increase for every users shown in equation (3.4.b), using the conventional scheme the bandwidth will decrease due to the inefficiency use of resources shown in equation (3.4.a).

With conventional scheme

$$D_R = B \times M \times C \quad (3.4)$$

$$= B \times (\log_2 N) \times C \qquad (3.4.a)$$

D_R: data rate

B: bandwidth

M: modulation factor

C: coding rate

With adaptive handover time scheme

$$= B \times (\log_2 N) \times C \qquad (3.4.b)$$

B here is increase due to the borrowing resources

- **Packet Delay**

It is the time taken for a packet to be transmitted across a network from source to destination. Packet delay it has inverse proportional to resources, in conventional scheme shown in equation (3.5a). in adaptive handover time the resources are increased illustrated in figure (3.5b)

With Conventional scheme

$$T = n\frac{(H + L(P))}{C} \qquad (3.5.a)$$

L: total size of application data

P: packet number

L: number of bits in packet

C: capacity of the link (bit/second)

H= header size (bit)

With Adaptive handover time scheme

$$T = n\frac{(H + L(P))}{C} \tag{3.5b}$$

C here is increased due to borrowing resources.

- **Jitter**

Jitter is a variation in packet transit delay caused by queuing, contention and serialization effects on the path through the network. Equation (3.6a) illustrate the jitter in the conventional scheme, by increasing the (m) resources in equation (3.6d) provided by the adaptive handover time scheme, the delay will decrease according to the equation (3.6c) .

With Conventional scheme

$$J = j + (|D(i-1, i)| - J) \tag{3.6a}$$

J: is the continuously calculate for each packets.

D: different for the packet and the previous packet (i-1)

Where

$$D = n \frac{H + L(P)}{C} \tag{3.6b}$$

With Adaptive handover time

$$J = j + \left(\left| D_{(i-1, i)} \right| - J \right) \tag{3.6c}$$

$$D = n \frac{H + L(P)}{C + m} \tag{3.6d}$$

Where

m: borrowing resources.

CHAPTER FOUR

RESULTS AND DISSCUSION

4.1. Simulation Parameters

The parameters used in the simulation using Matlab is shown in Table 4.1.

Table 4.1: Parameters Used in the Simulation:

Parameter	Assumed Value
Bandwidth	20 MHZ
Number of cells	3
Number of users	200
Number of channels	100
Delay	0.02

4.2. Results

After finishing the mathematical model, and using Matlab to simulate the development on performance metrics by taking average value of ten samples from ten seconds to calculate the improvement happens in the resource utilization, blocking probability, delay time, throughput and quality of services (data rate, packet delay and jitter).

4.2.1. Resource Utilization

The percentage of resource utilization in adaptive handover time scheme to the conventional scheme shown in Figure (4.1), where blue line indicate the adaptive handover time and the red dashed line illustrate the conventional scheme, taking the average value is increased by 192.2% due to increase the hotspot cell resources by borrowing the unused resources from the coldspot cell.

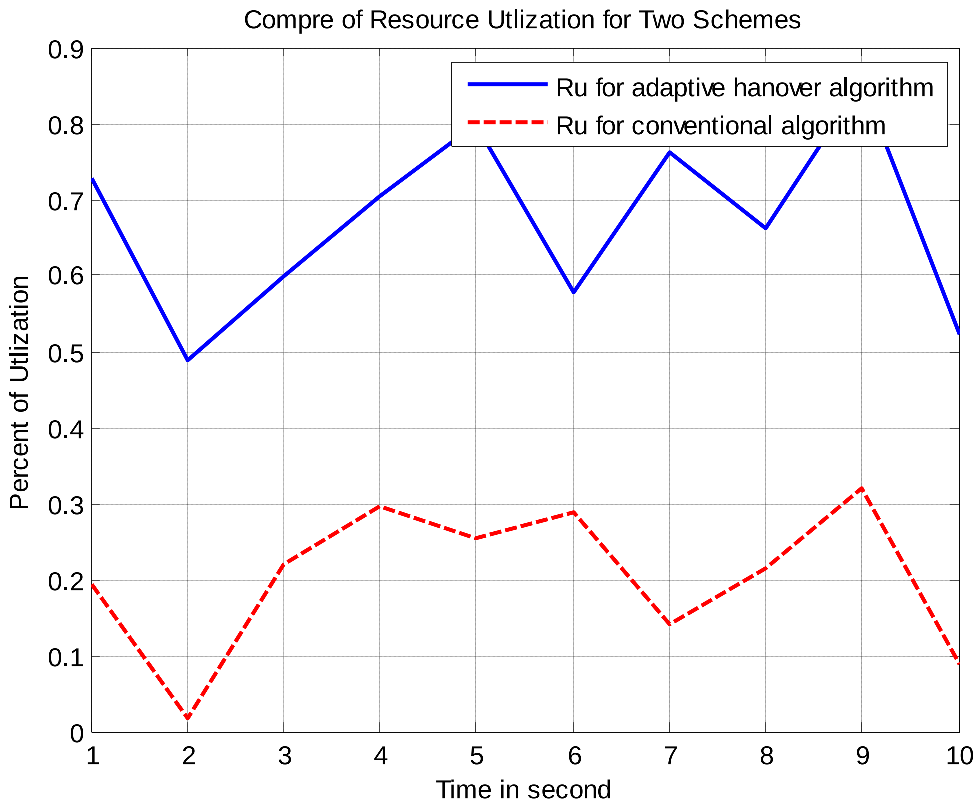


Figure 4.1: Compare of Resource Utilization between Adaptive Handover Time and Conventional Scheme

4.2.2. Blocking Probability

The resource utilized when using adaptive handover time scheme is much than conventional scheme which lead to decrease the blocking probability by 24.4% it’s show in Figure (4.2), where the red line represent the conventional scheme and the blue dashed line represent the adaptive handover time scheme.

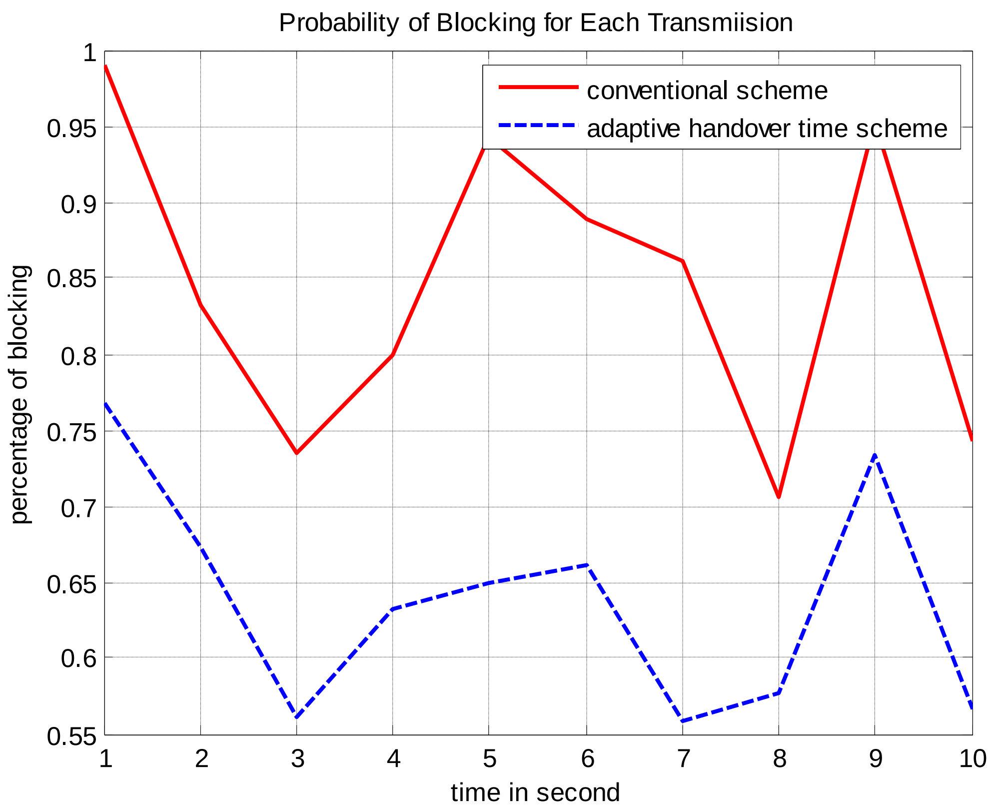


Figure 4.2: Compare Blocking Probability in Adaptive Handover Time Scheme and Conventional Scheme

4.2.3. Data Rate

The data rate shown in Figure (4.3), in which blue dashed line determine the adaptive handover time scheme and the red line determine the conventional scheme, increased by 139% than conventional scheme due to the increasing in the bandwidth and adding the adaptive modulation and coding AMC which change the modulation type and coding depending on the channel status .

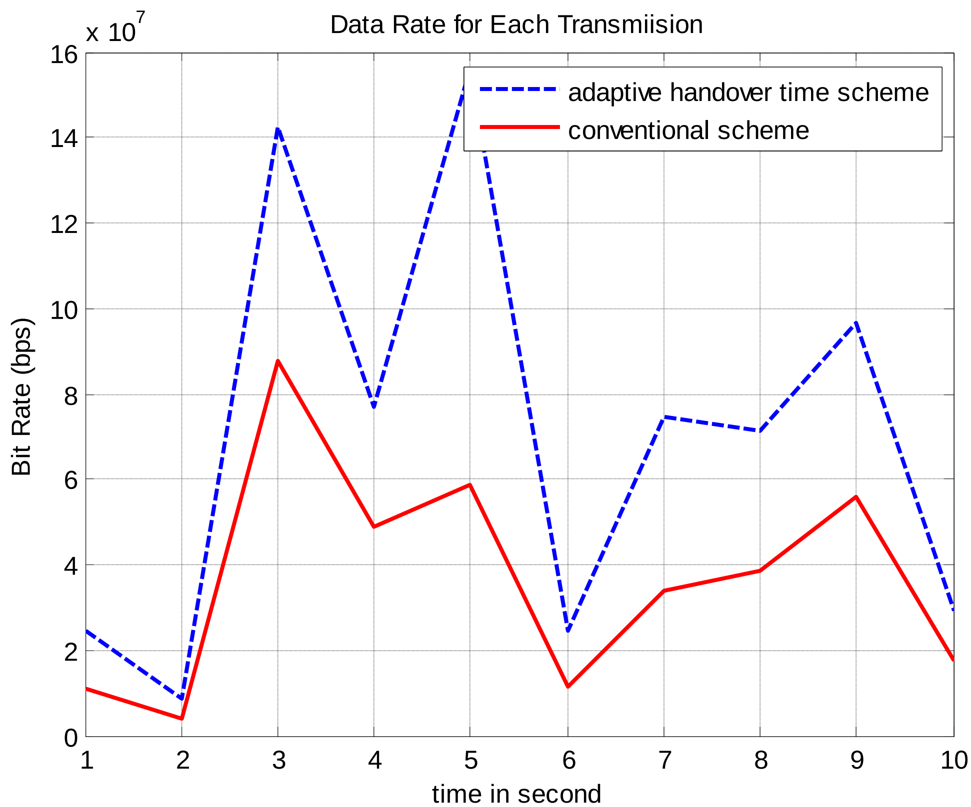


Figure 4.3: Compare Data Rate between Adaptive Handover Time and Conventional Scheme

4.2.4. Delay Time

The delay time when using adaptive handover time scheme is less than conventional scheme by 4.7% seen in a Figure (4.4), where the red line represent the conventional scheme and the dashed blue line represent the adaptive handover time scheme, due to adaptive handover time scheme the delay is equal to the current cell delay unlike the conventional which increased by the number of handed over cells.

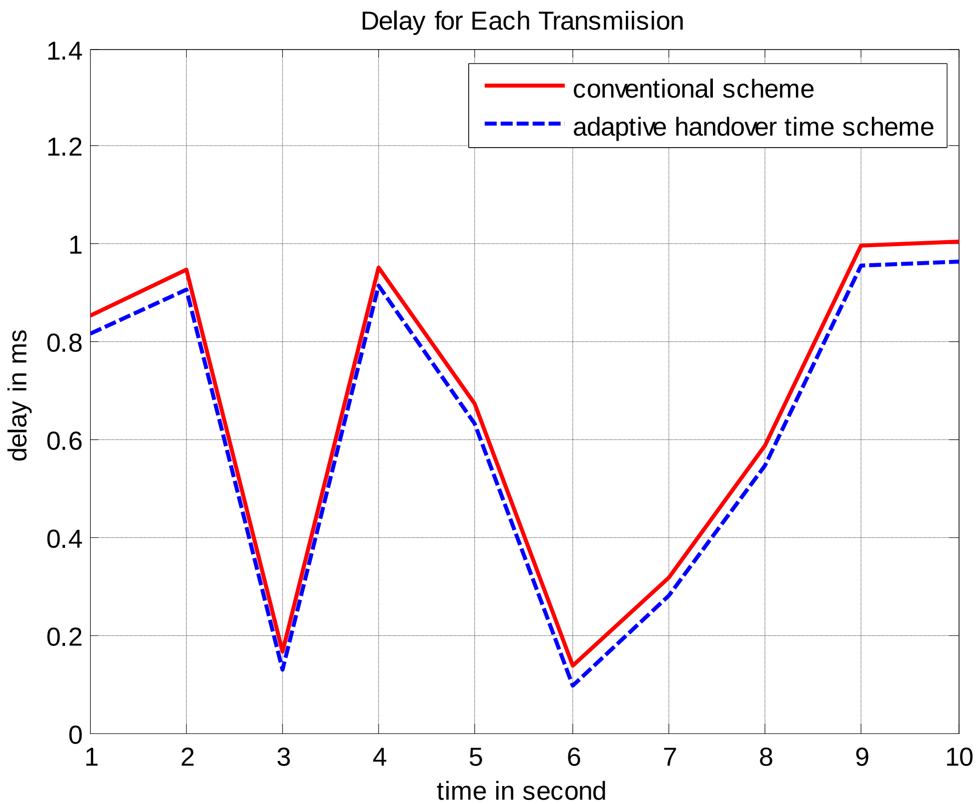
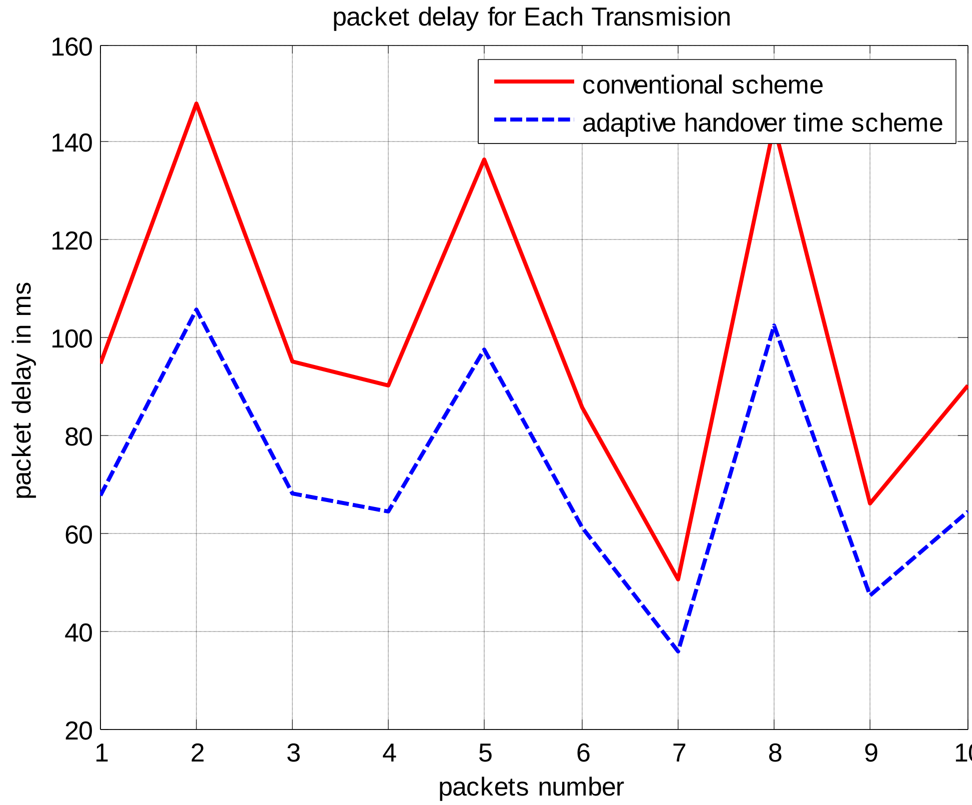


Figure 4.4: Delay Time in Adaptive Handover Time Scheme and in Conventional Scheme

4.2.5. Packet Delay

The adaptive handover time scheme enhancing the quality of service by reducing the packet delay by 27% than conventional scheme shown in Figure (4.5), where the red line indicate the behavior of the conventional scheme during the interval and the blue dashed line represent the adaptive handover time scheme, this decreasing is due to resource borrowing from coldspot cells and hence increasing the resources sufficiently in the hotspot cell lead to serve all users with minimum delay.



:

Figure 4.5: Comparing Packet Delay between Adaptive Handover Time Scheme and Conventional Scheme

4.2.6. Jitter

Adaptive handover time scheme decrease the jitter by 28.6% than conventional scheme because jitter depending on the packet delay in direct proportional way and this is illustrate in Figure (4.6),where adaptive handover time scheme behavior along the interval is represented by blue line and red line for the conventional scheme .

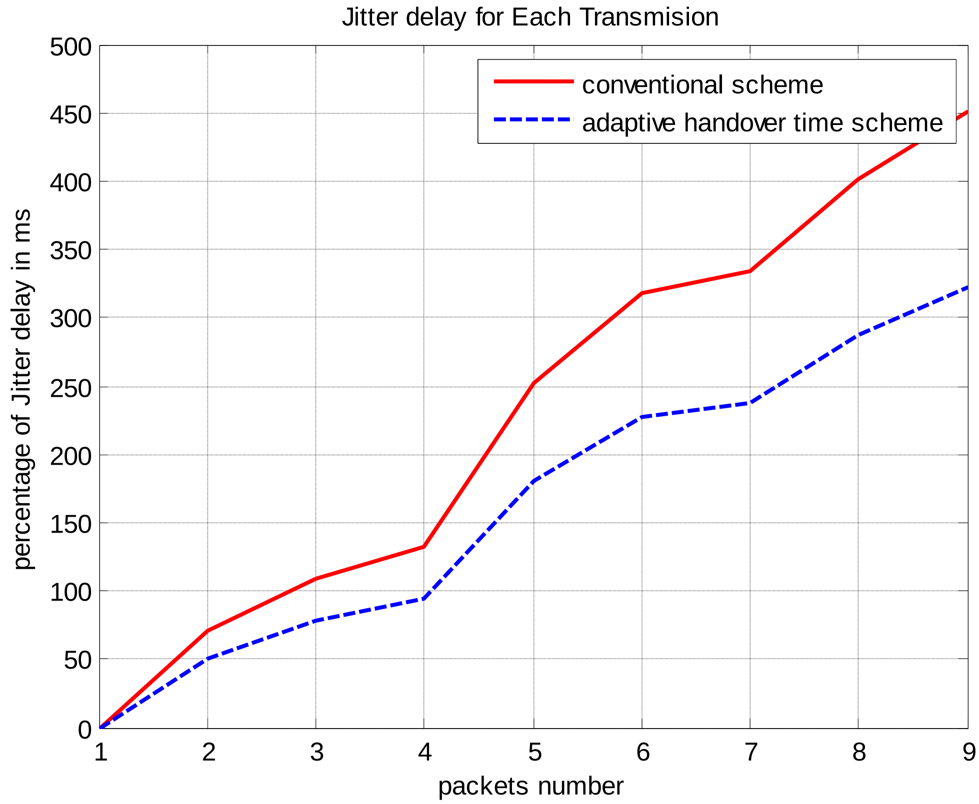


Figure 4.6: Jitter for Adaptive Handover Time Scheme and Conventional Scheme

4.2.7. Throughput

Corresponding to the increasing in the data rate by Adaptive handover time scheme lead to increase the throughput compared to the conventional scheme by 165%.shown in Figure (4.7).

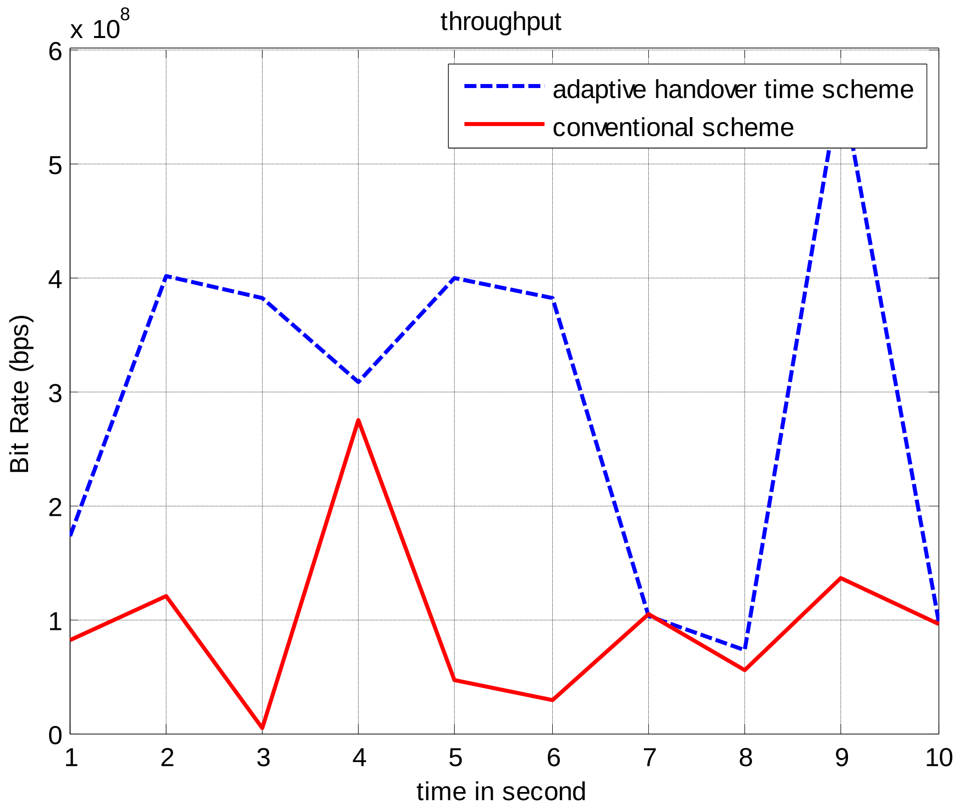


Figure 4.7: Throughput for Adaptive Handover Time Scheme and Conventional Scheme

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This research investigated chooses of the adaptive handover time scheme to enhance the system. It represents this enhancement by mathematical model and simulation using Matlab.

The results achieved in several parameters that affect the performance of the system due to use the adaptive handover time scheme mainly compared with conventional scheme. From the results can be noticed that resource utilization increased 192.2%, delay time decreased 4.7% , blocking probability by 24.4% decreased and also QoS parameters such as jitter which decrease 28%, 27% reduction of packet delay, improving in data rate and throughput by 139%,165% respectively of the conventional scheme .

5.2 Recommendations

Recommending continuing the researches of the system improvement:

- Evaluate other performance metrics such as subscriber growth.
- Investigate about other algorithm like vertical handoff in wireless network.

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APPENDIX: Matlab Code

```
clc,clear,close all,
%Number of Total Duplex Chaneel
Total_channel=300;
i=1;            % Sample for 50 Seconds
%% Three Cells are Taken
First_cell_Channel=100;
Second_cell_Channel=100;
Third_cell_Channel=100;
%% Number of User Distribuation IN Cells
%First Cell is the Hot_Spot_Cell
NUM_User_First=200;
NUM_User_Second=200;
NUM_User_Third=200;
%% Percent of Simultanously User Genarating Call
%First Cell is the Hot_Spot_Cell
while(i<=10)     %Repetation of Transmission 10 Times
Percen_First=rand(1)*0.5*NUM_User_First
Percen_Second=rand(1)*0.4*NUM_User_Second
Percen_Third=rand(1)*0.2*NUM_User_Third
%% Available Channel in First Cell for Old Scheme
R_AH(i)=First_cell_Channel-Percen_First
%% Available Channel in First Cell for New Scheme
R_TH(i)=R_AH(i)+(Second_cell_Channel-Percen_Second) ...
+(Third_cell_Channel-Percen_Third)
```

```
i=i+1;
end
plot(R_TH/Total_channel,'b','linewidth',2),hold on
plot(R_AH/Total_channel,'r--','LineWidth',2),
 hold off
legend('Ru for adaptive hanover algorithm','Ru for conventional algorithm')
xlabel('Time in second');
ylabel(' Percent of Utlization ');
title('Compre of Resource Utlization for Two Schemes')
grid
 %1-Delay Time
%With
Dt=0.02;%s
Dc=rand(1,10).*ones(1,10);%ms %Delay in new Scheme
N=2;
%Without
Delay1=Dc+Dt*N;     %Delay in old Scheme
plot(Delay1,'r','linewidth',2);hold on
plot(Dc,'b--','linewidth',2);hold off
legend('conventional scheme','adaptive handover time scheme ');
ylabel('ms'),title('Delay for Each Transmiision');
xlabel('time in second')
grid
```

```
%2-Data Rate
%Without
M=6*rand(1,10);
C=0.9*rand(1,10);
BW=20000000;                        %BandWidth in Old Scheme
Data_Rate1=BW.*M.*C.*ones(1,10);
tp1=sum(Data_Rate1(1,:)).*rand(1,10);
%With
R_H=N*(20000000-20000000*0.9*rand(1,10));%Availabel in other Cold Cells
BW=BW+R_H;                          %BandWidth in New Scheme
Data_Rate2=BW.*M.*C;
tp2=sum(Data_Rate2(1,:)).*rand(1,10);
figure(2)
plot(Data_Rate2,'b--','linewidth',2)
hold on;
plot(Data_Rate1,'r','linewidth',2),hold off
legend('adaptive handover time scheme ','conventional scheme');
ylabel('bps'),title('Data Rate for Each Transmiision');
xlabel('time in second')
grid
%%%%%%%%%%
figure(3)
plot(tp2,'b--','linewidth',2)
hold on;
```

```
plot(tp1,'r','linewidth',2),hold off
legend('adaptive handover time scheme ','conventional scheme');
ylabel('bps'),title('throughput');
xlabel('time in second')
grid
%3-Probability of Bolcking
Rt=300;            %Total Resource in System
%Without
Rh1=100*0.9*rand(1,10);  %Resourse Utlization in Old Scheme
POB1=(Rt-Rh1)/Rt;
%With
Rh2=100*0.8*rand(1,10)+(100*0.6*rand(1,10))+Rh1;   %Resourse Utlization in
New Scheme
POB2=(Rt-Rh2)/Rt;
figure(4)
plot(POB1,'r','linewidth',2)
hold on;%bar
plot(POB2,'b--','linewidth',2),hold off
legend('conventional scheme','adaptive handover time scheme');
ylabel('percentage of blocking'),title('Probability of Blocking for Each
Transmiision');grid
xlabel('time in second')
```

```
%%%%%%%%%%%%packet delay%%
c=100;
%capacity of the link
k=10;
%number of packets
i=1;
w=1500.*rand(1,10).*ones(1,10);
%w=h+lp(length of packet) in bytes
while(i<=k)
    %without the scheme
pd1=(i.*ones(1,10).*w)./c;
%%%with the scheme
m=200-(200*0.8);
pd2=(i.*ones(1,10).*w)./(c+m);
i=i+1;
end
figure(5)
plot(pd1,'r','linewidth',2)
hold on;
plot(pd2,'b--','linewidth',2),hold off
legend('conventional scheme','adaptive handover time scheme');
ylabel('packet delay in ms'),title('packet delay for Each Transmision');grid
xlabel('packets number')
 %Jittter Delay
j1=zeros(1,9);
j2=zeros(1,9);
```

```
for i=2:9
   j1(i)=j1(i-1)+abs(pd1(i)-pd1(i+1));
   j2(i)=j2(i-1)+abs(pd2(i)-pd2(i+1));
end
figure(6)
plot(j1,'r','linewidth',3)
hold on;
plot(j2,'b--','linewidth',3),hold off
legend('conventional scheme','adaptive handover time scheme');
ylabel('percentage of Jitter delay in ms'),title('Jitter delay for Each Transmision');grid
xlabel('packets number')
```