CHAPTER ONE

INTRODUCTION

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1.1. Introduction

A cellular network or mobile network is a communication network where the last link is wireless. The network is distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station. This base station provides the cell with the network coverage which can be used for transmission of voice and data. A cell might use a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed service quality within each cell. When joined together these cells provide radio coverage over a wide geographic area. This enables a large number of portable transceivers (e.g., mobile phones) to communicate with each other and with fixed transceivers and telephones anywhere in the network, via base stations, even if some of the transceivers are moving through more than one cell during transmission.

Overlapped cell provide coverage by more than one base station. Traffic is distributed over cells according to mobile speed, where fast moving mobiles are assigned channels from the large cell and slow moving mobiles are assigned to the smaller cell. One advantage of cell overlapping is that it increase capacity, but on the other hand it increase interference, as a larger number of users are active in the cell coverage area.

1.2. Problem Statement

To reduce new call blocking probability, additional channels may be added to the base station. However this solution may result is reducing Quality Of Service (QoS) level for calls. Alternatively, cell overlapping can be used to provide additional channels. There is a need to evaluate the QoS of calls under each strategy to identify the strategy which provides the best QoS.

1.3. Proposed solution

This research uses simulation to evaluate cell overlapping in 3G systems. It investigates the improvement in QoS of VoIP calls introduced by cell overlapping.

1.4. Objectives and Aims

Improving the (QoS) for VoIP calls by:

1. Reducing congestion in cells.
2. Reducing the new call blocking probability.
3. Improving radio resource utilization.

1.5. Methodology

The study uses simulation where a 3G system is simulated with cell overlapping. A new VoIP call arrives in the system and the call is handled with and without cell overlapping. Then the call QoS is compared under the two assumptions.

1.6. Scope

The work evaluates cell overlapping in 3G systems where one micro cell is overlapped by one macro cell. The simulations evaluates the QoS for one VoIP caller in the system.

1.7. Thesis organization

Chapter Two explains cellular system and their concepts. Chapter Three provides literature review of previous studies. Chapter Four explains the methodology used in this study. In Chapter Five the results of the simulation and discussion are demonstrated. Finally, Chapter Six is conclusions and recommendations.

CHAPTER TWO

Cellular Mobile Systems

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Cellular Mobile Systems

2.1. A cellular radio system

A cellular radio system provides a wireless connection to the public telephone network for any user located within the radio range of the system. The term mobile has traditionally been used to classify a radio terminal that can be moved during communication. Cellular systems accommodate a large number of mobile units over a large area within a limited frequency spectrum [1].

2.1.1.Frequency re-use

Frequency reuse is the method that is employed to enable the frequencies to be reused many time in the system; any radio transmitter will only have a certain coverage area. This means that it is possible to re-use a channel once outside the range of the radio transmitter. A distance between two similar frequencies is kept to prevent the interference, and the hexagonal cell shape cooperates to assign and reuse the frequencies without interference [1][2].

2.1.2.Cell cluster

Interference between adjacent channels is reduced by allocating different frequency bands or channels to adjacent cells so that their coverage can overlap slightly without causing interference. Often these clusters contain seven cells, but other configurations are also possible. Seven is a convenient number, but there are a number of conflicting requirements that need to be balanced when choosing the number of cells in a cluster for a cellular system. The requirements include interference level and the number of channels that can be allocated to each cell site [1][2].

2.1.3.Cell size

The different types of cells are given different names according to their size and function:

I. Macro cells: Macro cells are large cells that are usually used for remote or sparsely populated areas, and have a diameter of around 10 km.

II. Micro cells: Micro cells are normally found in densely populated areas, and have a diameter of around 1 km.

III. Pico cells: Pico cells are generally used for covering very small areas, such as buildings.

IV. Selective cells: are used where full 360 degree coverage is not required [1][2].

V. Femtocell : Femtocells are small, low-power cellular base stations, typically designed for use in a home or small business. A broader term which is more widespread in the industry is small cell, with femtocell as a subset. It is also called femto Access Point (AP).

2.1.4.Cell sectoring

Every cell has a base station (BS) which is located at the center of the cell. Cell sectoring may be used which is a way for increasing the system capacity while keeping the cell radius constant. An Omni directional antenna is used to minimize the error of co-channel interference. The Omni-directional antenna is split into 60 or 120 degree directional antennas and uses different channels in different sector to prevent interference [7][8].Figure 2.1 (a) and (b) show examples of cell sectoring at 60 and 120, respectively.

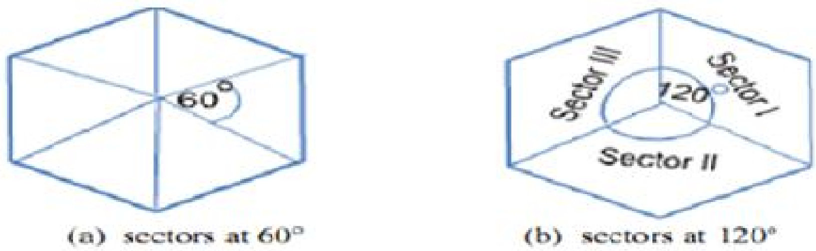

Figure 2.1 example of (a) 60 and (b) 120 cell sectoring [8]

2.1.5. Overlapped Cells in mobile networks

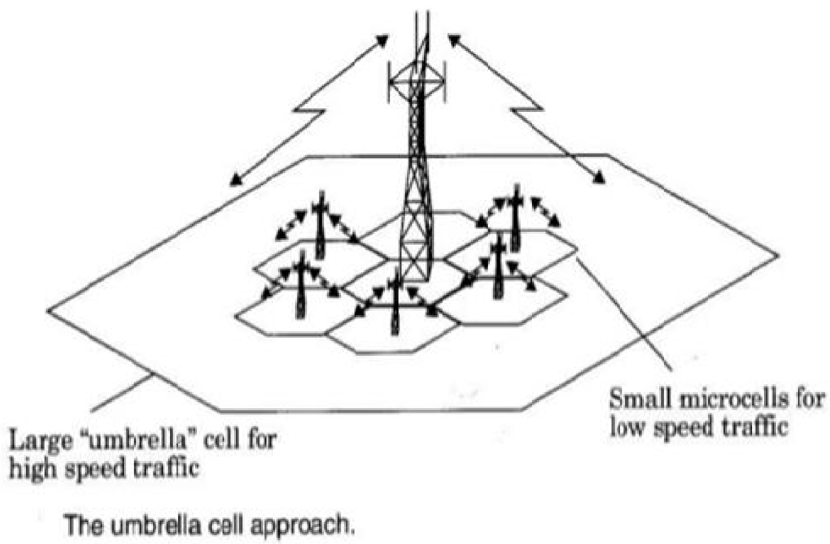

Figure 2.2 cell overlapping

Cell overlapping is when the cellular coverage area is controlled by two or more overlapping cells, Fig2.2 illustrates cell Overlapping. A cell is split into a number of smaller cells (pico, micro cells), to handle increased traffic, For fast moving MS, if channels are assigned from the micro cell, the number of handoffs will increase. Therefore highly mobile MSs are assigned channels from the large cell. MSs with low mobility are assigned to micro or Pico cells [8].

2.1.6. The advantages of cell overlapping

I. Reduce the call drop probability.
II. Mminimize delay probability.

III. Improve the Quality of Service of all the network.

2.1.7 The disadvantages of cell overlapping

I. Introduce additional network load.
II. Increase interference.

2.2. Radio resource management (RRM)

RRM plays a major role in Quality of Service (QoS) provisioning for wireless communication systems. RRM determines QoS performance at the individual user level and the network level as well. And optimizing RRM maximizes throughput. Radio resources are managed using various schemes that can be grouped in three sets [3].

1. The first set includes frequency/time resource allocation schemes such as channel allocation, scheduling, transmission rate control, and bandwidth reservation schemes.
2. The second set consists of power allocation and control schemes, which control the transmitter power of the terminals and the base stations.
3. The third set comprises call admission control, base station (BS) assignment, and handoff algorithms.

2.3. Evolution of mobile telecommunication systems

In 1946 in USA, AT&T and Southwestern Bell introduced the first American commercial mobile telephone service (typically in automobiles). In the mid-1960s, Bell Systems introduced the Improved Mobile Telephone Services (IMTS), which markedly improved the mobile telephone systems. In the late 1960s and early 1970s, the cellular concept was conceived and was then used to improve the system capacity and frequency efficiency. With the development of digital technologies and micro processing computing power in the late 1980’s and up to today, enormous interest emerged in digital cellular systems, which promised higher capacity and higher quality of services at reduced costs , which are shown in Table (I) taken from [7].

TABLE I

EVOLUTION OF MOBILE COMMUNICATION SYSTEMS.

Property	1G	2G	2.5G&3G	4G
Starting Time	1985	1992	2002	210-2012
Representative Standard	AMPS	GSM	IMT-2000	UWB
Radio Frequency (Hz)	400M-800M	800M-900M	1800M-2400M	2G-8G
Bandwidth(bps)	2.4K-3K	9.6K-14.4K	384K-2M	20M-100M
Multiple Access Technique	FDMA	TDMA, CDMA	WCDMA	OFDM
Switching Basis	Circuit	Circuit	Circuit,Packet	Packet
Cellular Coverage	Large area	Medium area	Small area	Mini area
Service Type	Voice	Voice, limited data	Voice, data, limited multimedia	Multimedia

2.4. Handoffs in cellular Mobile Systems:

A handoff it is the process of continuing a call without losing it even when the user is moving from one cell to another or one sector to another sector in the cell. When a mobile user is travelling from one area of coverage to another area within a call's duration the call should be transferred to the new sector or cell base station. Otherwise, the call will be dropped because the link with the current base station becomes too weak as the mobile recedes. This transfer shown in fig 2.3 is called a handoff, and it has two main types [5].

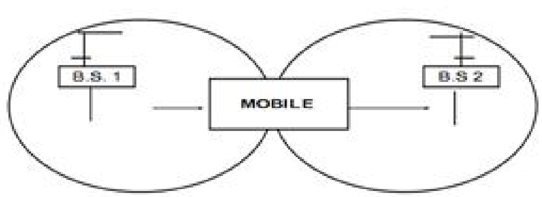

Figure 2.3 handoff from one BS to another BS

1. **Hard handoff**

Break before make: where it first breaks the call with the old base station and then makes the handoff to the new cell. If the handoff delay is high, the call may be lost.

2. **Soft handoff**

Make before break: where it firstly connects to the new cell and then breaks the connection with the old cell.

2.4.1.Handoff prioritization

Prioritizing handoffs is one way to reduce the handoff failure rate which maximizes the performance of the traffic [4].

There are two basic methods of handoff prioritization:

2.4.1.1. Guard channels

Guard channels improve the probability of successful handoffs by reserving a fixed or dynamically adjustable number of channels exclusively for handoffs. Although a good method to reduce handoff failure rate, guard channels result in unutilized resources if a large number of them are not used [4].

2.4.1.2. Queuing of handoff requests

Queuing is a way of delaying handoff, because no channel is available. Queuing new calls results in increased handoff blocking probability. The probability of a successful handoff can be improved by queuing handoff requests at the cost of increased new call blocking probability and a decrease in the ratio of carried-to-admitted traffic since new calls are not assigned a channel until all the handoff requests in the queue are served. Queuing is possible due to the overlap region between the adjacent cells in which the MS can communicate with more than one

BS. If handoff requests occur uniformly, queuing is not needed; queuing is effective only when handoff requests arrive in groups and traffic is low.

Joint optimization of queuing and handoff parameters may be better due to the following reasons:-

I. When handoff algorithms are designed to minimize the number of unnecessary handoffs, excessive call drops may occur during high traffic intensities. These strategies minimize the number of handoff attempts per boundary crossing, and sufficient time may not be available for entertaining handoff requests under heavy traffic conditions.
II. Different handoff algorithms introduce different delays in handoff requests. Hence, the delay associated with handoff queuing may not be acceptable for some handoff algorithms. The performance improvement achievable with handoff queuing is variable and dependent on handoff algorithms.
III. Some handoff requests may demand higher priority in a queue to save the call. This can be investigated properly by noting both the traffic and transmission characteristics [4].

2.4.2. Handoff QoS parameters :

Some of the quantities which are most significant in determining QoS of handoffs are as follows:

I. Call blocking probability: is the probability with which a new call is blocked.
II. Handoff call blocking probability: is the probability with which a handoff call is blocked, or placed in the handoff request queue.
III. Call dropping probability : is the probability with which a call is either blocked or accepted but immature termination occurs during the call life [5][6].
IV. Handoff delay: is the time from which the handoff request was made to the time it was executed.

2.5. Call Admission Control in Mobile Cellular Networks

Call Admission Control (CAC) is the practice or process of regulating traffic volume in voice communications, particularly in wireless mobile networks and in VoIP (voice over Internet Protocol, also known as Internet telephony). Call admission control can also be used to ensure, or maintain, a certain level of audio quality in voice communications networks, or a certain level of performance in Internet nodes and servers where VoIP traffic exists. Most CAC algorithms work by regulating the total utilized bandwidth, the total number of calls, or the total number of packets or data bits passing a specific point per unit time. Call admission control deals with deciding whether to accept or reject a call request.

2.5.1. Call admission control mechanisms

There are many type of call admission control algorithms, following are some examples:

2.5.1.1. Basic Call Admission Control (BCAC)

Basic Call Admission Control (BCAC) is a static admission control mechanism. The decision of the acceptance or rejection of the call is based only on the availability of radio resources. The call is accepted only if there are enough available radio resources.

2.5.1.2 Multi-Service Call Admission Control (MSCAC)

Multi-Service Call Admission Control (MSCAC) is proposed in [4] for 3G/4G networks. Two types of service classes are defined for (MSCAC):-

I. Real Time (RT) for conversational and streaming calls.
II. Non-Real Time (NRT) for Best Effort calls.

MSCAC divides the resources into two parts: a part for NRT calls and a second part for RT calls.

2.5.2. QoS requirements for real time and non-real time classes

The cellular mobile system has become the main medium for communication now a days and serves various types of services and traffic. Multimedia traffic typically consists of streams of text, video, voice and images, which may be one-way real-time transfer, interactive or non-real time like web services or file transfers. Interactive applications, such as voice over IP, have stringent QoS requirements needing higher data rate, less delay, and jitter guarantees. Some applications need to be in real time to prevent the error and achieve to interactive [6].

2.5.3. CAC Approach for differentiated services

Various schemes have been proposed to address the issue of traffic type differentiation in the call admission process. The next generation wireless and mobile networks are designed to support a true combination of both real-time and non-real time services [6].

2.6. UMTS system main components

Universal Mobile Telecommunication System (UMTS) is the dominating 3G standard. Following is an explanation of the main components of (UMTS) systems, which are implemented in the simulation of this study.

2.6.1.Node-B :(UMTS Base Station)

Node-B is the telecommunications node in particular mobile communication networks, that adhere to the UMTS standard. The Node-B provides the connection between mobile phones (UEs) and the wider telephone network.

2.6.2 RNC :

The Radio Network Controller (or RNC) is a governing element in the UMTS radio access network (UTRAN) and is responsible for controlling the Node-Bs (UMTS base station) that are connected to it. The RNC carries out radio resource management, some of the mobility management functions and is the point where encryption is done before user data is sent to and from the mobile.

2.6.3 SGSN :

The serving GPRS Support Node (SGSN) is a main component of the General Packet Radio Service (GPRS) core network, which handles all packet switched data within the network, e.g. the mobility management and authentication of the users. The SGSN performs switching and coordination of packet switched services.

2.6.4 GGSN :

The Gateway GPRS Support Node (GGSN) is responsible for the interworking between the GPRS network and external packet switched networks.

2.6.5 Router :

A router is a networking device that forwards data packets between computer networks. Routers perform the traffic directing functions on the Internet. A data packet is typically forwarded from one router to another router through the networks that constitute an internetwork until it reaches its destination node. A router is connected to two or more data lines from different networks. When a data packet comes in on one of the lines, the router reads the network address information in the packet to determine the ultimate destination. Then, using information in its routing table or routing policy, it directs the packet to the next network on its journey.

2.6.6. FTP Sever :

A File Transfer Protocol (FTP) server is a standard network protocol used for the transfer of computer files between a client and server on a computer network. The main features of an FTP server are:

I. Cross Platform.

II. Multiple Protocols: Supports FTP, FTPS (FTP with SSL), HTTP, HTTPS, and SFTP server.
III. Remote web based administration.
IV. Multiple Domains: multiple virtual servers on the same IP address can be run.
V. Several Authentication Methods XML files, ODBC database, Mysql database, LDAP and Windows AD Authentication (NTLM or Active Directory).
VI. Programming Interface Provides a set of APIs that can be called in Lua Scripts.
VII. Real-Time information enables monitoring FTP server in real-time. information can be gathered each connected user.
VIII. Multiple Languages :Supports 14 languages.
IX. Support for iOS/ Andriod: This feature helps iOS and Andriod users access the web client easily.

2.6.7. Voice Server :

Voice application servers consist primarily of software, operating on Sun or Linux servers located in a service provider network, and functioning in conjunction with other standard network elements such as routers, gateways, integrated access devices (IADs) and telephones.

2.7. Summary:

In this chapter we talk about overlapped cells in mobile networks. We also discussed the advantages and disadvantages of overlapped cells as well as the mean concepts of UMTS systems.

CHAPTER THREE

Previous studies

CHAPTER THREE

Previous studies

3.1. Introduction

This chapter explains previous studies related to this work.

3.2. Temporarily new call channel allocation

In the call admission control mechanism , each station independently reserves a number of channels in order to guarantee a specified probability of handoff call drop is not exceeded according to predetermined quality of service. The reserved handoff call channels change dynamically in order to respond to the varying traffic conditions in the cell. When channel allocation has become more highly utilized, all calls are still admitted, but lower priority calls are admitted conditionally. These calls are aware that the channel is heavily used and that they may lose their connection or have their service reduced if more traffic arrives[7].

3.3. A Call-Admission Control (CAC) algorithm for providing guaranteed QoS in cellular networks

With increasing demand for mobile computing services and limited available bandwidth, wireless networks increase the number of simultaneous users in the network systems by reducing the cell size. It is projected that future wireless networks will adopt a micro/pico-cellular architec- ture . However, smaller cell size naturally increases the number of handoffs a MT is expected to make. As the new call arrival rate or load increases, so does the probability of handoff failure; this phenomenon, combined with the large number of handoffs before completion of a call, increases the forced termination probability of calls to increase demand for mobile computing Channel Prioritization Schemes

The work in [9] proposes using guard channel schema as a handoff prioritization scheme. In this method, a number of wireless channels, say G out of a total of C channels, called “guard channels,” are exclusively reserved for handoff calls of profiled users. The remaining channels, called “normal channels”, are shared among all types of calls.

3.4. Call admission control strategy to utilize sparce spectrum

The authors devise a scheme – A Novel Handoff Decision Algorithm in Call Admission Control Strategy (NHDA). In this proposed new scheme, the channels for handoff requests are dynamically allocated based on the handoff failure probability observed for a certain past period in the network. This scheme aims to utilize the scarce spectrum efficiently and also to balance the load in the network traffic. The new call dropping rate determines the fraction of new calls that are rejected. The handoff blocking rate is closely related to the fraction of admitted calls that terminate prematurely due to handoff. Limited channels, a scarce resource, should be utilized effectively [10].

3.5. Call Admission control scheme and handover management

The actual wireless network require more data traffic with the exponential increased demand and number of users, but the capacities of macro cells still not sufficient to satisfy it. The mobile networks are attempted to provide high demand of bandwidth with low cost for diverse data and multimedia services but assuming an enhanced quality of service QoS. The network operators actually try to propose effective solutions to improve existing infrastructure, and to expect the huge demand of traffic by introducing more and smaller base stations to permit higher amount per area. The femto cell is one of the best solutions proposed for network operator to face the great demand of the growing capacity of wireless network. The work in [11] proposes a call admission control CAC strategy for newly arriving calls. When a new call reaches the network, the call admission control firstly verifies the availability of the Home eNodeB (HeNB) coverage. If HeNB femto cell coverage is available, so a femto cell base station is the first choice to connect a call. If the signal level is satisfied, and the moving user is with a low velocity not with high speed to avoid the ping ponging effect and the resources in the HeNB are available, the HeNB femto cell accepts a new arriving call.

3.6. Algorithm for CAC in wireless networks

An adaptive algorithm for CAC in wireless networks is proposed in [12]. This algorithm is built upon the concept of guard channels, and it imposes a hard constraint on the handoff call blocking probability. This approach tries to achieve performance and good QoS. Experiments show that improved VIA is reliable and effective. Firstly, the proposed optimal policy has much less computational load compared to conventional numerical methods. Also, the simulation confirms that the optimal policy is effective in maintaining high QoS performance.

3.7. Hybrid new call blocking and forced termination probability call admission

The Authors of [13] proposed call admission control algorithms for a cellular and microcellular systems and are evaluated based on two Quality of Service (QoS) metrics: the new call blocking probability and the forced-termination probability. It has been shown that the Hybrid Control Scheme yields the best performance, particularly during periods when load differs from the expected level. The authors have also proposed an improved call admission policy, based on the fractional guard channel scheme, which additionally considers the blocking of new calls and has improved performance.

3.8. Performance analysis of adaptive joint call admission control to support QoS in heterogeneous 4G wireless networks

Radio Resource Management (RRM) strategies are responsible for an efficient utilization of the resources in any Radio Access Network (RAN). In heterogeneous networks a policy-based approach is usually assumed for Common RRM (CRRM) operations. One of the most important common radio resource management (CRRM) mechanisms used in wireless networks is call admission control (CAC). The coexistence of different cellular networks in the same geographical area necessitates a common radio resource management (CRRM) for enhanced QoS provisioning and efficient radio resource utilization. Joint call admission control (JCAC) algorithm became a vital tool for CRRM environments.

Bandwidth adaptation technique for the Adaptive Joint CAC (AJCAC) is analyzed. The AJCAC algorithm degrades the bandwidth of some ongoing users to make room for new incoming ones. A restoration process must take place when the network is underutilized; where the algorithm restores the maximum bandwidth service to the degraded users. If the partition capacity is above a predefined threshold- called the adaption threshold-it is considered oversubscribed and it will degrade the bandwidth of some ongoing calls to free some radio resources to accommodate the new call. If there are no more ongoing calls to degrade, the new call will be blocked [14].

3.9Multi-Objective Handover in LTE Macro/Femto-Cell Network

The Authors of [15] proposed Handover with more complex parameter using carrier to interference plus noise ratio (CINR). LTE femto cells often suffers from resource constraints in the target femto-cell. Leading to handover failure. They propose using a Macro/Femto overlapped layer resulting in a multi-objective handover solution for LTE cellular systems.

3.10 Macro cell / Microcell Selection Schemes

High speed mobile terminals (MTs)are serviced in Macro cell and low speed MTs are serviced in micro cell to minimize the number of handoffs. This is the assumption of the study in [16] which improved the service by increasing number of users.

Compare

The name	Year	Cell size1	Cell size2	The assumption	Results
1-Multi-Objective Handover in LTE Macro/Femto-Cell Network	2012	Macro cell	Femto cell	1-Handover operation more complex challenging. 2 –carrier to interference plus noise ratio (CINR). 3-it often suffers from resource constraints in the target femto-cell. 4-leading to handover failure.	Propose a new efficient, multi-objective handover solution for LTE cellular systems.
2- Macro cell / Microcell Selection Schemes Based on a New Velocity Estimation in Multitier Cellular System	2002	Macro cell	Micro cell	1-High speed mobile terminals (MTs)are serviced in Macro cell and low speed MTs are serviced in micro cell to minimize the number of handoffs.	Provide multimedia Service to support increasing number of users
3- A comparative study of deployment options, capacity and cost structure for macro cellular and femto cell networks	2011	Macro cell	Femto cell	Compare the cost & capacity performance of femto cell and macro cellular networks.	The femto cell solution is less cost efficient due to the need to deploy a large number of access points in order to ensure coverage.
4- Analysis of Macro User Offloading to Femto Cells for5GCellularNetworks	2017	Macro cell	Femto cell	1-Demand for high data rates is on the rise, mainly because of the wide spread of devices like tablets and smart phones That increasingly rely on data intensive applications to	Analysis of Macro user offloading and ultra densification of Future 5G Cellular Networks and Femto cells Using CLSM have been designed. Different aspects of the proposed schemes have been evaluated, with the help of a simulator enabling

				enhance End user's quality of experience 2- a large number of IoT (InternetofThings) devices would also be connected to the cellular networks in near future	**reproducibility. 2- An idea of heterogeneous network having Node Band Small cell base stations (Femto cells) has Been presented**

3.12. Summary:

In this chapter we have overviewed previous studies related to this work and explained the assumption and the results of these studies.

CHAPTER FOUR

Research Methodology

CHAPTER FOUR

Research Methodology

4.1 Introduction

This chapter explains the system environment, the evaluated scenarios, QoS parameters and simulation tool.

4.2 system Environment

In this study we considered two scenarios. The first scenario is a system with no cell overlapping, where the mobile is in the coverage area of one base station. The second scenario considers cell overlapping where two layers of cells provide service in the area. Here, we considered one macro cell overlapping one microcell and compare QoS under the two scenarios.

4.3 System without cell overlapping

Most CAC algorithms work by regulating the total utilized bandwidth, the total number of calls, or the total number of packets or data bits passing a specific point per unit time. If there is no available channel to accommodate the new call request, the call is rejected. Otherwise the call is accepted, even if the cell is congested. The acceptance of the new call may cause degradation in QoS of callers in the cell. This process is shown in figure 4.1

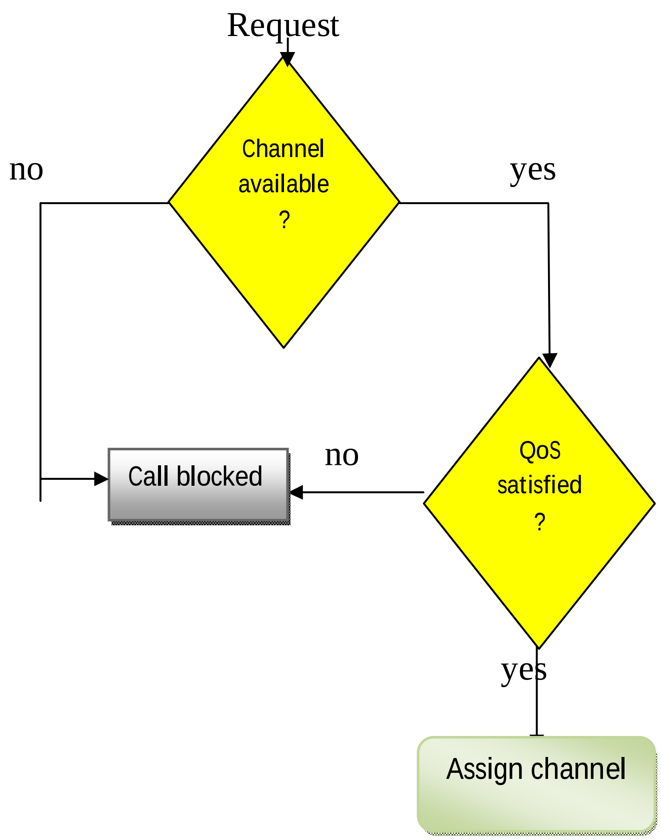

Figure 4.1 flowchart of scenario without cell overlapping

4.4 System with cell overlapping

Another method involves accepting the call and performing a handover process to the overlapped cell to minimize the call blocking. If a channel is available in the cell and QoS is satisfied, the call is accepted. Otherwise the call request is transferred to the overlapping cell. In the case where the overlapping cell does not have a free channel, the call is blocked. Figure 4.2 shows this process.

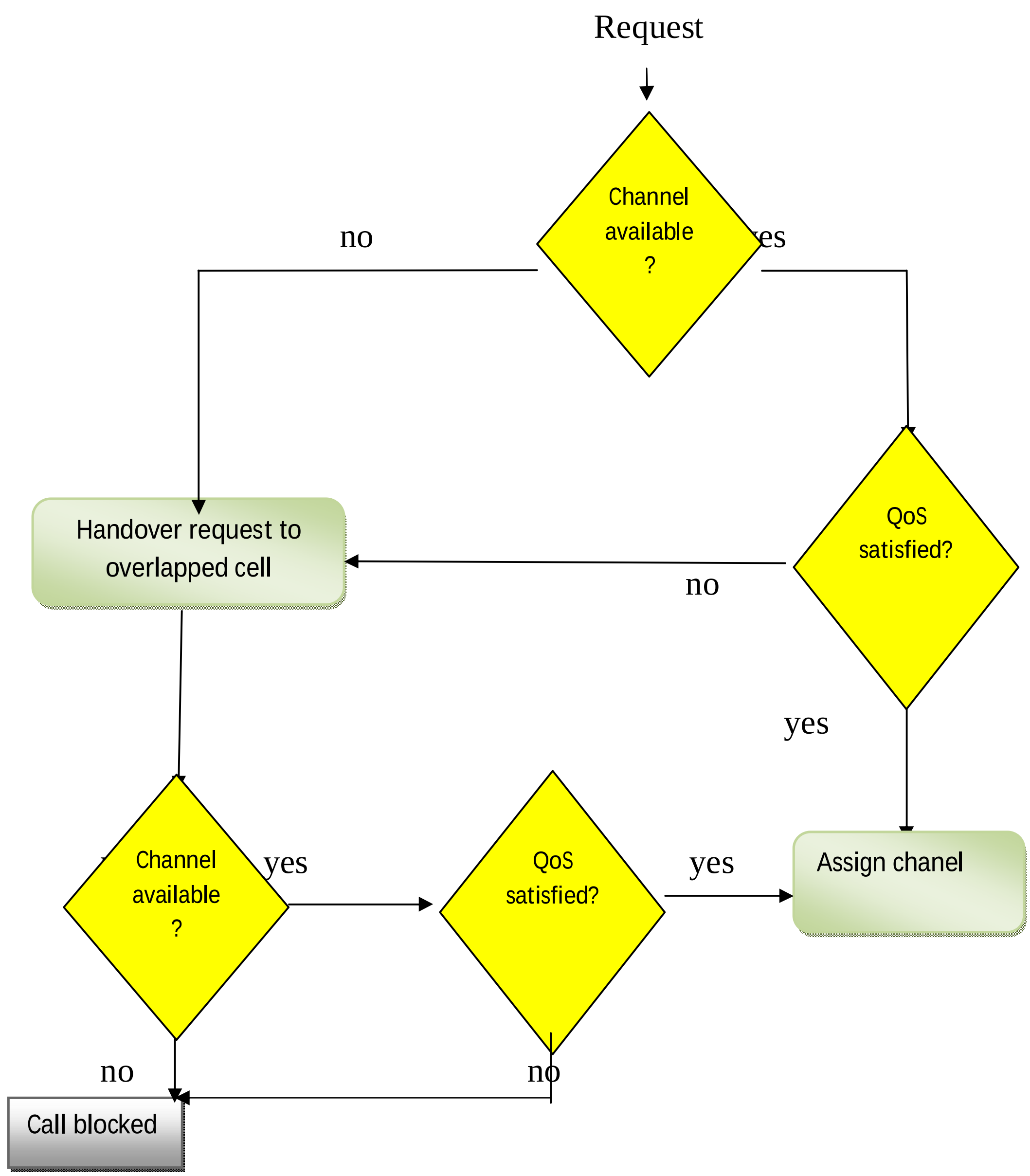

Figure 4.2 flowchart of cell overlapping scenario

4.5. Quality of Service parameters

Quality of service (QoS) is the description or measurement of the overall performance of a service, such as a mobile or computer network or a cloud computing service, particularly the performance seen by the users of the network. To quantitatively measure quality of service, several related aspects of the network service are often considered. In mobile telecommunication system, a number of parameters are use to evaluate the system. These parameters include packet loss, bit rate, throughput, packet delay and jitter.

4.5.1. Packet loss

Packet loss occurs when one or more packets of data travelling across a computer network fail to reach their destination. Packet loss is either caused by errors in data transmission, typically across wireless networks or network congestion. Packet loss is measured as a percentage of packets lost with respect to packets sent. The Transmission Control Protocol (TCP) detects packet loss and performs retransmissions to ensure reliable messaging. Packet loss in a TCP connection is also used to avoid congestion and thus produces an intentionally reduced throughput for the connection.

4.5.2. Bit rate

In telecommunications and computing, bit rate (bitrate or as a variable R) is the number of bits that are conveyed or processed per unit of time.

4.5.3. Throughput

Throughput is the maximum rate of production or the maximum rate at which something can be processed. When used in the context of communication networks, such as Ethernet or packet radio, throughput or network throughput is the rate of successful message delivery over a communication channel. The data these messages belong to may be delivered over a physical or logical link, or it can pass through a certain network node. Throughput is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second (p/s or pps) or data packets per time slot.

4.5.4 Packet delay (end-to-end delay)

End-to-end delay or one-way delay (OWD) refers to the time taken for a packet to be transmitted across a network from source to destination. It is a common term in IP network monitoring, and differs from round-trip time (RTT) in that only the path in the one direction from source to destination is measured.

4.5.5 Jitter

Jitter is the deviation from true periodicity of a presumably periodic signal, often in relation to a reference clock signal. In clock recovery applications it is called timing jitter. Jitter is a significant, and usually undesired, factor in the design of almost all communications links. Jitter is the variation in the delay of received packets. High jitter results in choppy voice or temporary glitches. jitter is generally caused by congestion in the IP network. The congestion can occur either at the router interfaces or in a provider or carrier network if the circuit has not been provisioned correctly.

4.6 Simulation tool

We use the OPNET 14.5 modular to simulate the network performance evaluation. Optimized Network Engineering Tool, OPNET is a network simulation tool with lots of features and toolsets. Some of the features provided by OPNET are:

I. Packet format that defines protocols.
II. Node model for specifying network component interface.
III. Process model for abstraction of behavior of a particular network component.
IV. Project window for defining the topology of the network and various linkages.
V. Simulation window that is able to capture and/or show the results of network simulation.

OPNET Modeler also has a development environment that allows for modeling any network type and various other technologies like VOIP, MPLS, IPv6, and TCP.

CHAPTER FIVE

Results and Discussion

CHAPTER FIVE

Results and Discussion

5.1 Introduction

The challenging part of VoIP traffic is that it needs to compete with all other traffic and also be delivered in real-time in order to achieve a good audio quality level. With email or file downloads, if a packet is received out of order or delayed by a few seconds, the user probably won't even notice. On the contrary, VoIP packets have to arrive in real-time in order to have an intelligible conversation.

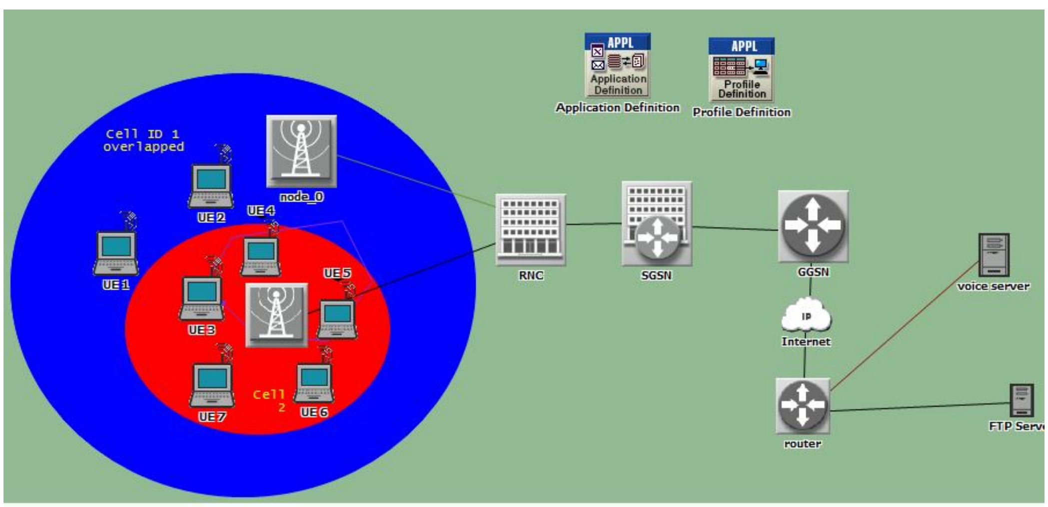

Figure 5.1 System model

Figure 5.1 illustrates the system with two cells, the small microcell and the large overlapped macro cell. This work illustrates the importance of the overlapped cell, since when the call request arrives at the small cell and there is no channel available, the signal is too week, or the QoS is not satisfied the call admission control(CAC) will hand over the request to the overlapped cell and allocate an available channel and therefore avoiding blocking the call. We evaluate the QoS of new call request and overall system with and without cell overlapping. We compare the delay, jitter and received traffic for the two scenarios.

Table1 Input values

Parameter	Value
No of UE	7
Simulation time	5 minute
Number of macro cell	1
Number of micro cell	1
Number of MS	7

5.2 Delay

5.2.1Overall end –to-end delay

Figure 5.2 illustrate the end-to-end delay of the call in overlapped cell and non -overlapped cell. The overall end-to-end delay is 11.7% less when cell overlapping is used.

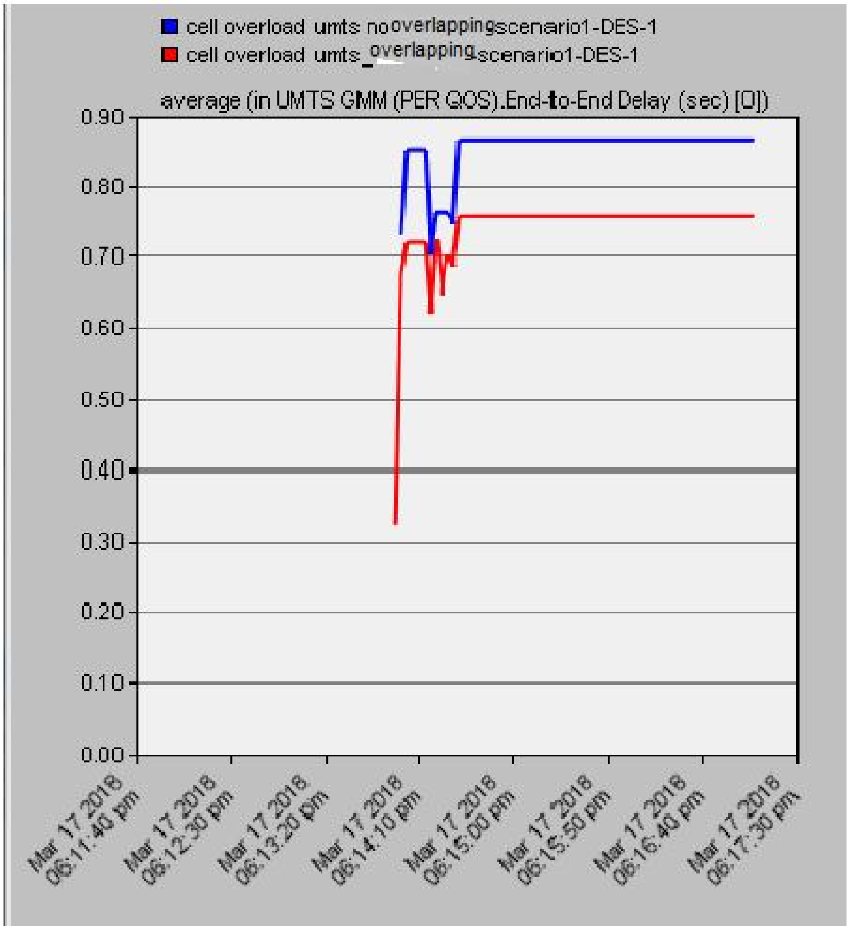

Figure 5.2 End-to-End Delay

5.2.2 Overall packet delay variation

Figure5.3 shows the average in voice overall packet delay variation. The packet delay using non overlapped cells is 7.1% more than using overlapped cells. This is because when there is no cell overlapping, more users are served by the Node-B, increasing the delay.

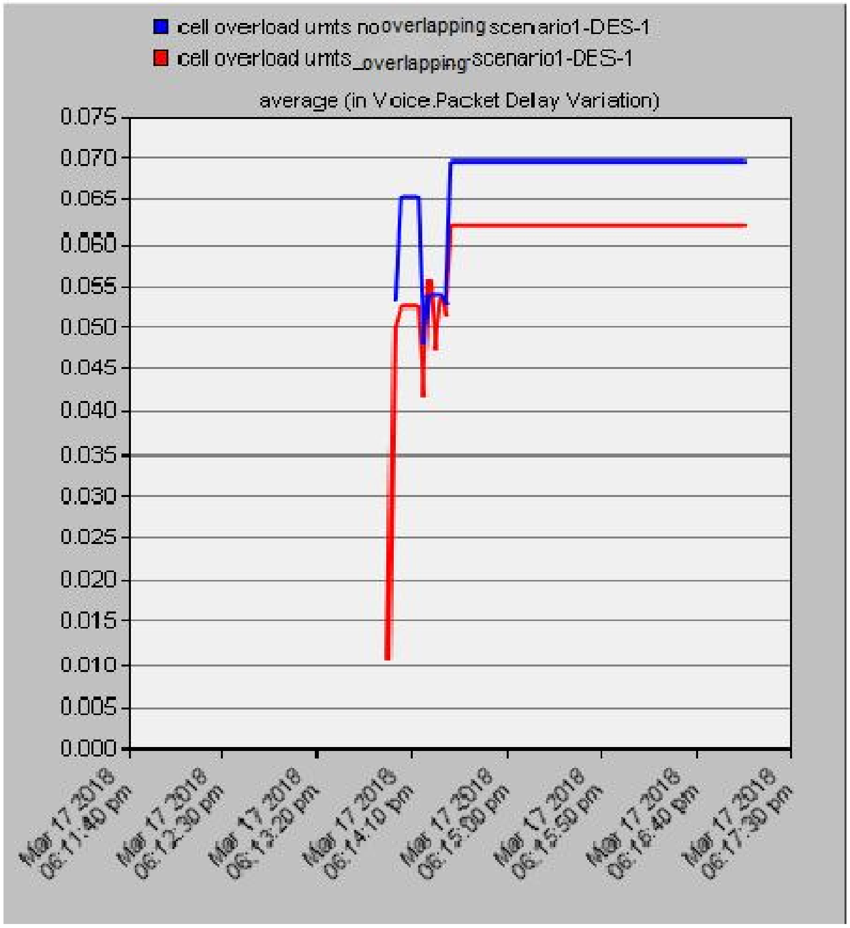

Figure 5.3 Average in voice packet delay variation

5.2.3 User average end-to-end delay

Figure 5.4 illustrates packet End-to-End delay in non-overlapped cells and overlapped cells. The user end-to-end delay in overlapped cells is 17.7% higher than in non-overlapped cells. This is because more time is consumed in transferring the call to the overlapped cell.

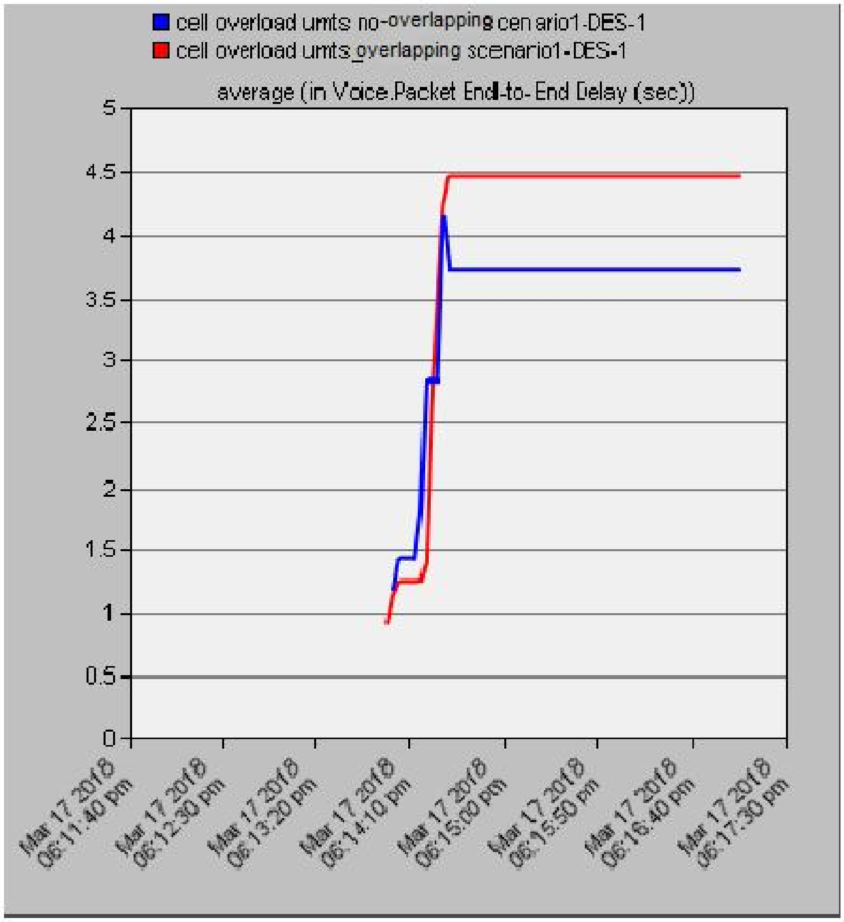

Figure 5.4 Average (in voice packet End-to-End Delay)

5.2.4 User average packet delay variation

Figure 5.5 illustrates the user packet delay variation in non-overlapped and overlapped cells. The user end-to-end delay is 21% less when no cell overlapping is used, as more time is spent to transfer the call to the overlapped cell. The delay for a single user is more, but for the overall network the performance is improved, as seen in Figure5.2

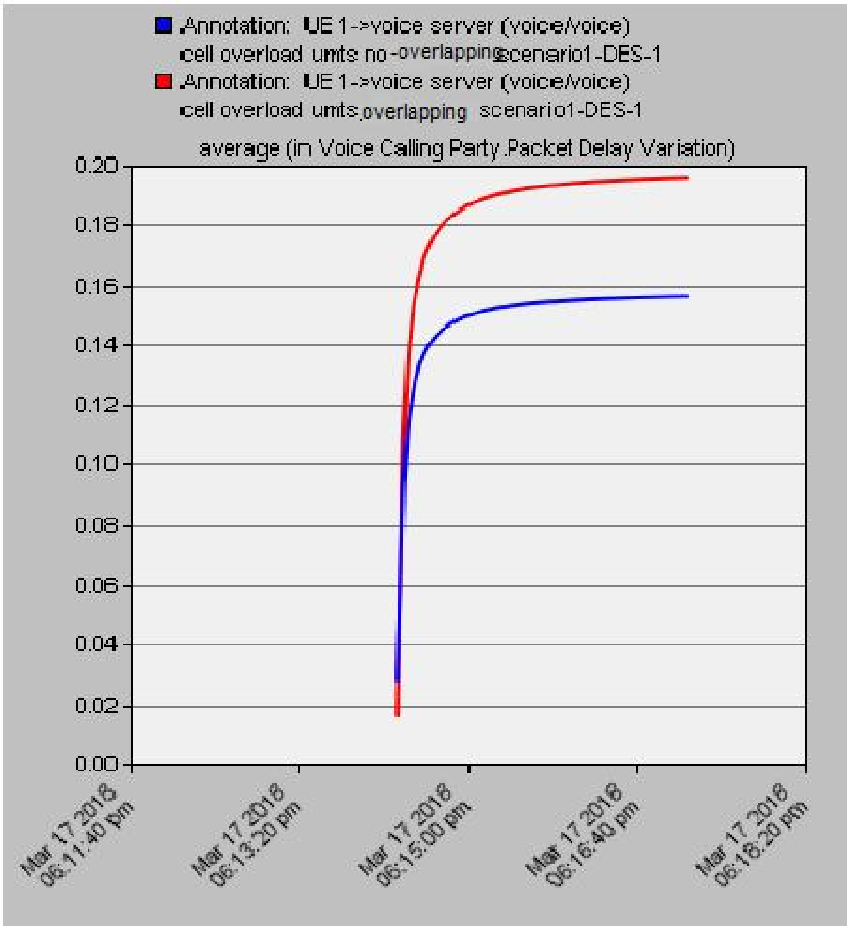

Figure 5.5 UE1(Average packet delay variation)

5.3 Jitter

Figure 5.6 illustrates jitter in non-Overlapped cells and overlapped cells. The jitter in non-Overlapped cells is 5% more compared to overlapped cell.

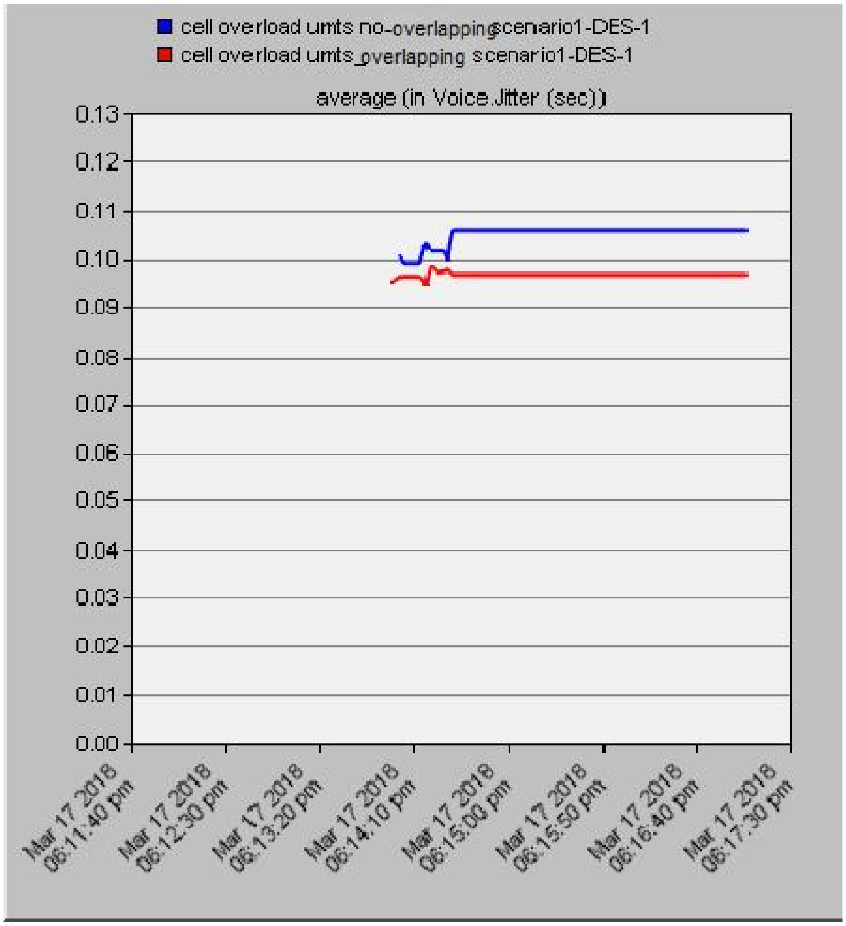

Figure 5.6 Average(in voice jitter(sec))

5.4 Received traffic

5.4.1 User received traffic

Figure5.7 illustrates the traffic received by the user in overlapped and non -overlapped cells. In both scenarios the traffic received by the user is the same.

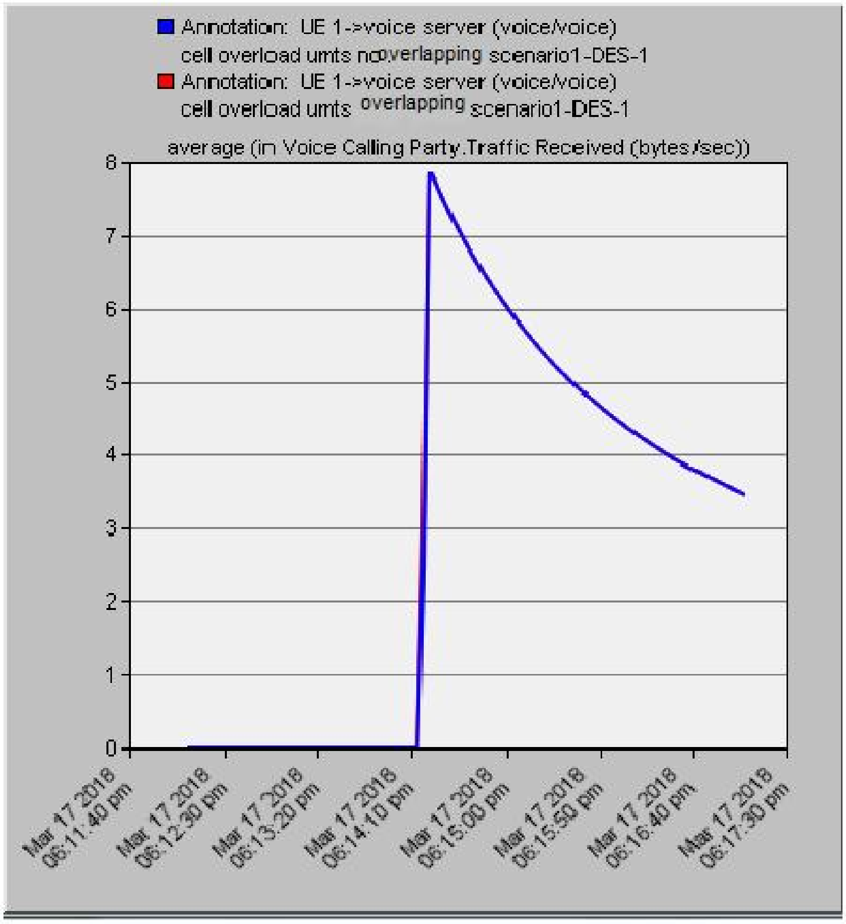

Figure 5.7 User received traffic

5.4.2 Average received traffic

Figure 5.8 illustrates the received traffic in non-overlapped and overlapped cells. As can be seen the average traffic is similar using both scenarios. In both scenarios the average traffic received by the user is the same.

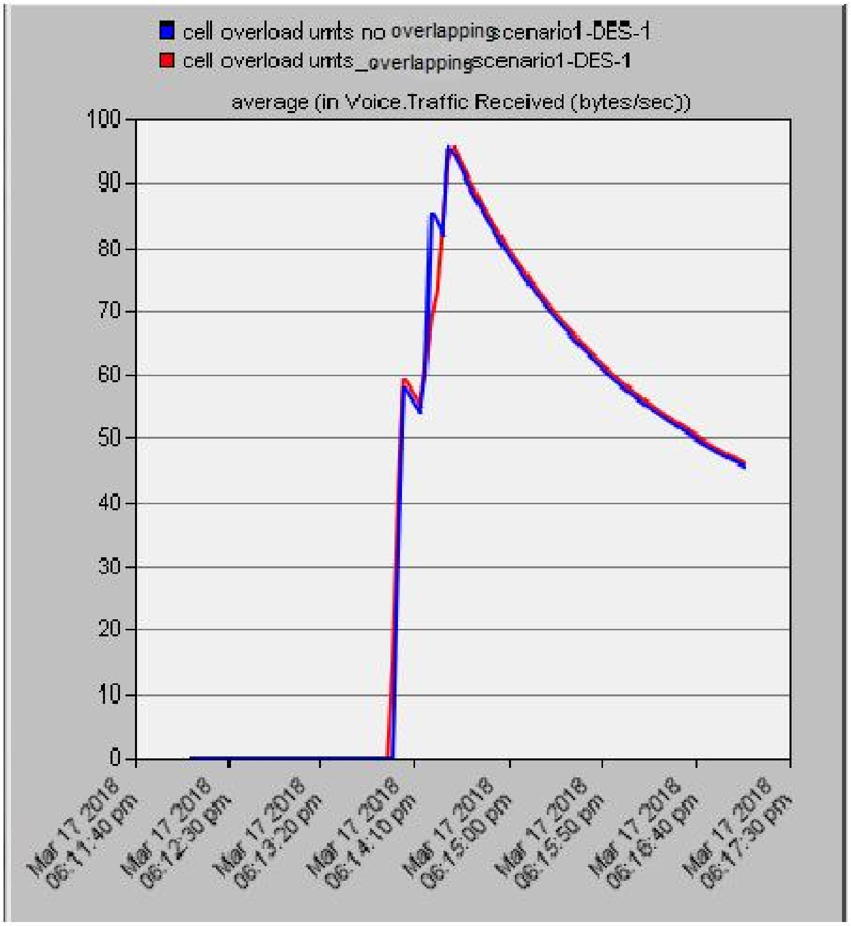

Figure 5.8 Average traffic Received

5.5 Result Discussion:-

In figure 5.2 We have shown the overall End -to-End delay of the call in overlapped cell and non-overlapped cell. The overall end-to-end delay is less when cell overlapping is used.

Figure 5.3 shown the average in voice overall packet delay variation. The packet delay using non overlapped cells is more than using overlapped cells. This is because when there is no cell overlapping, more users are served by the Node-B, increasing the delay.

In figure 5.4 we have shown packet End-to-End delay in non-overlapped cells and overlapped cells. The user end-to-end delay in overlapped cells is higher than in non-overlapped cells. This is because more time is consumed in transferring the call to the overlapped cell

Figure 5.5 have shown the user packet delay variation in non-overlapped and overlapped cells. The user end-to-end delay is less when no cell overlapping is used, as more time is spent to transfer the call to the overlapped cell. The delay for a single user is more, but for the overall network the performance is improved, as seen in Figure5.2.

Figure 5.6 we shown jitter in non-overlapped cells and overlapped cells. The jitter in non-overlapped cells is more compared to overlapped cell.

Figure5.7 we shown the traffic received by the user in overlapped and non-overlapped cells. In both scenarios the traffic received by the user is the same.

Figure 5.8 we shown the received traffic in non-overlapped and overlapped cells. As can be seen the average traffic is similar using both scenarios.

CHAPTER SIX

Conclusions and Future works

CHAPTER SIX

Conclusions and recommendation

6.1. Conclusion

This research has evaluated the QoS of VoIP in overlapped cells. Two scenarios are considered; the first scenarios with no overlapping, and the second scenarios having micro cell overlapped with a macro cell. A call request is made in the macro cell, and the QoS is evaluated for both scenarios and compared.

The results have shown that cell overlapping decreases the overall end-to-end delay even though it is slightly increased for the transferred call. Jitter is also reduced using cell overlapping. Cell overlapping does not lead to any significant packet loss.

6.2 Future works

To improve the current work, the following future works is recommended:

1. Consider a multi-cell environment where each overlapped layer contains more than one cell.

2. Using other simulators that supports 4G and evaluate cell overlapping in 4G systems.

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