Performance Enhancement in LTE-Advanced for Mobile Communication System

BY

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APPROVAL

This Project titled **“Performance Enhancement in LTE-Advanced for Mobile Communication Systems**”, submitted by Abdikarim Mohamed Ali to the Department of Electronics and Telecommunication Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfilment of the requirements for the degree of MSc. in Electronics and Telecommunication Engineering and approved as to its style and contents. The presentation was held on August, 2019

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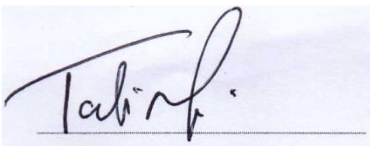

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ABSTRACT

The long term evolution (LTE) project was initiated in 2004 motivated by the need to reduce the cost per bit. And the flexible use of new and the existing frequency band. LTE-Advanced is the project named of the evolved version of LTE that is being developed by the 3GPP.LTE Advanced offers considerably higher data rates than even the initial releases of LTE. While the spectrum usage efficiency has been improved, this alone cannot provide the required data rates that are being headlined for 4G LTE Advanced. So as to accomplish higher data rates and efficiently utilize the available resources to design good channel with QOS the using **CA** and **MIMO** is the best solution for growing number of subscribers and good transmission. This thesis focusing on **CA** stands for Carrier Aggregation enables greater speeds because it allows you to download data from multiple sources at the same time. Instead of connecting to the best signal in your vicinity, your smartphone can combine multiple signals, even on different frequencies. Up to five of these "component carriers," each offering up to 20MHz of bandwidth, can be combined, which creates a maximum aggregated data pipe up to 100MHz and **MIMO** stands for Multiple Input Multiple Output, and it can increase the overall bitrate by transmitting two (or more) different data streams on two (or more) different antennas. All this accomplished by using MATLAB software program which simulate the performance enhancement of LTE-Advanced by using **CA** and **MIMO** techniques.

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LISTOFABBREVIATIONS

1G	First Generation
2G	Second Generation
3G	Third Generations
3GPP	Third Generation Partnership Project
4G	Fourth Generations
CA	Carrier Aggregation
CC	Carrier Component
CDMA	Code Division Multiple Access
CP	Cyclic Prefix
EDGE	Enhanced Data Rates for Global Evolution
FDM	Frequency Division Multiplexing
FDMA	Frequency Division Multiple Access
FFT	Fast Fourier Transform
GSM	Global system for mobile communications
GPRS	General Packet Radio Service
IFFT	Inverse Fast Fourier Transform
LTE	Long Term Evolution
LTE-A	Long Term Evolution Advanced
MIMO	Multiple Input Multiple Output
OFDM	Orthogonal Frequency Division Multiplexing

OFDMA	Orthogonal Frequency Division Multiple Access
PAR	Peak-to-Average Ratio
QAM	Quadrature Amplitude Modulation
SC-FDMA	Single Carrier Frequency Division Multiple Access
S/N – SNR	Signal to Noise Ratio
TDMA	Time Division Multiple Access
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
WIMAX	Worldwide Interoperability for Microwave Access
IMT	International Mobile Telecommunication
DSP	Digital Signal Processing
ETSI	European Telecommunications Standards Institute
USB	Universal Series Board
FDD	Frequency Division Duplex
TDD	Time Division Duplex
QOS	Quality of Service
EPC	Evolved Packet Core
HSPA	High Speed Packet Access
2CC	2 Carrier Components
3CC	3 Carrier Components
LSTI	LTE/SAE Trial Initiative

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Within thirty years, a big step in communication systems has been done Going from the First Generation (1G) to the fourth Generation (4G) made possible more services available on the mobile phones this evolution has been obtained due to the digitalization of the information and the updating of the used technology[1].

The first Generation was implemented around 1970s and it was launched in United States as First Generation of mobile system it was based on frequency division multiple access (FDMA) technology and it was a system which allowed users to make voice call within one country No data traffic was available yet, the voice itself was the main traffic [2].

At the end of 1980s the Second Generation (2G) was developed Digitalization of the control link between mobile and base station and digitalization of the voice signal were the most advanced Characteristic. The new system provided better quality and higher capacity Global system for mobile communications (GSM) and general packet radio service (GPRS) were the services available and time division multiple accesses (TDMA) the technology used [3].

The first Third Generation (3G) network was deployed in Japan in 2001 The systems in this standard are an update from 2G, going from circuit switched nodes to packet oriented nodes The advantages of 3G Systems are mainly the increase of available bandwidth per single user and the possibility to have multimedia entertainment services on the mobile phones A lot of technology are being standardized for the 3G system all around the World, but the most important change comparing with the 2G is the use of code division multiple access (CDMA) as access technology Regarding the 3G, some of the services have been standardized are enhanced data rates for global evolution (EDGE) and universal mobile telecommunications system (UMTS) [4].

Looking forward for the 4G Communication System, its services are the advanced version of the 3G services the 4G services are expected to be broadband, with large capacity, with high-speed transmission and to provide optimum services everywhere and anywhere. Going from 3G to 4G, the infrastructure will have only packet switched traffic also named as all-IP .Voice, data and multimedia application all on the same Communication System The 4G systems are OFDM-based system, which is a technology that increases the system capacity and the spectrum utilization in order to have a wide band communication. The technologies which are considered to be pre-4G are WIMAX and 3GPP LTE [1] [5].

1.2 Motivation

The focus of LTE Advanced is to provide higher capacity in a cost efficient manner. 3GPP Release 10 defines LTE Advanced, which unlike its predecessor, completely fulfills the ITU's requirements for IMT Advanced, making it truly 4G. The 3GPP requirements include performance targets such as increased peak data rates (3 Gbps – downlink and 1.5 Gbps – uplink), higher spectral efficiency of 30 bps/Hz, and support for an increased number of active subscribers simultaneously, and improved performance at cell edges. Plus LTE Advanced must be backwards compatible and fully operate with its predecessor, LTE. Finally, the 3GPP requires a commitment to continuous improvement efforts in the LTE technology.

1.3 Aims and Objectives

The general aim of this research is to investigate the effeteness of using carrier aggregation techniques to improve the overall performances these performances are:

- To provide the necessary specification support to efficiently realize the benefits of LTE-A in transmission and related work.
- Mathematical equations and parameter that used in Simulation model with a QOS of LTE-A in networks and all the scenario of channel such as noisy channel by Mat lab.
- To implement a QOS in the network to improve data rate, throughput, delay of data and spectrum efficiency which allow more subscribers in LTE-A.
- Compare the performance of two approaches: LTE Network and LTE-A in all result.

1.4 Thesis Outlines

This thesis is divided into six chapters their outlines are as follows:

Chapter 1: is Introduction .This chapter presents background of project, objectives project layout, and thesis organization.

Chapter 2: is Literature Review. This chapter shows the necessary theoretical aspects of this project Such as LTE. LTE - Advanced OFDMA, Coordinated Multipoint Transmission, Relay nodes, Heterogeneous network and Carrier Aggregation.

Chapter 3: is problem statement, explaining existing system vs. proposed system.

Chapter 4: is LTE-Advanced. This chapter gives the mathematical expressions used to explain the concepts of Carrier Aggregation and its techniques.

Chapter 5: is Simulation and Results. This chapter presents the simulation process and resulting graphs for Carrier Aggregation.

Chapter 6: is performance analysis. This chapter presents problem statement and also proposed solution

Chapter 7: is Conclusion and future work. This chapter concludes the project and proposes some subjects that can be investigated for a future work.

Chapter Two

Literature Review

In this chapter the necessary theoretical aspects of the project such as LTE, LTE-Advanced, OFDMA, and Carrier Aggregation are presented.

2.1 The History OF LTE

Long-Term Evolution (LTE) commonly marketed as **4G** is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements. The standard is developed by the 3GPP (3rd Generation Partnership Project) and is specified in its Release 8 document series, with minor enhancements described in Release 9[12].

LTE is the natural upgrade path for carriers with both GSM/UMTS networks and CDMA2000 networks. The different LTE frequencies and bands used in different countries will mean that only multi-band phones will be able to use LTE in all countries where it is supported [12].

Although marketed as a 4G wireless service, LTE (as specified in the 3GPP Release 8 and 9 document series) does not satisfy the technical requirements the 3GPP consortium has adopted for its new LTE Advanced standard. The requirements were originally set forth by the ITU-R organization in its IMT Advanced specification. However, due to marketing pressures and the significant advancements that WiMAX, Evolved HSPA and LTE bring to the original 3G technologies, ITU later decided that LTE together with the aforementioned technologies can be called 4G technologies. The LTE Advanced standard formally satisfies the ITU-R requirements to be considered IMT-Advanced to differentiate LTE Advanced and WiMAX-Advanced from current 4G technologies, ITU has defined them as "True 4G"[11].

LTE stands for Long Term Evolution and is a registered trademark owned by ETSI (European Telecommunications Standards Institute) for the wireless data communications technology and a development of the GSM/UMTS standards. However other nations and companies do play an active role in the LTE project. The goal of LTE was to increase the capacity and speed of wireless data networks using new DSP (digital signal processing) techniques and modulations that were developed around the turn of the millennium. A further goal was the redesign and simplification of the network architecture to an IP-based system with significantly reduced transfer latency compared to the3G architecture. The LTE wireless interface is incompatible with 2G and 3G networks, so that it must be operated on a separate radio spectrum [11].

LTE was first proposed by NTT DoCoMo of Japan in 2004, and studies on the new standard officially commenced in 2005 In May 2007, the LTE/SAE Trial Initiative (LSTI) alliance was founded as a global collaboration between vendors and operators with the goal of verifying and promoting the new standard in order to ensure the global introduction of the technology as quickly as possible. The LTE standard was finalized in December 2008, and the first publicly available LTE service was launched by TeliaSonera in Oslo and Stockholm on December 14, 2009 as a data connection with a USB modem. The LTE services were launched by major North American carriers as well, with the Samsung SCH-r900 being the world's first LTE Mobile phone starting on September 21, 2010 and Samsung Galaxy Indulge being the world's first LTE smartphone starting on February 10, 2011\both offered by MetroPCS and HTC Thunderbolt offered by Verizon starting on March 17 being the second LTE smartphone to be sold commercially.In Canada, Rogers Wireless was the first to launch LTE network on July 7, 2011 offering the Sierra Wireless AirCard® 313U USB mobile broadband modem, known as the "LTE Rocket™ stick" then followed closely by mobile devices from both HTC and Samsung Initially, CDMA operators planned to upgrade to rival standards called UMB and WiMAX, but all the major CDMA operators (such as Verizon, Sprint and MetroPCS in the United States, Bell and TELUS in Canada, au by KDDI in Japan, SK Telecom in South Korea and China Telecom/China Unicom in China) have announced that they intend to migrate to LTE after all. The evolution of LTE is LTE Advanced, which was standardized in March 2011 Services are expected to commence in 2013[11].

The LTE specification provides downlink peak rates of 300 Mbit/s, uplink peak rates of 75 Mbit/s and QoS provisions permitting a transfer latency of less than 5 ms in the radio access network. LTE has the ability to manage fast-moving mobiles and supports multi-cast and broadcast streams. LTE supports scalable carrier bandwidths, from 1.4 MHz to 20 MHz and supports both frequency division duplexing (FDD) and time-division duplexing (TDD). The IP-based network architecture, called the Evolved Packet Core (EPC) designed to replace the GPRS Core Network, supports seamless handovers for both voice and data to cell towers with older network technology such as GSM, UMTS and CDMA2000. The simpler architecture results in lower operating costs (for example, each E-UTRA cell will support up to four times the data and voice capacity supported by HSPA [11].

2.2 Long Term Evolution LTE

Long Term Evolution (LTE) is the next step forward in cellular 3G Services. LTE is a 3GPP standard that provides for an uplink speed of up to 50 Mbps and a downlink speed of up to 100 Mbps LTE will bring many technical benefits to cellular networks Bandwidth will be scalable from 1.4 MHz to 20 MHZ. This will suit the needs of different network operators that have different bandwidth allocations, and also allow operators to provide different services based on spectrum LTE is also expected to improve spectral efficiency in 3G networks, allowing carriers to provide more data and voice services over a given bandwidth [10].

2.3 Long Term Evolution Advanced LTE-A

LTE-Advanced is required to deliver a peak data rate of 1000 Mbps in the downlink, and 500 Mbps in the uplink using a total bandwidth of 100 MHz that is made from five separate components of each 20 MHz, LTE-Advanced is designed to be backwards compatible with LTE, in the sense that an LTE mobile can communicate with a base station that is operating LTE-Advanced and vice-versa [10].

2.4 Comparison between LTE and LTE- Advanced

Summary comparison of performance requirements of LTE with some of the Current agreements of LTE Advanced [10].

Table 2.1: That shows the comparison between LTE and LTE-A

Technology	LTE	LTE-Advanced
Peak Data Rate Down Link	150mbit/s	1Gbit/s
Peak Data Rate Up Link	75mbits/s	500mbits/s
Transmission Bandwidth Down link	20MHZ	100MHZ
Transmission Bandwidth up link	20MHZ	40MHZ(40 MHz (as defined by ITU)
Mobility	Optimized for low speeds (<15 km/Hr), High performance as speeds up to 120 km/hr, Maintain links at speeds up to 350 km/hr	Same as in LTE
Coverage	Full Performance up to 5 Km	(a) Same as LTE Requirement (b) should be optimized or deployment in local

		areas/micro cell environments
Scalable Bandwidths	1.3, 3, 5, 10, and 20 MHz	up to 20-100 MHz
Capacity	200 active users cell in 5 MHz	3 times higher than that in LTE

2.5 Orthogonal Frequency Division Multiple Access

Orthogonal Frequency Division Multiple Access (OFDMA) is a combination of modulation and multiplexing the main concept in OFDMA is orthogonally of sub-carriers this allows simultaneous transmission on a lot of sub-carriers without interference with each other (overlapped) as shown in Figure 2.1[6].

OFDMA is used in the downlink part of MIMO, SC-FDMA (single carrier) is used in the uplink OFDMA uses multi-carrier transmission where data are divided on different sub-carriers of one transmitter and that convert the wideband channel (frequency-selective channel) into group of narrowband channels (flat fading channel) [6].

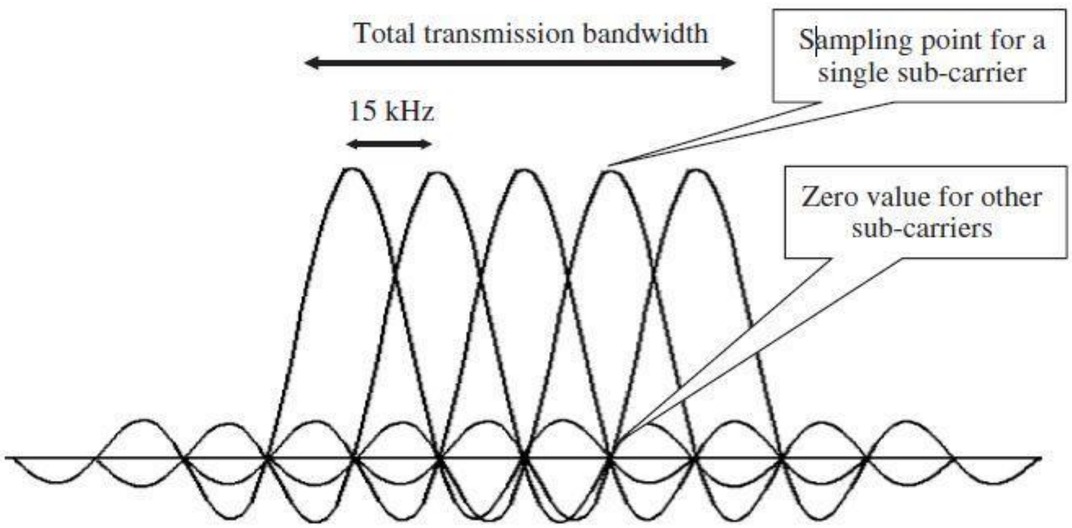


Figure 2.1: Maintaining the sub-carriers' orthogonally

2.5.1 OFDMA Transmitter and Receiver

OFDMA uses Fast Fourier Transform (FFT) block and the inverse Operation (IFFT) to move between time and frequency domain

Representation and reduce the complexity of receivers and transmitters (instead of using N Modulators/Demodulators for sub-carriers) [6].

In the transmitter of an OFDMA system (Figure2.2), the data source feeds to the serial-to-parallel conversion and further to the IFFT block, and then uses IFFT block to create the signal each input for the IFFT block corresponds to the input representing a particular sub-carrier (or particular frequency component of the time domain signal) and can be modulated independently of the other sub-carriers. The IFFT block is followed by adding the cyclic extension (cyclic prefix). The motivation for adding the cyclic extension is to avoid inter-symbol interference [20].

When the transmitter adds a cyclic extension longer than the channel impulse response, the effect of the previous symbol can be avoided by ignoring (removing) the cyclic extension at the receiver the cyclic prefix (CP) is added by copying part of the symbol at the end and attaching it to the beginning of the symbol as shown in Figure (2.3) [7].

The receiver of an OFDMA system does the inverse operations. It needs synchronization to allow the correct frame and symbol time to be obtained so that the CP removed. The equalizer revert the channel impact for each sub-carrier as shown in Figure (2.2) [7].

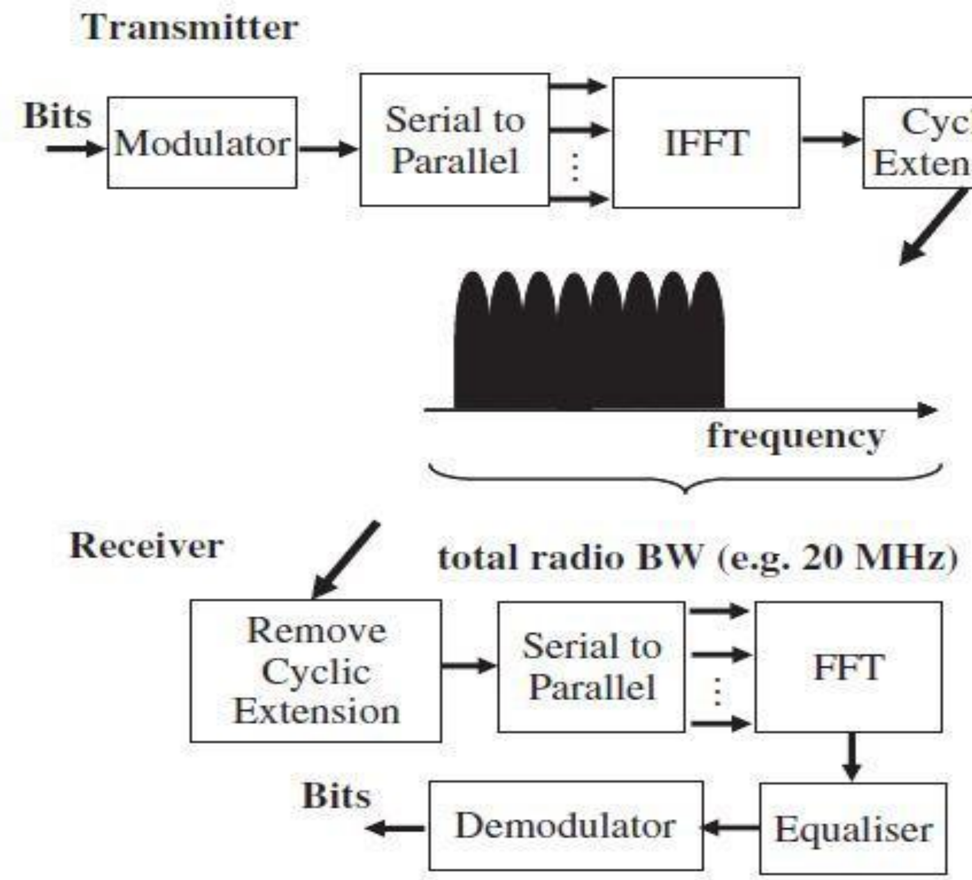


Figure 2.2: OFDMA transmitter and receiver

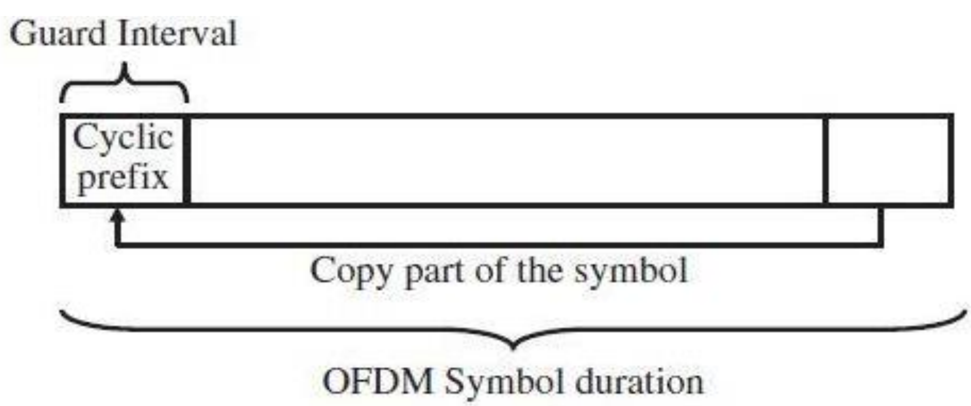


Figure 2.3: Creation of the guard interval for the OFDM symbol.

2.5.2 Advantages OF OFDMA

There are Five Advantages of Orthogonal Frequency Division Multiple Access These Advantages are :

- The first one is Good performance in frequency selective fading channels.
- The Second one is Low complexity of base-band receiver.
- The Third one is Good spectral properties and handling of multiple bandwidths.
- The Fourth one is Link adaptation and frequency domain scheduling.
- The Last one is Compatibility with advanced receiver and antenna technologies.

2.5.3 Challenges OF OFDMA

- Tolerance to frequency offset. This was tackled in LTE design by choosing a subcarrier. Spacing of 15 kHz which gives a large enough tolerance for Doppler shift due to velocity [20].
- The high Peak-to-Average Ratio (PAR) of the transmitted signal, which requires high linearity in the transmitter The linear amplifiers have low power conversion efficiency and therefore are not ideal for mobile uplinks. In LTE this was solved by using the SC-FDMA, which enables better power amplifier efficiency.

2.6 LTE Advanced Enabling Technologies

To meet the demanding requirements of LTE-A, the 3GPP is in the process of development of certain technological proposals. To this end, 3GPP has focused its attention on different points that required technological innovations: support of wider bandwidth (carrier aggregation), advanced MIMO techniques, relaying, enhancements for HeNBS, and so on, In the following sub-subsections, some examples of technologies considered for LTE-Advanced are outlined.

2.6.1 MIMO WITH LTE

For many years base station antennas have been modified in one way or another to optimize the transmission or reception of signals. Multiple antenna elements may be used to shape beams and steer nulls in one direction or another. In the terminal, too, one may double the number of receive antennas to nearly double the received power and increase the SINR by nearly 3 dB.

In wireless communication, the transmitted signals are being attenuated by obstacles between the transmitter and the receiver, yielding a fundamental challenge for reliable communication.

2.6.1.1 Types of antennas technology:

SISO (single input, single output) refers to a wireless communications system in which one antenna is used at the source (transmitter) and one antenna is used at the destination (receiver). SISO is the simplest antenna technology. In some environments, SISO systems are vulnerable to problems caused by multipath effects. When an electromagnetic field (EM field) is met with obstructions such as hills, canyons, buildings, and utility wires, the wavefronts are scattered, and thus they take many paths to reach the destination.

The late arrival of scattered portions of the signal causes problems such as fading, cut-out (cliff effect), and intermittent reception (picket fencing). In a digital communications system, it can cause a reduction in data speed and an increase in the number of errors.

SIMO (single input, multiple output) is an antenna technology for wireless communications in which multiple antennas are used at the destination (receiver). The antennas are combined to minimize errors and optimize data speed. The source (transmitter) has only one antenna.

MISO (multiple input, single output) is an antenna technology for wireless communications in which multiple antennas are used at the source (transmitter). The antennas are combined to minimize errors and optimize data speed. The destination (receiver) has only one antenna.

And

MIMO (multiple input, multiple output) multiple-input multiple-output (MIMO) antennas isa well-known diversity technique to enhance the reliability of the communication. Furthermore, with multiple antennas, multiple streams can be sent out and hence, we can obtain a multiplexing gain which significantly improves the communication capacity. MIMO systems have gained significant attention for the past decades, and are now being incorporated into several new generation wireless standards (e.g LTE-Advanced, 802.16m).Figure (2.4) shows the four types of antenna technology.

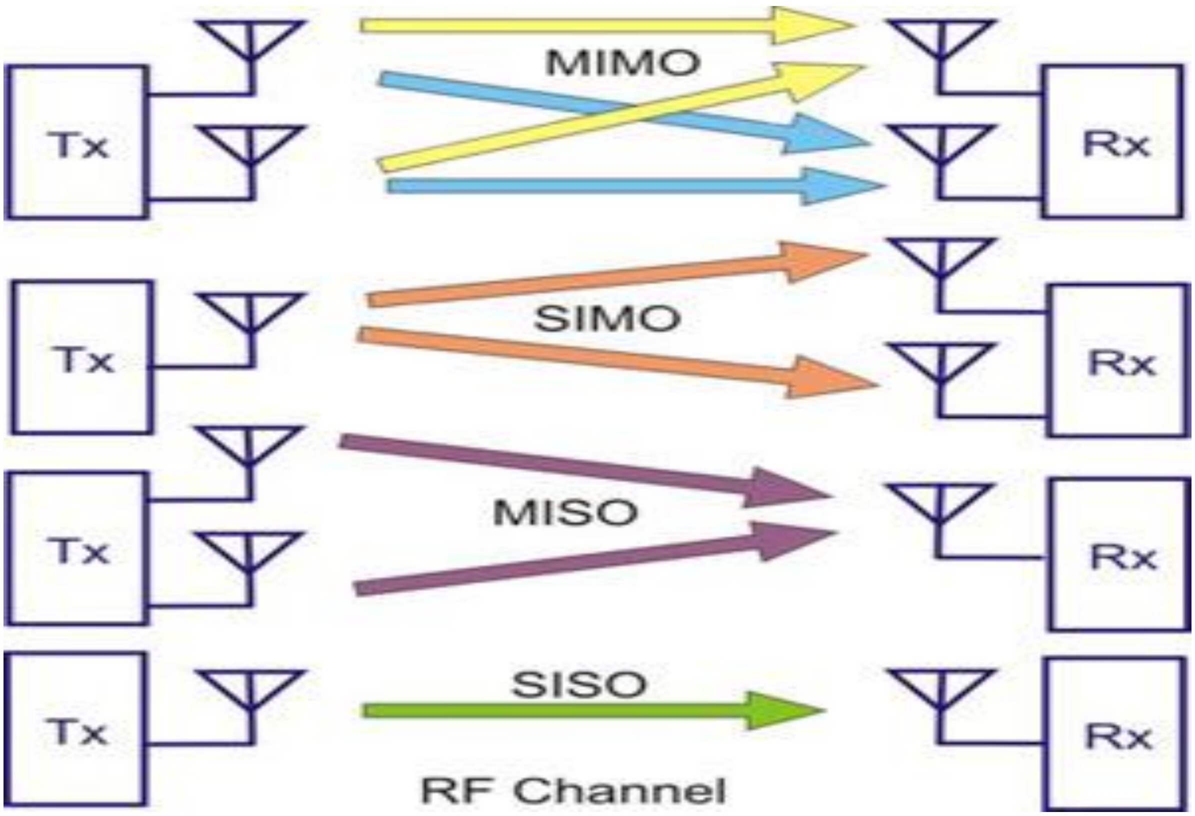


Figure (2.4)the four types of antenna technology.

Introducing multiple antennas at the tx and rx improves both the capacity and reliability of the communication system without any extra bandwidth or power needed.

Three types of gain can be provided by a MIMO system:

1. Beam forming gain.

2. Multiplexing gain.

3. Diversity gain.

2.6.1.2 Types of MIMO technology:

2.6.1.2.1 SU-MIMO (Single User MIMO)

The basic understanding of the single user technology. It came along as an optional technology with the 802.11n wireless standard in 2007. It enabled multiple streams of data to be simultaneously transmitted or received between two Wi-Fi devices using multiple antennas and beam forming technology. It helps increase the speed at which data passes between those two Wi-Fi devices. Single-user MIMO can only talk to one client at a time. All the work necessary to multiplex those data streams require the full attention of a single access point for the period in time that the client is transmitting. That means that crowded wireless networks can see reduced throughput because of shorter transmit windows.

The most obvious down side to single user MIMO is that the multiple streams of data must be sent or received between just one device at time. However, there are more cons as well. For instance, single user MIMO requires both the transmitting and receiving Wi-Fi radios support the MIMO technology, along with having multiple antennas. The multiple antennas add cost, weight, and size to the Wi-Fi devices and the processing of the MIMO signals requires more resources as well. These are especially evident with the smaller devices, like smartphones and tablets.

2.6.1.2.2 MU-MIMO (Multi User MIMO)

We know that several users are simultaneously served by a multiple-antenna base station (BS).

With MU-MIMO setups, a spatial multiplexing gain can be achieved even if each user has a single antenna. This is important since users cannot support many antennas due to the small physical size and low cost requirements of the terminals, whereas the BS can support many antennas, Multi user MIMO is being released in the second wave of the 802.11ac wireless standard. It enhances the MIMO technology by enabling Wi-Fi to simultaneously transmit those multiple streams to different Wi-Fi devices, instead of just one single device as with the older versions shown in Figure (2.5).

So for instance, say an access point is capable of sending four data streams simultaneously, it could send all four to a device that can accept four. Alternatively, it could send two streams to one device and the other two streams to two different devices.

In all, three different devices would be receiving streams simultaneously.

MU-MIMO in cellular systems brings improvements on four fronts:

- Increased data rate, because the more antennas, the more independent data streams can be sent out and the more terminals can be served simultaneously.

- Enhanced reliability because the more antennas the more distinct paths that the radio signals can propagate over.

- Improved energy efficiency, because the base station can focus its emitted energy into the spatial directions where it knows that the terminals are located.

- Reduced interference because the base station can purposely avoid transmitting into directions where spreading interference would be harmful.

All improvements cannot be achieved simultaneously, and there are requirements on the propagation conditions, but the four above bullets are the general benefits. MU-MIMO technology for wireless communications in its conventional form is maturing, and incorporated into recent and evolving wireless broadband standards like 4G LTE and LTE-Advanced (LTE-A). The more antennas the base station (or terminals) are equipped with, the better performance in all the above four respects—at least for operation in time division duplexing (TDD) mode. However, the number of antennas used today is modest.

The most modern standard, LTE-Advanced, allows for up to 8 antenna ports at the base station and equipment being built today has much fewer antennas than that.

For instance, multi user MIMO, Wi-Fi devices receiving one of the MIMO data streams doesn't have to have multiple antennas. The receiving Wi-Fi devices must support the multi user MIMO technology, but if there's only one antenna then it could still receive one of the multiple data streams from the wireless router or access point.

Furthermore, the wireless router or access point is the device that does the heavy processing of the MIMO signals, thus it's less taxing on the processors of the Wi-Fi devices. This all means saved cost, weight, and size for the devices supporting the multi user MIMO technology.

In addition to increase speeds, multi user MIMO also has the potential to increase the capacity of wireless networks. Since Wi-Fi devices can be served quicker, the more devices there can be. A noticeable difference could be especially realized on public Wi-Fi hotspot networks with a dense amount of users in certain area.

One very interesting side effect of the signal processing of multi user MIMO is that the data is scrambled while traveling from the wireless router or access points through the airwaves to the Wi-Fi devices. This basically means unsecure or unencrypted connections, such as when on public Wi-Fi hotspots, can see an increase in security. Any eavesdroppers nearby capturing the Wi-Fi traffic won't be able to make use of any of the data that's transmitted as multi user MIMO. This is also useful on private networks as well that are using the personal (PSK) mode of Wi-Fi security. Normally, any eavesdropper nearby that knows the Wi-Fi password can decrypt the wireless traffic from the other users, but that won't be the case for multi user MIMO traffic.

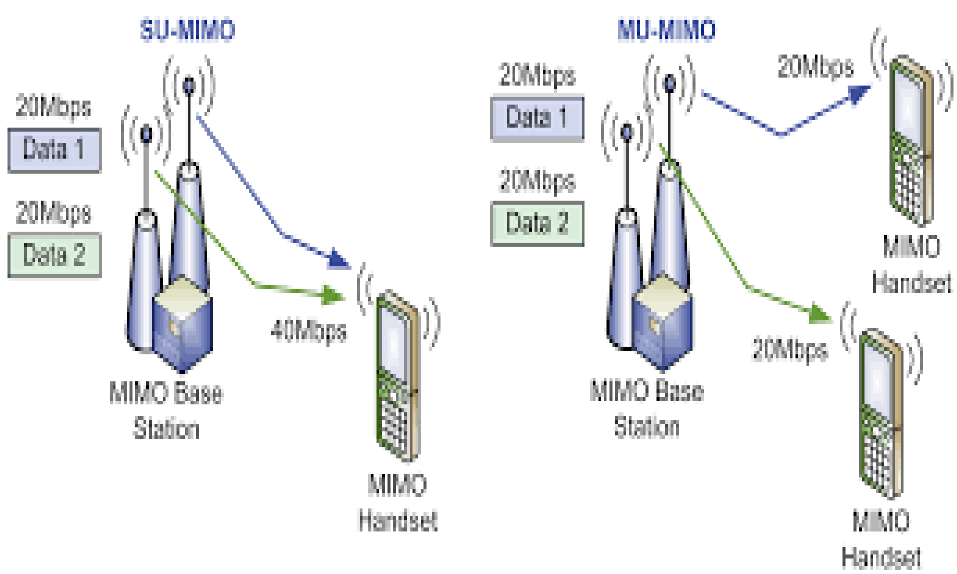


Figure (2.5) shows SU MIMO vs. MU MIMO

The rules and regulations for single MIMO and beam forming that were designed with the 802.11n wireless standard weren't as standardized as they are with the multi user MIMO and the 802.11ac standard. Having a more standardized technology means that products from different manufacturers will all support the same technology and methods. More products with the technology, means the better the chance the technology will make a difference on your network.
The major stipulation of multi user MIMO is that it currently only works on the downlink connection of Wi-Fi: the transmissions from the wireless router or access point to the Wi-Fi devices users have connected. Right now Wi-Fi devices can only transmit a single stream of data to the wireless router or access point with the multi user MIMO technology no matter how many antennas there are on either device. Though single user MIMO actually worked on both the uplink and downlink connection, multi user MIMO is typically seen as a better option overall when you weigh all the pros and cons of each technology.
Another important fact about multi user MIMO is that it only works on the 5GHz Wi-Fi band. Though 802.11ac devices also support the older standards, like 802.11n or even 802.11b/g, this newer MIMO technology only works for connections utilizing the actual 802.11ac standard, which is a 5GHz-only technology. Thus other than the positive side effects like I discussed, increased total throughput, the multi user MIMO technology doesn't directly affect devices using 802.11n or earlier. Apart of the MIMO technology is beam forming, where the Wi-Fi signals are directed towards the intended recipient rather than always being sent equally in all areas. This raises a potential issue for rapidly moving Wi-Fi devices. The movement can complicate and slow the MU-MIMO performance. However, the wireless router or access point should detect this when it arises and will likely revert to single user MIMO, which isn't so sensitive to movement, for any problem devices when needed, while continuing multi user MIMO with any other devices. It's safe to say multi MIMO won't be much of a benefit to networks with a majority of roaming devices.
There are two scenarios associated with MU-MIMO, Multi-user MIMO:

- Uplink - Multiple Access Channel, MAC: The development of the MIMO-MAC is based on the known single user MIMO concepts broadened out to account for multiple users.
- Downlink - Broadcast Channel, BC: The MIMO-BC is the more challenging scenario. The optimum strategy involves pre-interference cancellation techniques known as "Dirty

Paper Coding". This is complemented by implicit user scheduling and a power loading algorithm

MU-MIMO does not only reap all benefits' of MIMO systems, but also overcomes most of propagation limitations in MIMO such as ill-behaved channels. Specifically, by using scheduling schemes, we can reduce the limitations of ill-behaved channels. Line-of-sight propagation, which causes significant reduction of the performance of MIMO systems, is no longer a problem in MU-MIMO systems. Thus, MU-MIMO has attracted substantial interest.

There always exists a tradeoff between the system performance and the implementation complexity.

2.6.2 Heterogeneous Networks

The need to provide a greater amount of data for a large number of subscribers is shaping network developments as the traditional macro-cellular networks are not always adequate to deal with the increased capacity demands. With the limit in the increase in the capacity per Hz, the dimension to explore is that of cell size. As the demand for the capacity is not expected to be uniform, the networks of today are expected to evolve increasingly in the direction where the cell sizes vary drastically. In areas of less demand, improvements in macro-cell capacity can cope with the increased demands, but in densely populated areas there is a need to enhance capacity with smaller cells, from macro cell level down to micro and Pico cells, and in some cases even to Femtocells [8], Figure2-6.example of heterogeneous Networks.

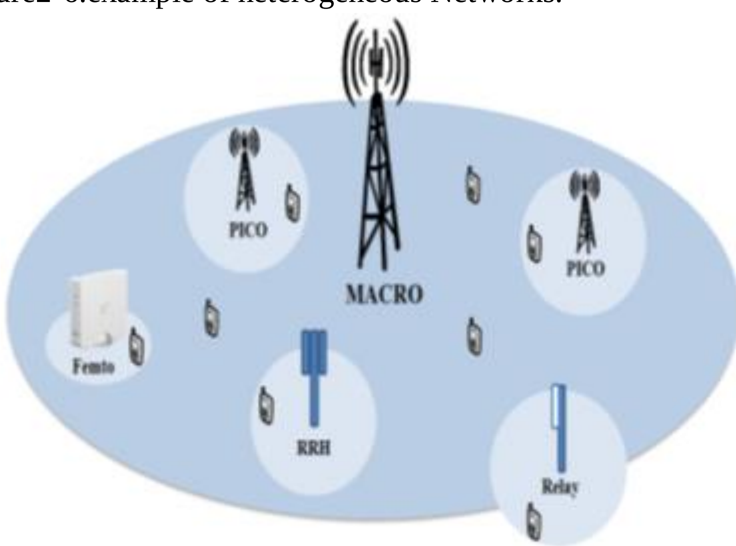


Figure 2.6 Example of heterogeneous Networks.

2.6.3 Relays Nodes

One of the new technology components, that is standardized in release 10, is relaying. The concept of Relay Node (RN), has been introduced to enable traffic signaling forwarding between eNB and UE to improve the coverage of high data rates, group mobility, cell edge coverage, and to extend coverage to heavily shadowed areas in the cell or areas beyond the cell range. The relay nodes are wirelessly connected to the radio access network via a donor cell. Next Figure 2-7. Use of RN to improve indoor coverage [8]

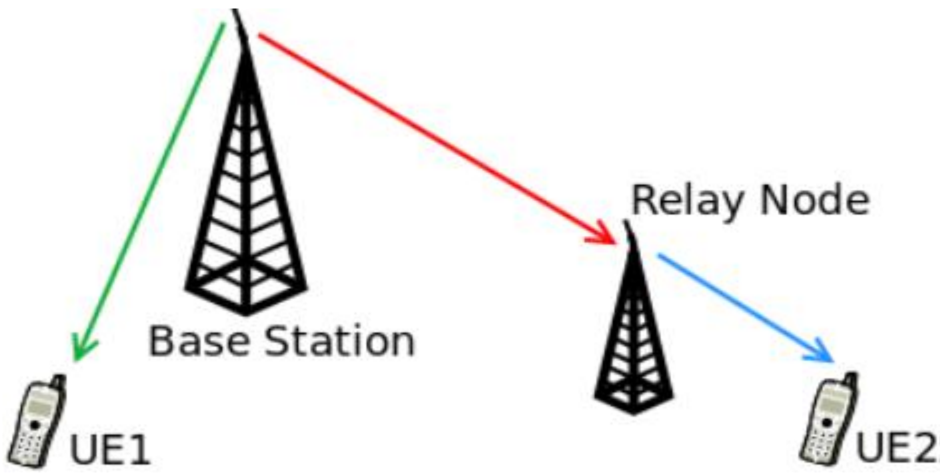


Figure 2-7. Use of RN to improve indoor coverage

The connections can be either in-band or out-band. In in-band connection, the eNB to relay link shares the same band with the direct eNB to UE link within the donor cell. In this case, Rel-8 UEs should be able to connect to the donor cell. For out-band connection, on the other hand, the eNB to relay connection is at a different band from that of the direct eNB to UE link. The relay Node scan be classified into two types; transparent and non-transparent. In transparent relay, the UE is not aware that it is communicating with the eNB via a relay. Transparent relay was proposed for the scenarios where it is intended to achieve throughput enhancement of UEs located within the coverage of the eNB with less latency and complexity but it may also be used for filling in coverage holes. The transparent relay operation supports the separation of the control signal and the data transmission. Since the UE is located within the coverage of the eNB, the DL control signal from the eNB can directly reach the UE without going through the RN.

Therefore, the UE may synchronize to the eNB and receives some control signals, The direct DL control connection between eNB and UE would reduce the scheduling latency and the signaling overhead for multi-hop relay networks.

In non-transparent relay the UE is aware that it is communicating with the eNB via a RN. All the data traffic and control signal transmission between eNB and UE are forwarded along the same relay path. Although non transparent relaying is applicable for almost all cases, wherever the UE is, within the coverage of eNB or coverage holes, it may not be an efficient way for all scenarios, because both the data and control signaling are conveyed multiple times over the relay links and the access link of a relay path.

2.6.4 Coordinated Multipoint Transmission or Reception

The coordinated multipoint transmission/reception is considered by many companies as a clear candidate to improve the system capacity and cell-edge user spectral efficiency, thus fulfilling the requirements of LTE-A. The LTE Release 8 allows a certain degree of cooperation between base stations in order to reduce interference. However, a big improvement is expected in this technique with LTE-A as compared with LTE Release 8 [9].

2.6.5 Carrier Aggregation

Carrier aggregation is one of the most distinct features of 4G systems including LTE-Advanced It allows scalable expansion of effective bandwidth through concurrent utilization of radio resources across multiple carriers to be delivered to a user terminal These carriers may be of different bandwidths, and may be in the same or different bands to provide maximum flexibility in utilizing the scarce radio spectrum available to operators By combining the deployment of new radio equipment and additional spectrum operators are able to increase capacity substantially So, in this way the Carrier Aggregation (CA) technology can support very high data rate transmissions over wide frequency bandwidths [8][18].

2.6.5.1 The Need for Carrier Aggregation

The multi-antenna techniques cannot continuously increase transmission performance, because the constraints on terminal size, complexity, and cost limit the number of antennas that can be installed on a UE unit In order to achieve the performance requirements of IMT-Advanced systems, Carrier Aggregation (CA) has been proposed in order to aggregate two or more component carriers for supporting high-data-rate transmission over a wide bandwidth (i.e., up to 100 MHz for a single UE unit), while preserving backward compatibility to legacy systems Without any carrier aggregation the system bandwidths are 10 or 20 MHz, the cases with more than 20 MHz of bandwidth will result in multiple 20 MHz systems working in parallel. With these assumptions the average data rates will be 20 or 40 Mbps and the peak data rates will be 100 or 200 Mbps [9][18].

2.6.5.2 Carrier Aggregation Classification

Carrier Aggregation may be classified in three different spectrum scenarios.

- Intra band contiguous carrier Aggregation, this is where a contiguous bandwidth wider than the 20 MHz is used for carrier aggregation Although this may be a less likely scenario given frequency allocations today it can be common when New spectrum bands like 3.5 GHz are allocated in the future in various parts of the world.
- Intra band Non Contiguous Carrier Aggregation, this is where multiple CCs belonging to the same band are used in none contiguous manner this can be common in countries where spectrum allocation is non- contiguous within a single band.
- Inter band non- contiguous carrier Aggregation, this is where multiple component carriers belonging to different bands e.g., 2GHz and 800MHz are aggregated [9].

The current standards allow for up to five 20 MHz carriers to be aggregated, although in practice two or three is likely to be the practical limit. These aggregated carriers can be transmitted in parallel to or from the same terminal, thereby enabling a much higher throughput to be obtained [9].

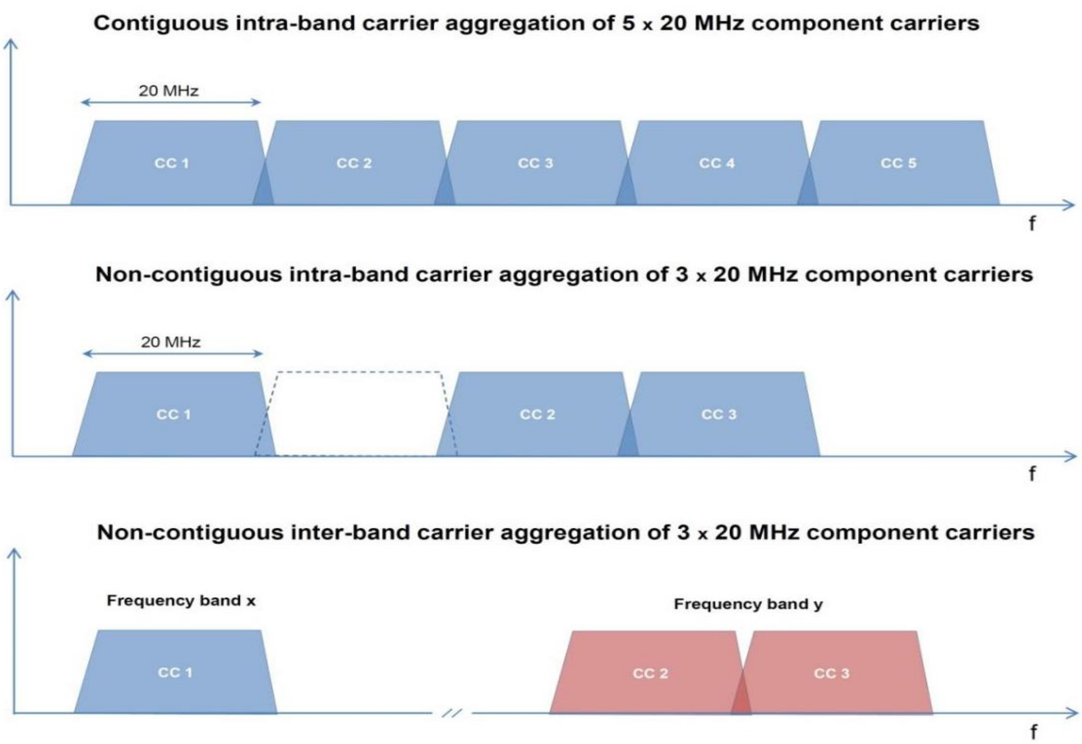


Figure 2.8 Illustration of Carrier Aggregation Classification

2.7 Related Works

Unlike wired digital networks, wireless digital networks are much more prone to bit errors. Packets of bits that are received are more likely to be damaged and considered unusable in a packetized system. Error detection and correction mechanisms are vital and numerous techniques exist for reducing the effect of bit-errors and trying to ensure that the receiver eventually gets an error free version of the packet. The major techniques used are error detection with Automatic Repeat Request (ARQ), Forward Error Correction (FEC) and hybrid forms of ARQ and FEC (H-ARQ). Forward Error Correction (FEC) is the method of transmitting error correction information along with the message. At the receiver, this error correction information is used to correct any bit-errors that may have occurred during transmission. The improved performance comes at the cost of introducing a considerable amount of redundancy in the transmitted code. There are various FEC codes in use today for the purpose of error correction. Most codes fall into either of two major categories: block codes and convolutional codes. Block codes work with fixed length blocks of code. Convolutional codes deal with data sequentially (i.e. taken a few bits at a time) with the output depending on both the present input as well as previous inputs. In terms of implementation, block codes become very complex as their length increases and are therefore harder to implement. Convolutional codes, in comparison to block codes, are less complex and therefore easier to implement. In packetized digital networks convolution ally coded data would still be transmitted as packets or blocks. However these blocks would be much larger in comparison to those used by block codes. The design of error correcting codes and their corresponding decoders is usually done in isolation. The code is often designed first with the goal of minimizing the gap from Shannon capacity and attaining the target error probability. To reflect the concerns of implementation, the code is usually chosen from a family of codes that can be decoded with low ―complexity‖ .On the implementation side, decoders are carefully designed for the chosen code with the goal of consuming low power while achieving the required decoding throughput2. This ―division of labor‖ has been extremely successful and forms the paradigm behind many modern long-distance communication system designs. Shannon-theoretic limits, complemented by modern coding-theoretic constructions, have provided codes that are provably good for minimizing transmit power. Can we develop a parallel approach in order to minimize the total system power? With simplistic encoding/decoding models, the issue of fundamental limits on total (transmit +encoding+ decoding). These fundamental limits abstract power consumed in computational nodes, and wiring in the encoder/decoder implementation and can provide insights into the choice of the code and its corresponding decoding algorithm. While such theoretical insights can serve to guide the choice of the code family, the simplicity of these theoretical models, which (to an extent) is needed in order to be able to obtain fundamental bounds, also limits their applicability. Even if the models are refined further, the large-deviations techniques used are usually tight only in asymptotic. Thus, at reasonably high error probability and small distances it is unlikely that the bounds themselves can be used to give precise answers on what codes to use. Given the limitations of the fundamental bounds, how do we search for a total-power-efficient code & decoder? After all, for a given block length, there are super-exponentially many possible codes. Further, for each code, there are many possible decoding algorithms. Even when the code and its corresponding decoding algorithm are fixed, there are many possible implementation architectures. Even today, the design and optimized implementation of just a single decoder requires significant effort. It is therefore infeasible to implement and measure the power consumption of every code and decoder in order to determine the best combination.

As technology scales, Multiple Cell Upsets (MCUs) become more common and affect a larger number of cells. In order to protect memories against MCUs as well as SEUs is to make use of advanced Error detecting and correcting codes that can correct more than one error per word. A sub-group of the low-density parity checks (LDPC) codes, which belongs to the family of the Majority logic decoding has been recently proposed for memory application and Difference set codes are one example of these codes which contributes for error detection and correction.ML decodable Codes are suitable for memory applications due to their capability to correct a large number of errors. In this paper, the proposed scheme for fault-detection and correction method significantly makes area overhead minimal and to reduce the decoding time through DC codes than the existing technique and it gives promising option for memory applications. HDL implementation and synthesis results are included, showing that the proposed techniques can be efficiently implemented.

This paper presents a solution to design and implement a hardware error detection and correction circuit using associative memories. This type of memory allows search of a binary value stored, having input data a partial (or modified) amount of this value. This property can be used in communication, for detection and correction of errors. In our analysis, the obtained experimental results were compared with performances of other hardware systems.

CHAPTER THREE

PROBLEM STATEMENT

3.1 Introduction

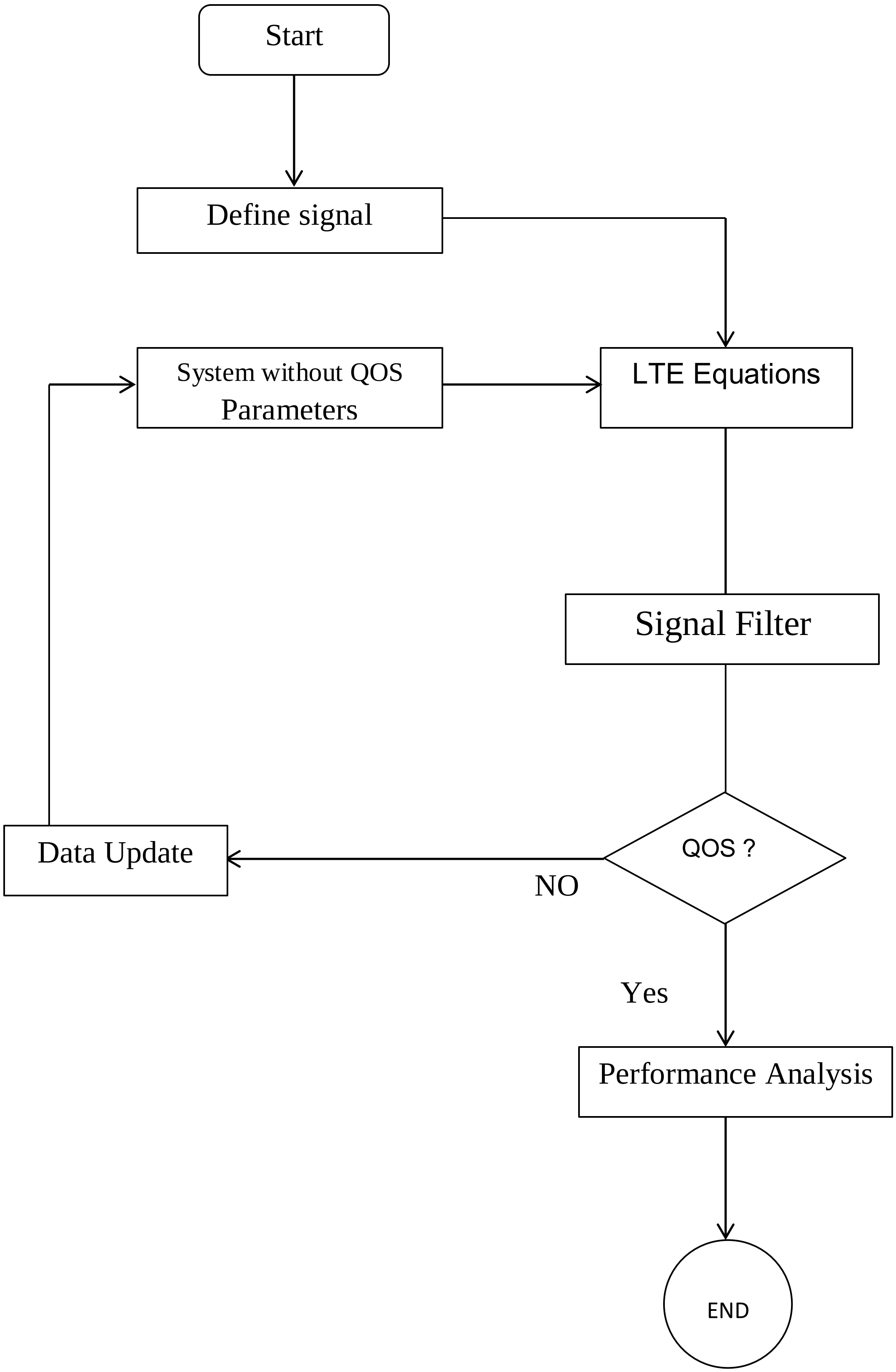
In this chapter, we will present the performance enhancement for LTE - Advanced will introduce the existing and proposed systems

3.2 Existing System Model

Data can be corrupted during transmission; some applications can tolerate a small level of error. For example, random errors in audio or video transmissions may be tolerable, but when we transfer text, we expect a very high level of accuracy. And traditionally mobile operators have met the surge in mobile data traffic and the growing number of subscribers. The main problem is when to transmit data in can be corrupted because of Interference, multipath propagation, noise, fading and need to overcome this problem, so there is need for QOS in transmission.

Some limitations of existing model

- ✓ The Performance of data rate is low
- ✓ The performance of per user throughput is low
- ✓ Reducing spectral efficient
- ✓ Increased transmission delay
- ✓ The system is very vulnerable to error



Flow Chart of Existing Model Fig 3.1

3.3 Proposed System Model

Networks must be able to transfer data from one device to another with acceptable accuracy and QOS. For most applications, a system must guarantee that the data received are identical to the data transmitted. Any time data are transmitted from one node to the next, they can become corrupted in passage in bade QOS. Many factors can alter one or more bits of a message, the best solution to design good channel and with QOS and the LTE is the best solution for growing number of subscribers and good transmission.

Some advantages of proposed model

- ✓ Support wider bandwidth signals
- ✓ Increase data rates
- ✓ The performance of per user throughput is high
- ✓ Increasing spectral efficient
- ✓ Reducing transmission delay
- ✓ Improve network performance

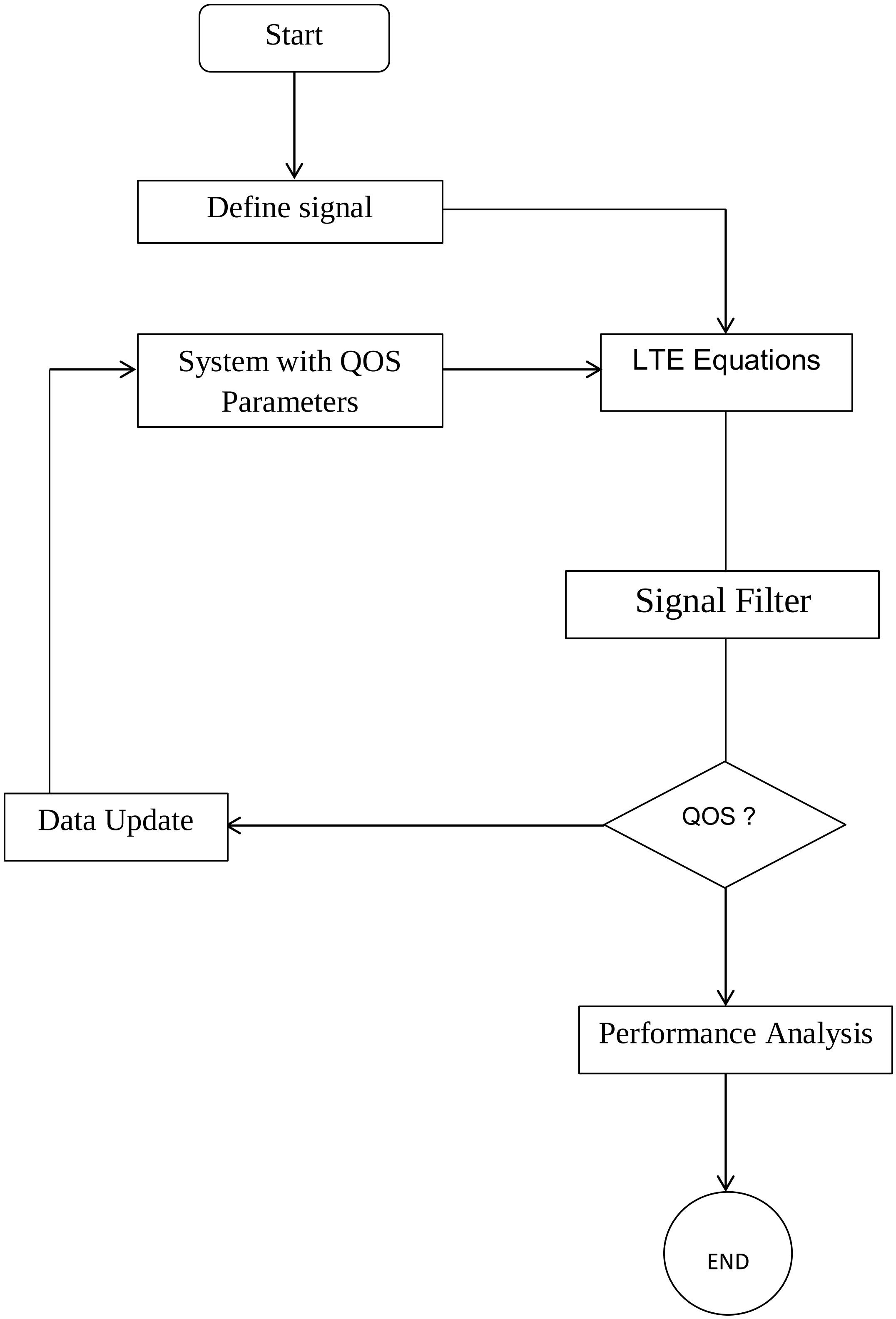


Fig 3.2 Flow Chart of Proposed Model

Chapter Four

Long Term Evaluation Advanced LTE-A

4.1 Introduction

In this chapter the mathematical expressions is used to explain the concepts of LTE-A and its techniques are presented in this chapter

4.2 Long term Evaluation Advanced (LTE-A)

LTE advanced is a mobile communication 4G standard approved by International Telecommunication Union (ITU) in Japan 2012. LTE advanced (LTE-A) is an emerging and as the name suggests a more advanced set of standards and technologies that will be able to deliver bigger and speedier wireless-data payloads. The most important thing to know is that in LTE-A promises to deliver true 4G speeds unlike current LTE networks. You can expect the real- world speed of LTE-A to be two to three times faster than today's LTE.

To be considered true 4G (also known as "IMT-Advanced"), a mobile network must fulfill a number of benchmarks, including offering a peak data rate of at least 100 megabits per second (Mb/s) when a user moves through the network at high speeds, such as in car or train, and 1 Gigabit per second (Gb/s) when the user is in fixed position.

Table 4.1 Shows basic differences between technologies

	3G	**Wimax**	**HSPA+**	**LTE**	**LTE-Advanced**
Peak data rate	3Mbps	128Mbps	168Mbps	300Mbps	1Gbps
Download rate (Actual)	0.5 – 1.5Mbps	2 – 6 Mbps	1 – 10 Mbps	10 – 100 Mbps	100 – 300 Mbps
Upload rate (Actual)	0.2 – 0.5 Mbps	1 – 2 Mbps	0.5 – 4.5Mbps	5 – 50 Mbps	10 – 70 Mbps

The higher possible rates are never achieved in real world conditions. Actual rates will be variable but we can expect LTE-A to be at least five times as fast as most LTE networks today, and that's great news for video streaming. LTE-A is supposed to provide higher capacity, an enhanced user experience and greater fairness in terms of resource allocation.

It does this by combining a bunch of technologies, many of which have been around for some years, so we are not really talking about the implementation of an entirely new system here.

4.2.1 Features of LTE-A

- Compatibility of services
- Peak data rates: downlink – 1Gbps
- Uplink – 500Mbps.
- Spectrum efficiency: 3 times greater than LTE.
- Peak Spectrum efficiency: downlink – 30bps/Hz; Uplink – 15bps/Hz.
- Spectrum use: the ability to support scalable bandwidth use and spectrum aggregation where non-contiguous needs to be used. The lower and upper bandwidths limits are 40MHz and 100MHz
- Latency (Delay): from idle to connected in less than 50 ms and then shorter than 5 ms one way for individual packet transmission.
- Cell edge user throughput to be twice that of LTE.
- Average user throughput to be 3 times that of LTE.
- Compatibility: LTE-A shall be capable interworking with LTE and 3GPP systems

4.2.2 How LTE-Advanced is better than LTE

The main new functionalities introduced in LTE-Advanced are carrier aggregation (CA), enhanced use of multi-antenna techniques (MIMO) and supported Relay Nodes (RN)

4.2.2.1 Carrier aggregation

Carrier aggregation is used in LTE-Advanced in order to increase the bandwidth, and thereby increase the bitrate. Since it is important to keep backward compatibility with R8 and R9 UEs the aggregation is based on R8/R9 carriers. Carrier aggregation can be used for both FDD and TDD, see figure 3.1 for an example where FDD is used.

Carrier aggregation is one key enabler of LTE-Advanced to meet the IMT-Advanced requirements in terms of peak data rates it is a highly demanded feature from a network operator perspective, since it enables also the aggregation of different spectrum fragments.

Figure 4.1 Carrier Aggregation Frequency Division Duplex (FDD) The LTE-Advanced UE can be allocated DL and UL resources on the aggregated resource consisting of two or more Component Carriers (CC), the R8/R9 UEs can be allocated resources on any ONE of the CCs. The CCs can be of different bandwidths

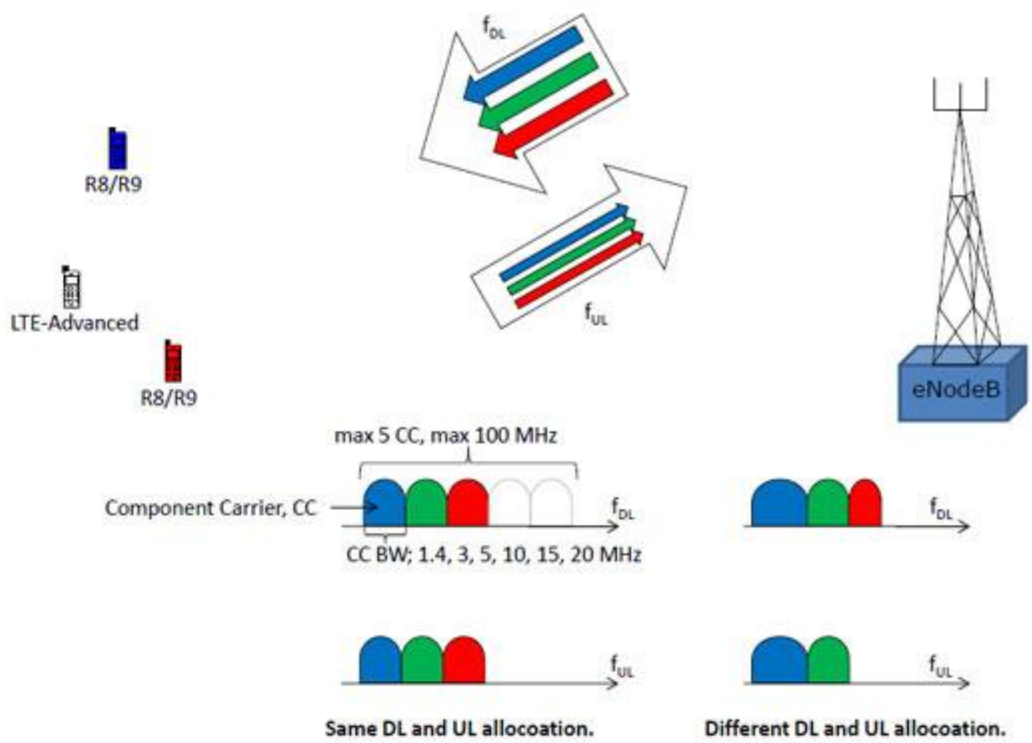


Figure 4.1 Frequency Division Duplex

Each aggregated carrier is referred to as a component carrier, CC The component carrier can have a bandwidth of 1.4, 3, 5, 10, 15 or 20 MHz and a maximum of five component carriers can be aggregated, hence the maximum aggregated bandwidth is 100 MHz In FDD the number of aggregated carriers can be different in DL and UL, see figure 3.1. However, the number of UL component carriers is always equal to or lower than the number OF DL component carriers. The individual component carriers can also be of different bandwidths For TDD the number of CCs as well as the bandwidths of each CC will normally be the same for DL and UL [13].

3GPP is currently finalizing the work on TDD-FDD carrier aggregation Carrier aggregation is used in LTE to boost the UE's data rate. This can be achieved by the user equipment receiving or transmitting data on pieces of spectrum that is spread out in different frequency bands. Previously, this has only been possible between FDD and FDD spectrum or between TDD and TDD spectrum. This post will give you some insight into what this means, as well as what benefits this brings [13].

In the case of FDD operation there are two carriers, one for uplink transmission and one for downlink transmission. In the other case of TDD operation there is a single carrier frequency only one uplink and downlink transmission are separated in the time domain on a cell base [13].

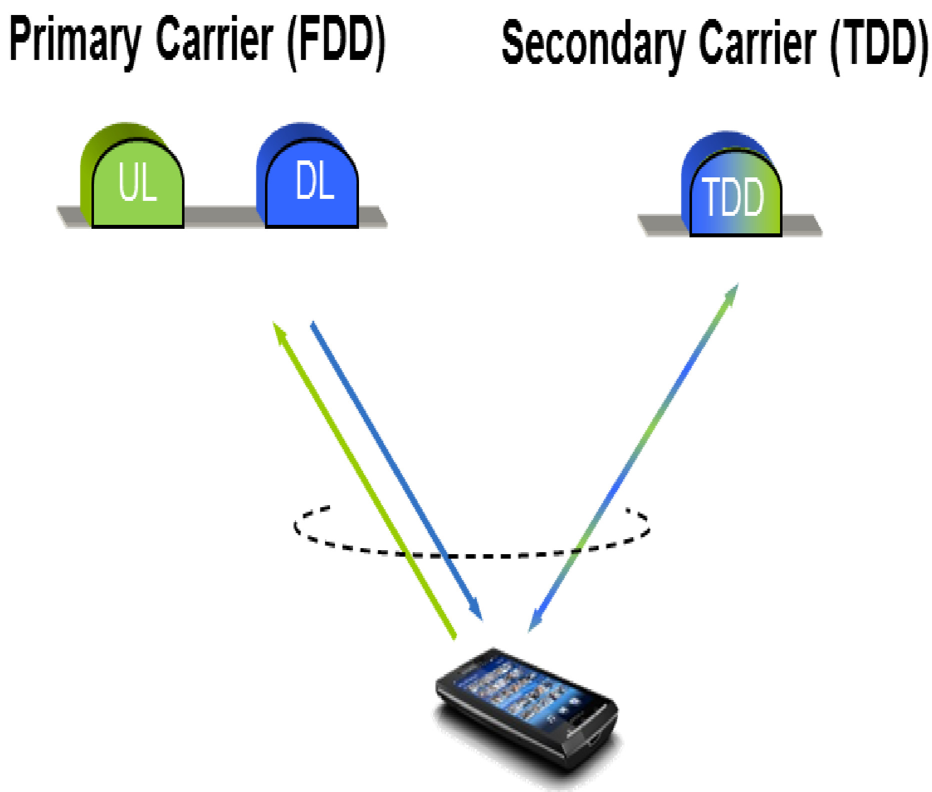


Figure 4.2 Frequency/Time Division Duplex

Carrier aggregation was first introduced in LTE with Rel-10 and implies that the UE aggregates a number of cells operating on different frequencies The primary cell is used to handle mobility, physical control signaling and broadcast information in addition to user data all the other cells are viewed as secondary cells with the main functionality of providing higher data throughput the Rel-10 carrier aggregation supports aggregation of up to 5 carriers in both DL and UL within either FDD or TDD (assuming the same upload/download (UL/DL) configuration for all aggregated carriers) in the core parts in terms of spectrum it is possible to aggregate up to 100 MHz of spectrum with the Rel-10 design In practice however the individual requirements are needed for each aggregation band combination and currently the focus is mainly on either 2 or 3 DL carriers [13].

Figure 4.3 shows the Delivering successively higher data rates.

Carrier aggregation offers successively higher peak data rates as well as better broadband experience across the coverage area.

The date rates scale with the amount of spectrum allowing 3GPP Rel 10 to support up to 5 carriers with up to 100 MHz of spectrum and commercial solutions to support up to 3 carriers with peak data rates up to 450 Mbps (Cat 5) [14][19].

Increased data rates of carrier aggregation can be traded off to get higher capacity for burst applications, such as web browsing, streaming, social media apps and others, meaning operators can choose a higher capacity for the same user experience, better user experience for the same capacity, or both [14].

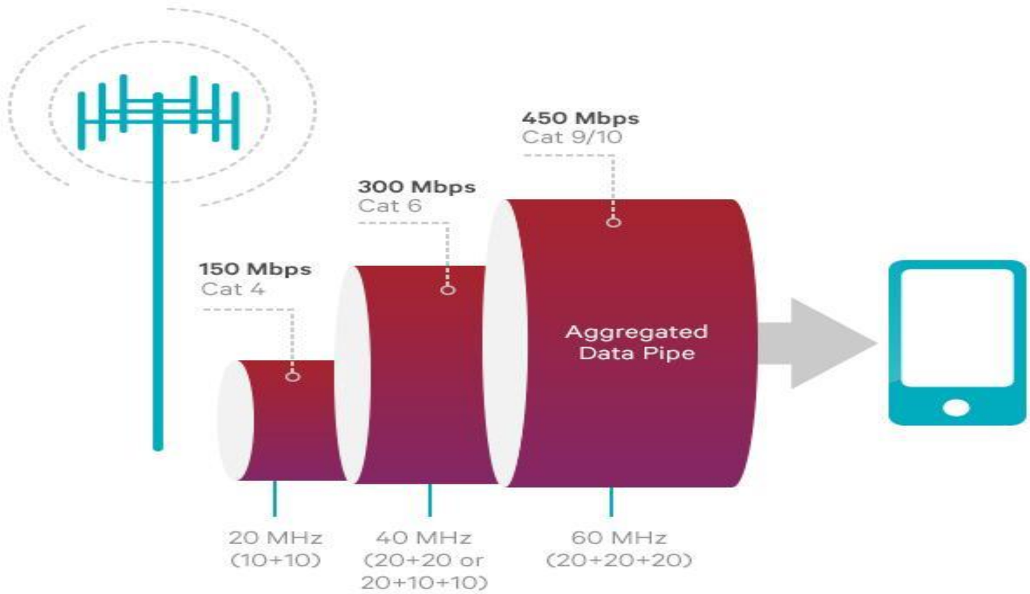


Figure 4.3 delivering successful of high data rates

4.2.2.2 Multi Input Multi Output (MIMO)

MIMO stands for Multiple Input Multiple Output, which allows base stations and mobile units to send and receive data using multiple antennas. MIMO can increase the overall bitrate by transmitting two or more different data streams on two or more different antennas.

Qualcomm's LTE-Advanced white paper explains that by leveraging more radio links through more antennas, you get "high spectral efficiency"

LTE already supports some MIMO but only for download stream. LTE limits the number of antennas to four transmitters in the base station and four receivers in the handset.

LTE Advanced allows for up to eight antenna pairs for the downlink and up to four pairs for the uplink. MIMO serves two functions. In noisy environments – such as at the edge of a cell or inside a moving vehicle – the multiple transmitters and receivers work together to focus the radio signals in one particular direction. "this beam forming" boosts the strength of the received signal without upping transmission power. If signals are strong and noise is low, however – such as when stationary users are close to base station – MIMO can be used to increase data rates or the number of users for a given amount of spectrum.

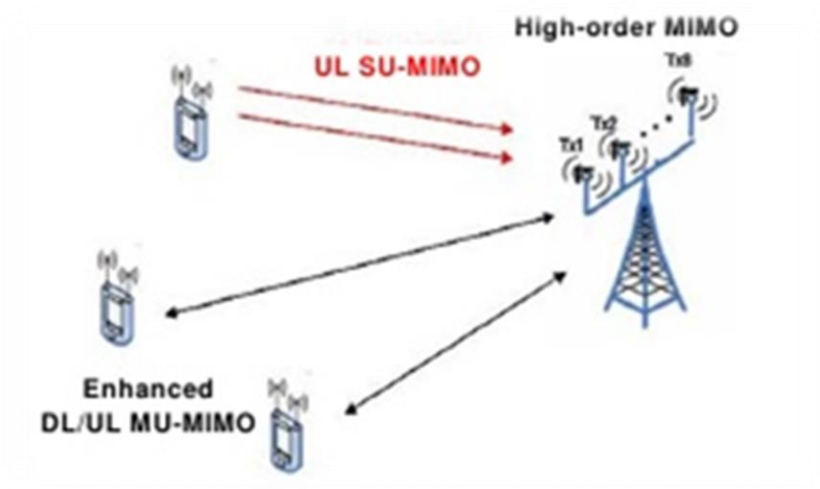


Figure 4.4 Advanced MIMO

4.2.2.3 Relay Node

Relay node extends coverage to places where reception is poor. Relay nodes are described by Wannstrom as, "low power base stations that will provide enhanced coverage and capacity at cell edges" they will increase the range of coverage and ensure that speeds are good, even if you are outskirts of your network. Wireless network architects have long used relays to extend a tower's reach such as into train tunnel, or a remote area. Traditional relays or repeaters are relatively simple. They receive signals, amplify them and then retransmit them.

LTE advanced supports more advanced relays which first decode the transmissions and then forward only those destined for the mobile units that each relay is serving. This scheme reduces interference and lets more users' link with the relay. LTE-Advanced also allows a relay to communicate with the base station and with devices using the same spectrum and protocols as the base station itself. The relay avoids interfering with the base station by scheduling its transmissions during certain times.

Relaying being one of the promising deployment scenarios deploys low-power base stations known as RN within the macro-overlaid network. It reduces the UE Infrastructure distance with a reduced cost. The relay link between RN and Donor eNB (DeNB) carries both UEs data traffic as well as control signaling for RNs. It also possess the S1 (Gateway-eNB), X2 (eNB-eNB) and normal LTE air interface (eNB-UE) characteristics, Similarly, the Direct Link and Access Link refer to DeNB-UE connection and RN-UE connection respectively as shown in figure 4.3.

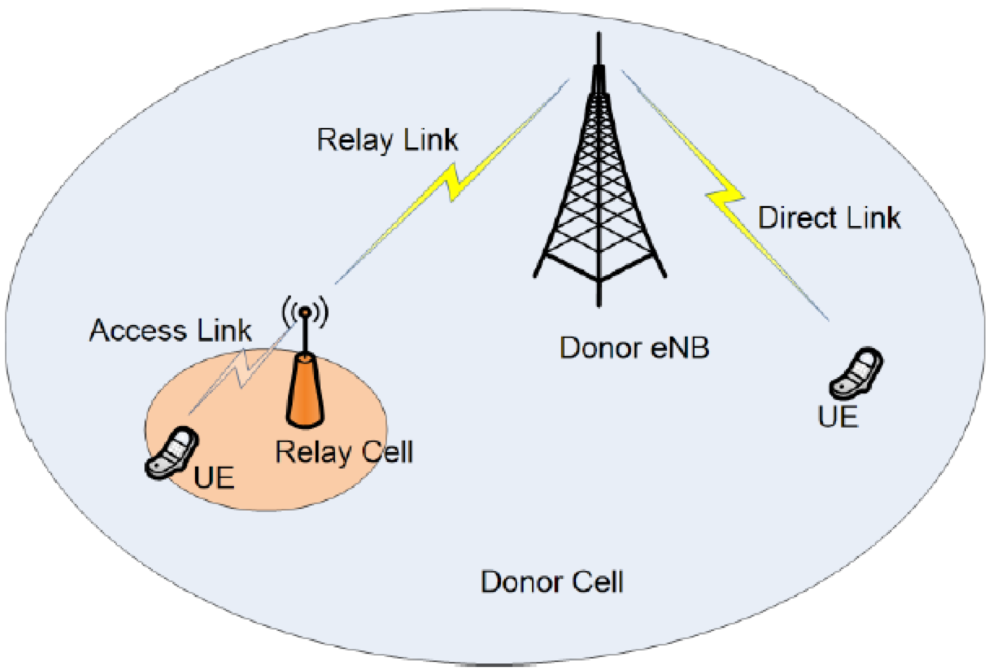


Figure 4.5 Network with Relay Node

4.3 Mathematical Equations

The Mathematical Equations that's used in simulation in matlab are flow:

4.3.1 Signal to Noise Ratio (SNR)

Signal-to-noise ratio (SNR) is a measure used in science and engineering that compares the level of a desired signal to the level of background noise. It is defined as the ratio of signal power to the noise power, often expressed in decibels. A ratio higher than 1:1 (greater than 0 dB) indicates more signal than noise while SNR is commonly quoted for electrical signals, it can be applied to any form of signal (such as isotope levels in an ice core or biochemical signaling between cells) [15].

The signal-to-noise ratio, the bandwidth, and the channel capacity of a communication channel are connected by the Shannon–Hartley theorem.

Signal-to-noise ratio is sometimes used informally to refer to the ratio of useful information to false or irrelevant data in a conversation or exchange For example, in online discussion forums and other online communities, off-topic posts and spam are regarded as "noise" that interferes with the "signal" of appropriate discussion [15].

$$SNR = \frac{\mathrm{p}}{\mathrm{I+N}} \qquad (3.1)$$

Where

P: power of the received signal

I: interface of power

N: noise power

4.3.2Data Rate

Is the amount of data that is moved from one place to another in a given time in Mb/S

$$DR = BW * M * C \qquad (3.2) \qquad M = 2^N$$

M: Modulation level

N: Number of bit per sample

C: Coding rate

BW= Available Bandwidth

4.3.3Throughput

The throughput as a ratio of the expected value of the payload information sent in a slot time to the expected duration of a slot time

Is the average data rate of successful message delivery over communication in bit/s [16].

$$\mathrm{TH} = \Sigma \mathrm{DR} \qquad (3.3)$$

Throughput= Payload Information Sent in a Slot Time/Length of a Slot Time.
This means the throughput can be measured in bits/s.

In general terms, throughput is the rate of production or the rate at which something can be processed [16]

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, logical link or it can pass through a certain network node throughput is usually measured in bits per second (bit/s), and sometimes in data packets per second (p/s) or data packets per time slot [16].

The system throughput or aggregate throughput is the sum of the data rates that are delivered to all terminals in a network. Throughput is essentially synonymous to digital bandwidth consumption; it can be analyzed mathematically by applying the queuing theory, where the load in packets per time unit is denoted as the arrival rate (λ), and the throughput in packets per time unit, is denoted as the departure rate (μ) [16].

The throughput of a communication system may be affected by various factors, including the limitations of underlying analog physical medium, available processing power of the system components, and end-user behavior. When various protocol overheads are taken into account, useful rate of the transferred data can be significantly lower than the maximum achievable throughput; the useful part is usually referred to as good put [16].

4.3.4 Spectral Efficiency

Spectral efficiency refers to the information rate that can be transmitted over a given bandwidth in a specific communication system It is a measure of how efficiently a limited frequency spectrum is utilized, measured in bit/s/Hz [16].

It is calculated from

$$\eta = \frac{DR}{BW} \tag{3.4}$$

η: spectral efficiency

4.3.5 Delay

The is delay caused by the data rate of the link in seconds

$$Delay = \frac{N}{DR} \tag{3.5}$$

4.3.6 Bandwidth Utilization

The bandwidth utilization is the percentage of bandwidth utilized of the total bandwidth available.

Bandwidth Utilization=Bandwidth of User/Total Bandwidth

The maximum bandwidth utilization, expressed in bits/s/Hz, when using 64 QAM consisting of 64 signaling alternatives and thus providing up to 6 bits of information per modulation symbol. However, the higher bandwidth utilization comes at the cost of reduced robustness to noise and interference [16].

Chapter Five

Simulation and Results

5. 1 introduction

In this chapter the simulation process and resulting graphs for LTE-A are presented.

5. 2 LTE - Advanced Simulation

This simulation investigates five aspects of LTE-A which are SNR, data rate, throughput, spectral efficiency and delay.

The following table shows the parameters used in the simulation.

Bandwidth is the difference between the upper and lower frequencies in a continuous set of frequencies. It is typically measured in hertz, and may sometimes refer to pass band bandwidth, sometimes to baseband bandwidth, depending on context [16].

Pass band bandwidth is the difference between the upper and lower cut off frequencies of, for example, a band-pass filter, a communication channel, or a signal spectrum. In the case of a low-pass filter or baseband signal, the bandwidth is equal to its upper cutoff frequency. The figure 5.1 shows the scenario of bandwidth in LTE and in LTE-Advanced, in LTE there is 20 MHZ and in LTE-Advanced there is 60 MHZ [16].

5.3 Simulation Parameters

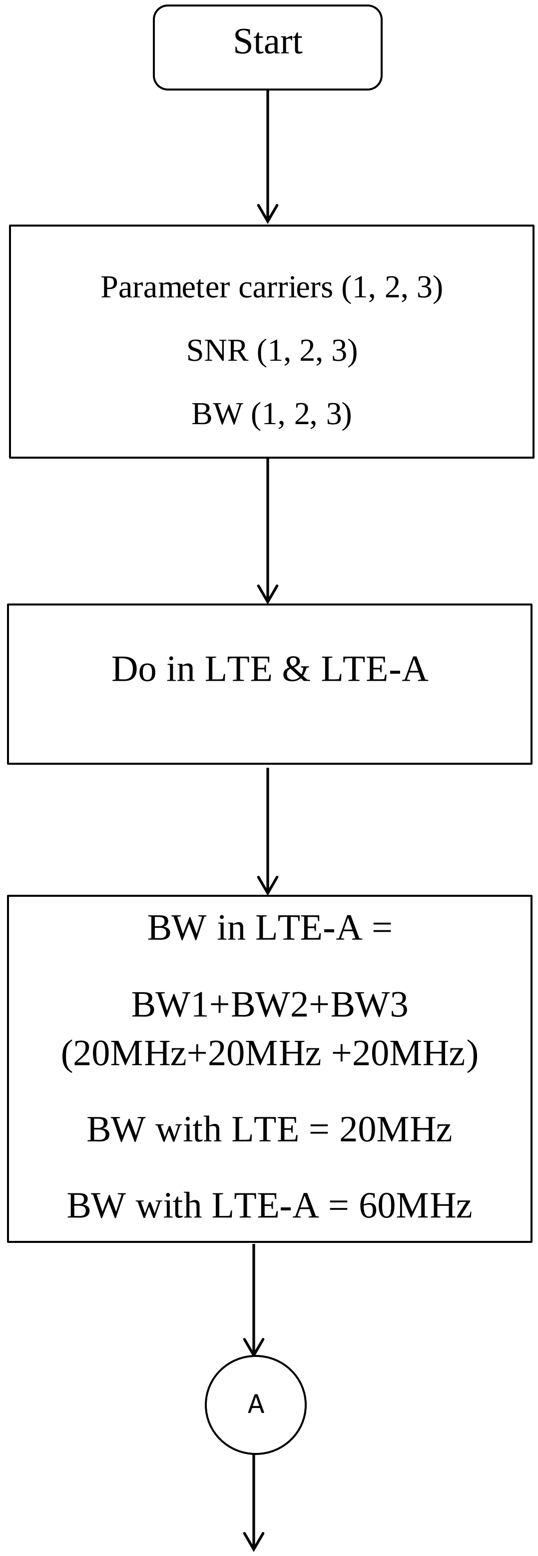
In this part we will discuss the design procedure of the LTE-Advanced simulator with the simulation parameters in details the simulation are performed by a regular hexagonal Cellular layout with BW, one FC, one HB, G and Data.

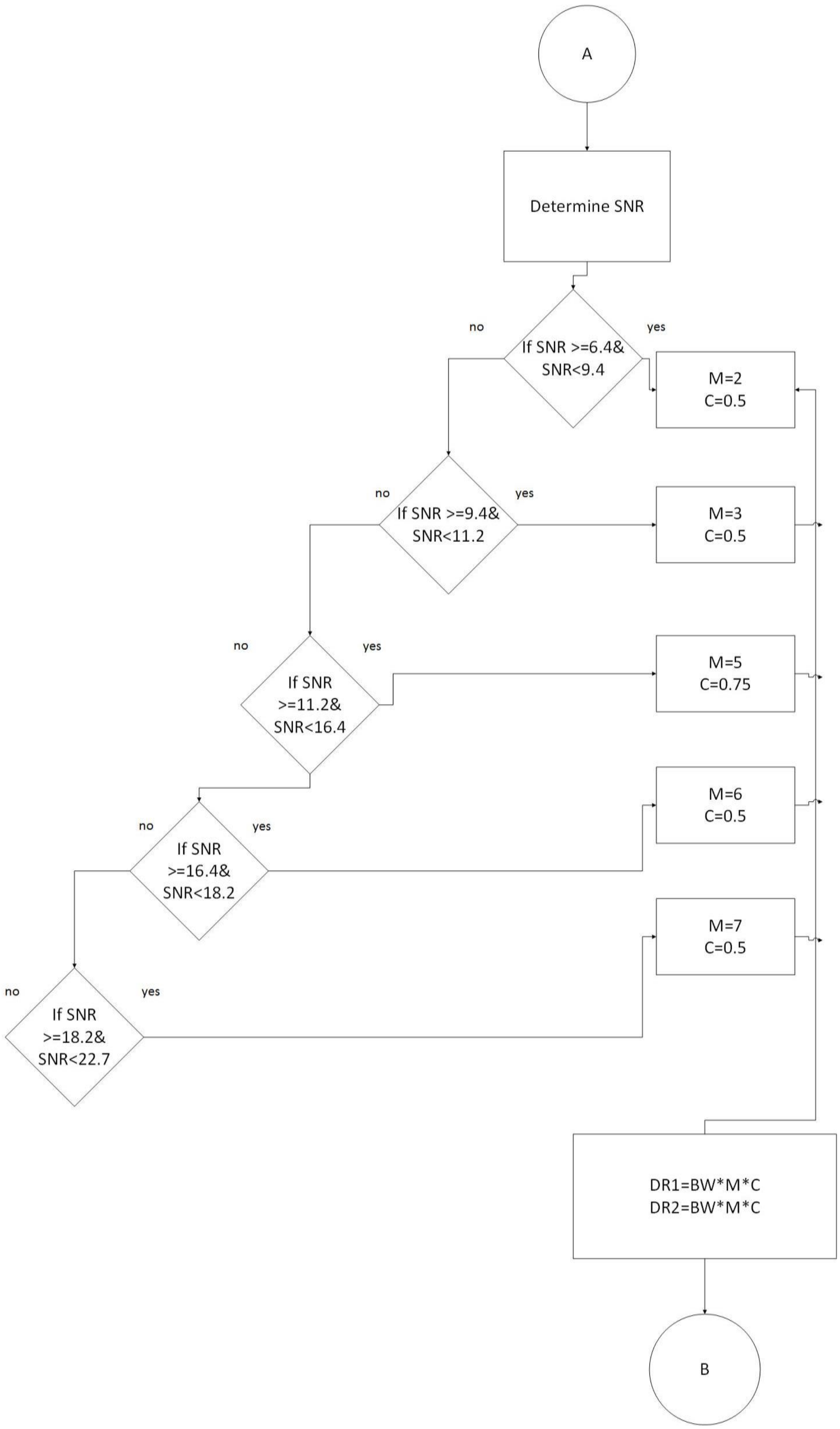
Table 5.1 Shows the Simulation Parameter

Time	0.2s
Bandwidth(BW) LTE	20 MHZ
Bandwidth (BW) LTE-A	60 MHZ
Frequency carrier	500 KHZ
Height base station (HB)	30 M
height mobile (HM)	2 M
Power (p)	30 dB
Power gain (G)	2 dB
Data	2 bit
Interference (I)	2 dB

5.4 Flow Chart of LTE-A

The figure 5.1 shows the flow chart we have three CA, BW, SNR, each BW is 20 MHZ in LTE while for LTE-A 60 MHZ.


Start
Parameter carriers (1, 2, 3)
SNR (1, 2, 3)
BW (1, 2, 3)
Do in LTE & LTE-A
BW in LTE-A =
BW1+BW2+BW3
(20MHz+20MHz +20MHz)
BW with LTE = 20MHz
BW with LTE-A = 60MHz
A


A
Determine SNR
If SNR >=6.4&
SNR<9.4
no
yes
M=2
C=0.5
If SNR >=9.4&
SNR<11.2
no
yes
M=3
C=0.5
If SNR
>=11.2&
SNR<16.4
no
yes
M=5
C=0.75
If SNR
>=16.4&
SNR<18.2
no
yes
M=6
C=0.5
If SNR
>=18.2&
SNR<22.7
no
yes
M=7
C=0.5
DR1=BW*M*C
DR2=BW*M*C
B

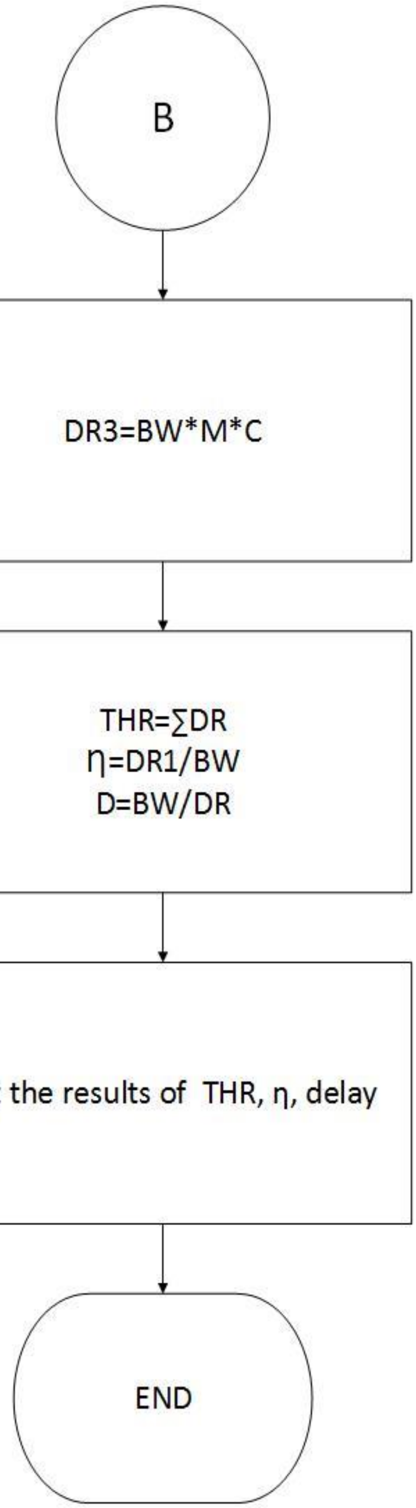


Figure 5.1 shows Flow Chart of LTE-A

5.5 Bandwidth

Figure 5.2 shows the bandwidth we have three BW in LTE we have 20MHZ while in LTE-A 60MHZ. It shows the capacity of the existing model and the proposing model systems in terms of bandwidth it increases rapidly with the bandwidth, which illustrates the better performance of a proposing model.

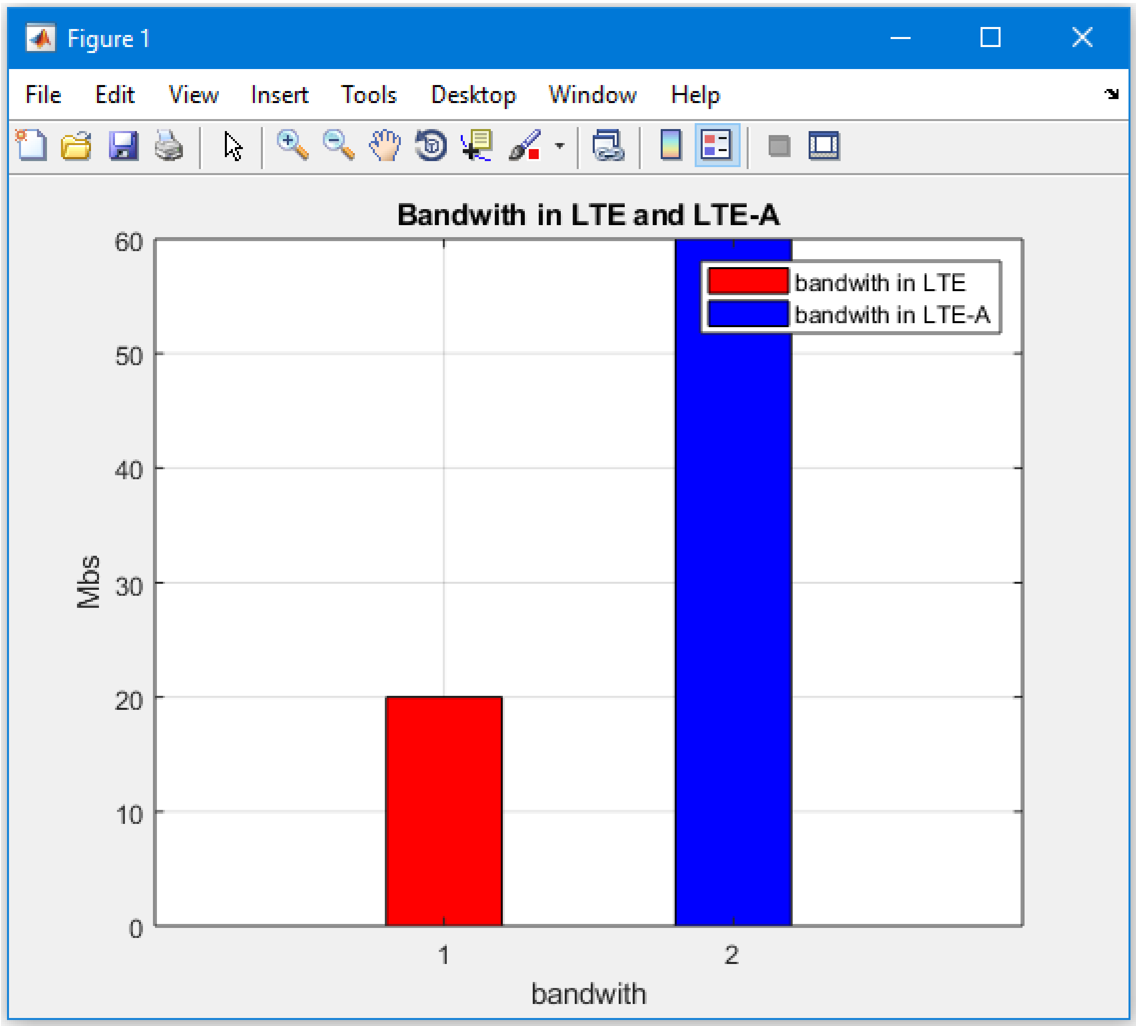


Figure 5.2 shows bandwidth

5.6 Signal To Noise Ratio (SNR)

Figure 5.3 shows the results of SNR in LTE and LTE-A after this equation $SNR = \frac{p}{I+N}$ applied the code the data rate increased from LTE to LTE-A. It shows the capacity of the existing model and the proposing model systems in terms of SNR It increases rapidly with the SNR, which illustrates the better performance of a proposing model.

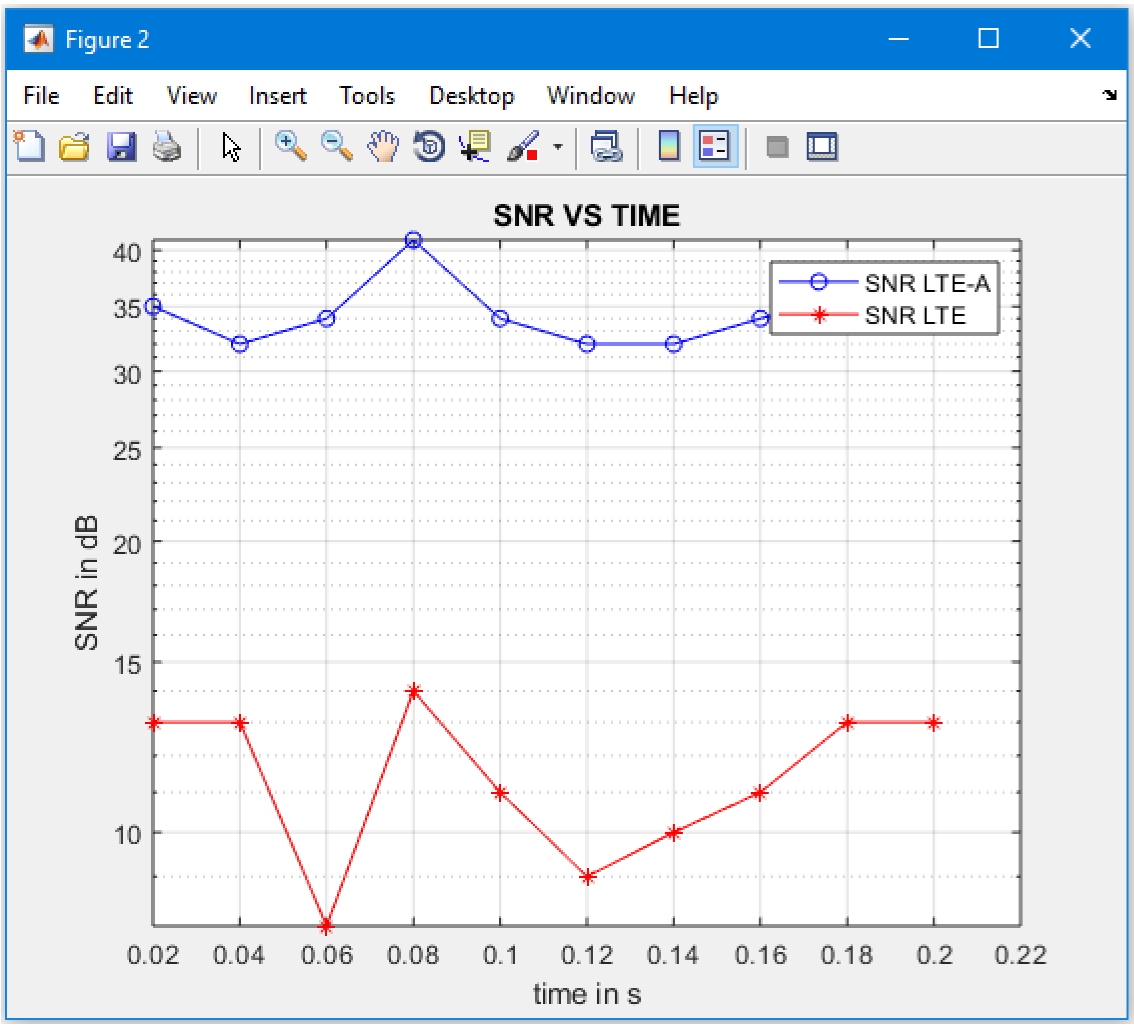


Figure 5.3 shows signal to noise ratio

5.7 Data Rate

Figure 5.4 shows the results of data rate in LTE and LTE-A after this equation $DR = BW * M * C$, $M = 2^N$applied the code the data rate increased from LTE to LTE-A. It shows the capacity of the existing model and the proposing model systems in terms of Data rate it increases rapidly with the data rate, which illustrates the better performance of a proposing model.

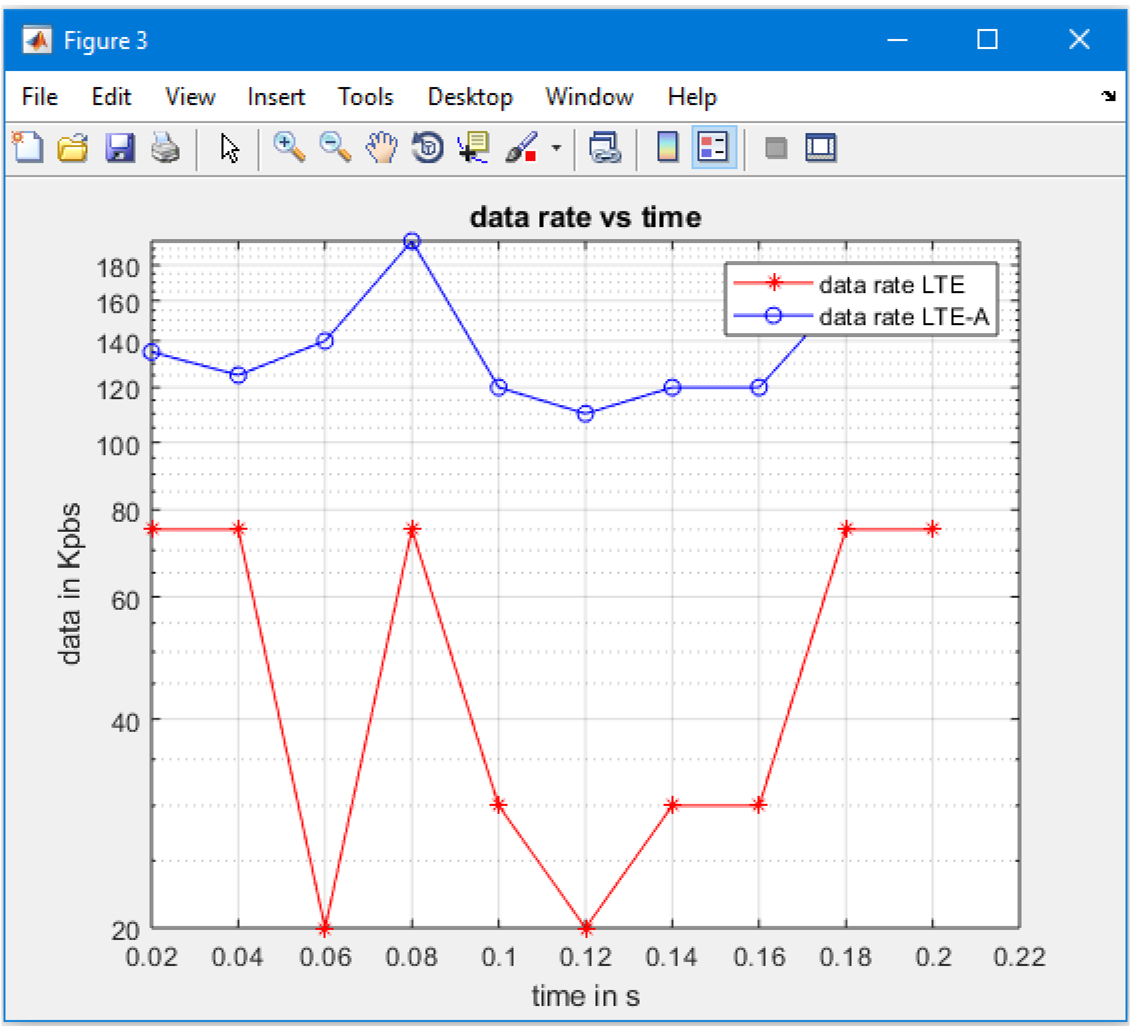


Figure 5.4 shows Data Rate

5.8 Throughput

Figure 5.5 shows the results of throughput in LTE and LTE-A after this equation TH = ΣDR applied the code the throughput increased from LTE to LTE-A. It shows the capacity of the existing model and the proposing model systems in terms of throughput it increases rapidly with the throughput, which illustrates the better performance of a proposing model.

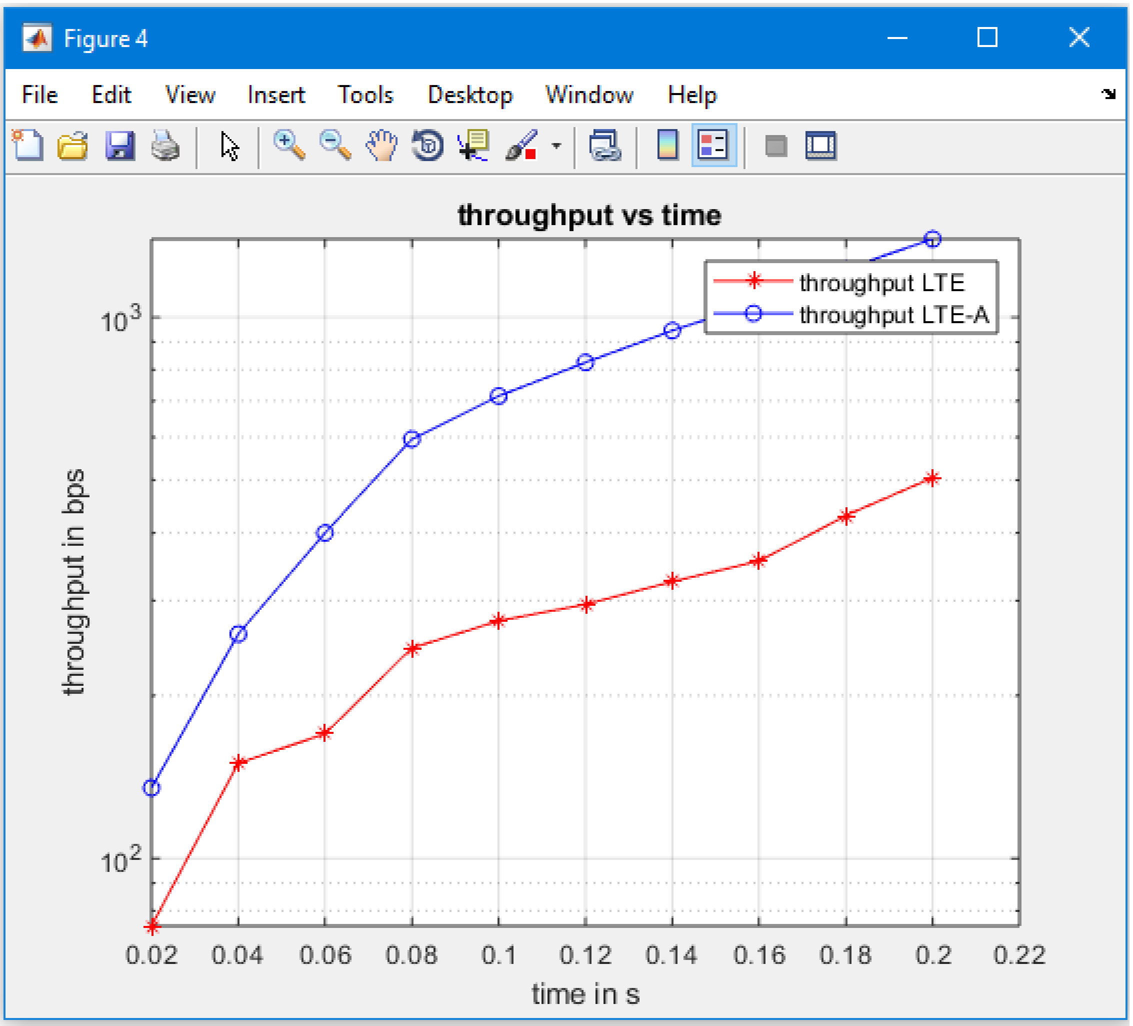


Figure 5.5 shows Throughput

5.9 Spectral Efficiency

Figure 5.6 shows the results of spectral efficiency in LTE and LTE-A after this equation $\eta = \frac{DR}{BW}$ applied the code the spectral efficiency increased from LTE to LTE-A. It shows the capacity of the existing model and the proposing model systems in terms of spectral efficiency it increases rapidly with the spectral efficiency, which illustrates the better performance of a proposing model.

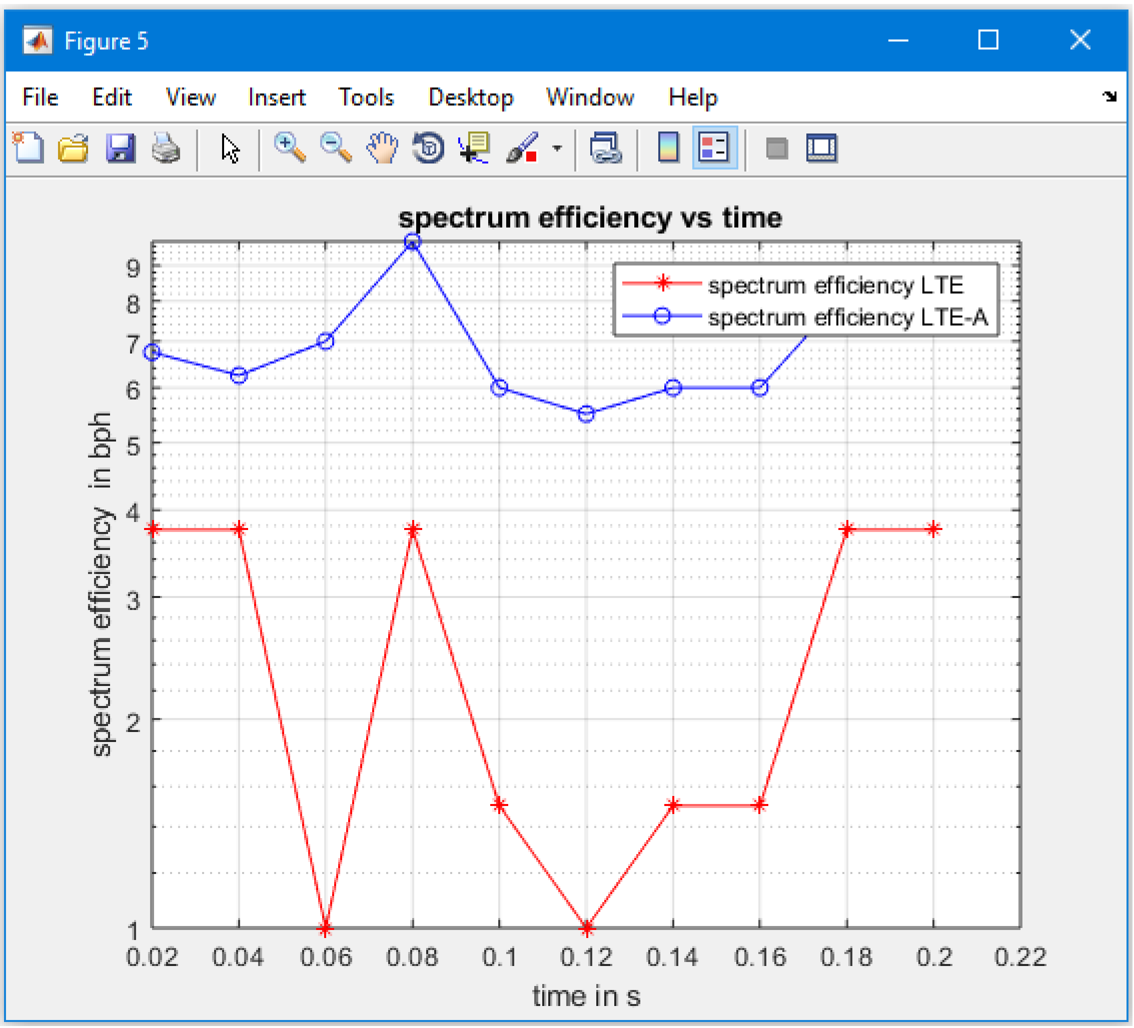


Figure 5.6 shows Spectral Efficiency

5.10 Delay

Figure 5.7 shows the results of delay in LTE and LTE-A after this equation $Delay = \frac{N}{DR}$ applied the code the delay decreased from LTE to LTE-A. It shows the capacity of the existing model and the proposing model systems in terms of delay it decreases rapidly with the delay, which illustrates the better performance of a proposing model.

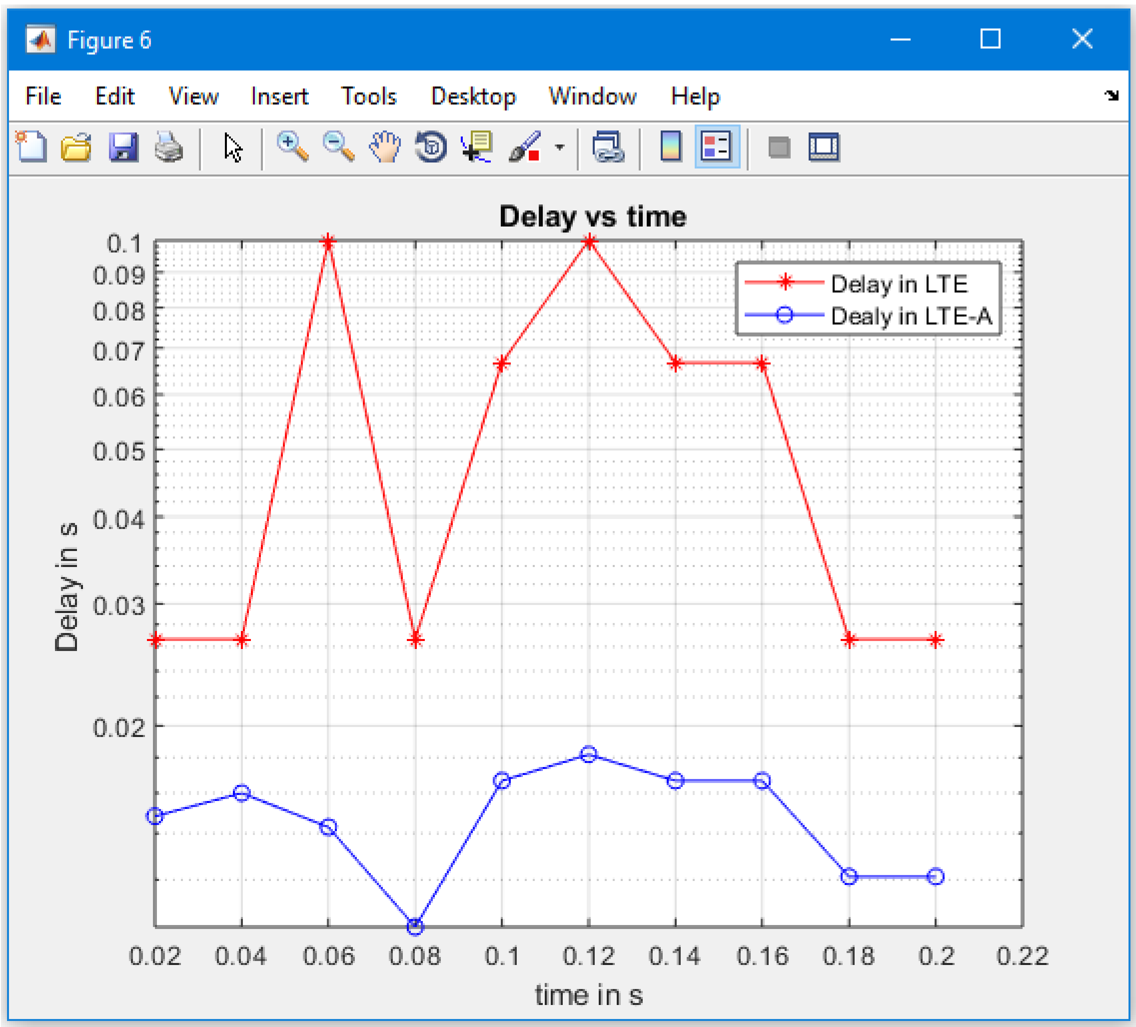


Figure 5.7 shows Delay

Chapter Six

Performance Analysis

6.1 Introduction

In this chapter will present performance analysis of existing and proposed models.

In this result, we investigated difference between Long Term Evaluation (LTE) and LTE-Advanced. The problem is when to transmit data it can be corrupted because of Interference, multipath propagation, noise, fading and need to overcome this problem, so there is need for QOS in transmission and wireless communication systems, it is required to view Video, listen to audio, browse the internet, upload media and use Cloud-based services that will make high demands of data rates. However, it is very difficult to achieve such high data rates using Conventional Communications methods without increasing the Bandwidth this motivates to develop and investigate new techniques to achieve such Data rates. In order to achieve higher data rates and efficiently utilize the available resources to design good channel and with QOS the LTE-Advanced is the best solution for growing number of subscribers and good transmission.

6.2 Performance analysis of proposed vs. existing models

Here we will show how the analysis of existing and proposed models, the red column stands on Proposed Model and the blue column stands on existing model.

The following table shows the parameters we used to compare the two models:

Parameters	LTE	LTE-A
SNR	14	35
Data rate	78	180
Throughput	30	110
Spectral efficiency	38	95
Bandwidth	20	60
Delay	25	10

Table 6.2 Parameters

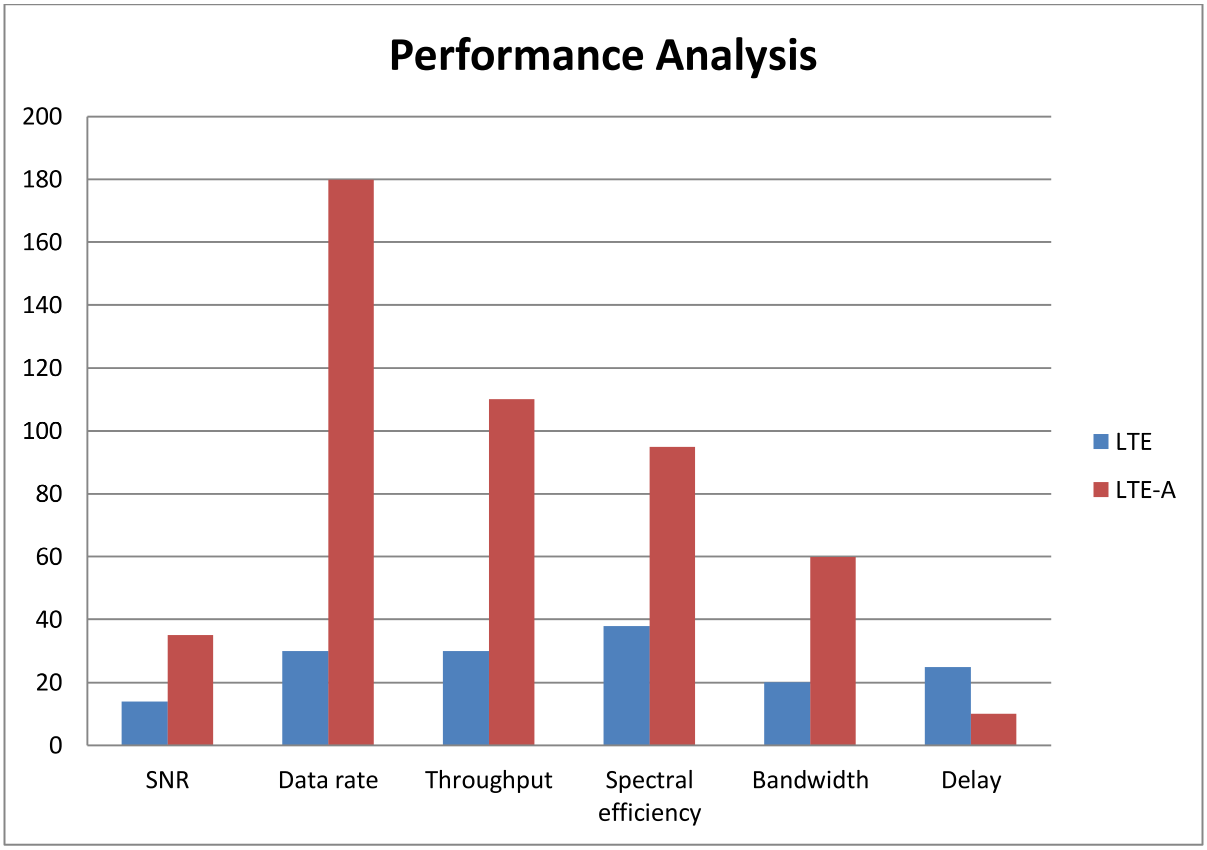


Figure 6.1 performance analysis of proposed model vs. existing model

The improvement in signal to noise ratio(SNR) in LTE-A is increased 35% where the SNR in LTE is increased by 14% , and also the data rate of LTE-A is increased 180% where the data rate in LTE increased 78% and the throughput in LTE-A is increased 110% where the throughput in LTE is 30% and spectral efficiency in LTE-A is increased 95% where the spectral efficiency in LTE is 38% and also the bandwidth in LTE-A is increased 60% where the bandwidth in LTE is increased 20% and also the delay in LTE-A is decreased 10% where the delay in LTE is increased by 25%, So that the proposed model is better performance than existing model.

CHAPTER SEVEN

CONCLUTION AND RECOMENDATION

7.1 CONCLUSION

In this thesis it is clear that many problems such as when transmitting data, it can be corrupted because of (Interference, multipath propagation, noise, fading) and the requirement to view Video, listen to audio, browse the internet, upload media and use Cloud-based services that will make high demands of data rates is solved as we use the carrier aggregation and MIMO techniques.

The performance was analyzed through a comparison between LTE and LTE-Advanced using MATLAB , from the simulations and analyzing the graphs we observed that LTE-A has better capability to form QoS towards the user of interest. Also we notice that LTE-A to be a couple of times speedier than the present LTE. LTE-A is supposed to provide higher capacity, an enhanced user experience and greater fairness in terms of resource allocation than LTE. LTE-A has much better performance than LTE.

7.2 Future Scope

1. However, future work might improve on the results obtained; by doing this more realistic and reliable simulation data could be achieved and presented.
2. More compare between generations for more enhance and show the deferent is wanted.
3. LTE is a very promising generation of wireless communication so removes all old releases and uses 4G.
4. LTE able to add intelligent technology for LTE can be used in the network; new ideas are being introduced by researchers.
5. There are several issues yet to be solved like incorporating the mobile world to the IP based core network, efficient billing system, smooth hand off mechanisms etc.

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Appendices

CA with and without

```
clear all,clc, close all
Bw1=20;
Bw2=20;
Bw3=20; % bandwidth system MHz
%BW_LTE-A=Bw1+BW2+BW3;
Fc=500; %kHZ
hB=30; %meter
hM=2;%meter
Pt=30; %power tx(dB)
G=2; %power gain(db)
data=2; %the data 2k bps
Dr=zeros(1,10);
DR1=zeros(1,10);
DR2=zeros(1,10);
DR3=zeros(1,10);
M1=zeros(1,10);
M2=zeros(1,10);
M3=zeros(1,10);
C1=zeros(1,10);
C2=zeros(1,10);
C3=zeros(1,10);
I=2;
Result=zeros(10,12);
pr1=randi([10 15],1,10);
SNR1=(pr1+G)-((randi([1 2],1,10)+I));
pr2=randi([10 15],1,10);
SNR2=(pr2+G)-((randi([1 2],1,10)+I));
pr3=randi([10 15],1,10);
SNR3=(pr3+G)-((randi([1 2],1,10)+I));
Result(:,2)=SNR1
Result(:,3)=SNR2
Result(:,4)=SNR3
for n= 1:10
Result(n,1)= n * 0.02;

if  ( SNR1(n) >=6.4 & SNR1(n) < 9.4  )
   M1(n)=2;
   C1(n)=0.5;
elseif ( SNR1(n) >=9.4 & SNR1(n) < 11.2  )
   M1(n)=3;
   C1(n)=0.5;
elseif ( SNR1(n) >=11.2 & SNR1(n) < 16.4  )
```

```
    M1(n)=5;
    C1(n)=0.75;
 elseif ( SNR1(n) >= 16.4 & SNR1(n) < 18.2  )
    M1(n)=6;
    C1(n)=0.5;
  elseif ( SNR1(n) >=18.2 & SNR1(n) < 22.7  )
    M1(n)=7;
    C1(n)=0.5;
end;
DR1(n)=Bw1*M1(n)*C1(n);
DR1(n)=DR1(n)/1000000;
Result(n,5)=DR1(n);
if   ( SNR2(n) >=6.4 & SNR2(n) <  9.4)
    M2(n)=2;
    C2(n)=0.5;
elseif ( SNR2(n) >=9.4 & SNR2(n) <11.2  )
    M2(n)=3;
    C2(n)=0.5;
elseif ( SNR2(n) >=11.2 & SNR2(n) <16.4  )
    M2(n)=4;
    C2(n)=0.75;
 elseif ( SNR2(n) >=16.4 & SNR2(n) <18.2  )
    M2(n)=5;
    C2(n)=0.5;
  elseif ( SNR2(n) >=18.2 & SNR2(n) <22.7  )
    M2(n)=6;
    C2(n)=0.5;
end;
DR2(n)=Bw2*M2(n)*C2(n);
DR2(n)=DR2(n)/1000000;
if   ( SNR3(n) >=6.4 & SNR3(n)<9.4  )
    M3(n)=2;
    C3(n)=0.5;
elseif ( SNR3(n) >=9.4 & SNR3(n) < 11.2  )
    M3(n)=3;
    C3(n)=0.5;
elseif ( SNR3(n) >=11.2 & SNR3(n)<16.4  )
    M3(n)=4;
    C3(n)=0.75;
 elseif ( SNR3(n) >=16.4 & SNR3(n)<18.2  )
    M3(n)=5;
    C3(n)=0.5;
  elseif ( SNR3(n) >=18.2 & SNR3(n)<22.7  )
    M3(n)=6;
    C3(n)=0.5;
end;
```

```
DR3(n)=Bw3*M3(n)*C3(n)
DR3(n)=DR3(n)/1000000;
%DR
Result(n,5);
Result(n,6)=DR1(n)+DR2(n)+DR3(n)
%TH
Result(1,7)=DR1(1)
Result(1,8)=DR1(1)+DR2(1)+DR3(1)
if n >= 2
Result(n,7)=Result(n-1,7)+DR1(n)
Result(n,8)=Result(n-1,8)+DR1(n)+DR2(n)+DR3(n)
end
%SE
 Result(n,9)=DR1(n)/Bw1
% Result(n,10)=(DR1(n)+DR2(n)+DR3(n))/(Bw1+Bw2+Bw3)
V1(n)=DR1(n)/Bw1
V2(n)=DR2(n)/Bw2
V3(n)=DR3(n)/Bw3
Result(n,10)=V1(n)+V2(n)+V3(n)
%DELAY
  Result(n,11)= data/(DR1(n))
 Result(n,12)=data/((DR1(n)+DR2(n)+DR3(n)))
end;
Result(:,9)
Result
M1
C1
Bw1
DR1
M2
C2
Bw2
DR2
M3
C3
Bw3
DR3
```

Signal to Noise Ratio and Data Rate

```
%*****************************
%SINR 1 2 3
figure
semilogy(Result(:,1),(Result(:,2)+Result(:,3)+Result(:,4)),'bo-')
hold on
semilogy(Result(:,1),Result(:,2),'r*-')
hold on
```

```
grid
xlabel('time in s')
ylabel('SNR in dB')
title('SNR VS TIME')
legend('SNR LTE-A','SNR LTE')
```

Data Rate

```
%****************data rate
figure
semilogy(Result(:,1),Result(:,5)*1000000,'r*-')
hold on
semilogy(Result(:,1),Result(:,6)*1000000,'bo-')
hold on
grid
xlabel('time in s')
ylabel('data in Kpbs')
title('data rate vs time')
legend('data rate LTE','data rate LTE-A')
```

Throughput

```
%*******************throughput
figure
semilogy(Result(:,1),Result(:,7)*1000000,'r*-')
hold on
semilogy(Result(:,1),Result(:,8)*1000000,'bo-')
hold on
grid
xlabel('time in s')
ylabel('throughput in bps')
title(' throughput vs time')
legend('throughput LTE','throughput LTE-A')
```

Spectral efficiency

```
%********************spectrum efficiency
figure
semilogy(Result(:,1),Result(:,9)*1000000,'r*-')
hold on
semilogy(Result(:,1),Result(:,10)*1000000,'bo-')
grid
xlabel('time in s')
ylabel('spectrum efficiency  in bph')
title(' spectrum efficiency vs time')
legend('spectrum efficiency LTE','spectrum efficiency LTE-A')
```

Delay

```
%*****************Dealy
figure
semilogy(Result(:,1),Result(:,11)/1000000,'r*-')
hold on
semilogy(Result(:,1),Result(:,12)/1000000,'bo-')
grid
xlabel('time in s')
ylabel('Delay in s ')
title(' Delay vs time')
legend('Delay in LTE','Dealy in LTE-A')
```

Bandwidth

```
%*****************Bandwith
figure
bar([Bw1 0],0.4,'r')
hold on
bar([0 Bw1+Bw2+Bw3],0.4,'b')
grid
xlabel('bandwith')
ylabel('Mbs')
title('Bandwith in LTE and LTE-A')
legend('bandwith in LTE','bandwith in LTE-A')
```