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ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

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DHAKA-BANGLADESH

RADIO NETWORK PLANNING INVOLVING OPTIMIZED 4G PARAMETERS

A THESIS SUBMITTED PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCIENCE IN TECHNICAL AND VOCATIONAL EDUCATION IN ELECTRICAL AND ELECTRONIC ENGINEERING

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THIS STUDY IS DEDICATED TO

OUR PARENTS AND BELOVED TEACHERS

DECLARATION

We do hereby that this report has not been submitted elsewhere for obtaining any degree or diploma or certificate or for publication.

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TABLE OF CONTENTS

LIST OF ACRONYMS

1G………………………………………………….......................... First generation

2G………………………………………………………….. Second generation

2.5G…………………………………………………Two and half generation

3G………………………………………………………….3rd Generations

MHZ…………………………………………………………... Mega hertz

KHZ………………………………………………………...... Kilo hertz

1XRTT…………………….1x (single-carrier) Radio Transmission Technology

3GPP……………………………………………...3G partnership projects

3GPP……………………………………...3rd Generation Partnership Project

3GPP2…………………………………………....3G partnership projects 2

ACIR………………………………….. Adjacent channel interference ratio

ACK…………………………………………………………. Acknowledgment

ACLR……………………………………Adjacent Channel Leakage Ratio

ACLR………………………………………. Adjacent channel leakage ratio

AFP………………………………………... Automatic Frequency Planning

AGW……………………………………………………. Access Gateway

AMPS…………………………………….. Advanced Mobile Phone Service

AMS………………………………………. American Musicological Society

API……………………………………Application Programming Interface

ARPU……………………………………….... Average Revenue Per User

BCCH…………………………………………Broadcast Control Channel

BLER……………………………………………………Block Error Rate

BTS………………………………………….. Base Transceiver Station

BW………………………………………………………………. Bandwidth

CAPEX……………………………………………………Capital expenses

CCPCH………………………………. Common Control Physical Channel

CDMA……………………………………….. Code Division Multiple Access

CINR……………………………...Carrier-to-Interference Plus Noise Ratio

CN………………………………………………………….Core Network

CP……………………………………………………….....Cyclic Prefix

CPICH……………………………Code on the primary common-pilot channel

CW………………………………………………………….Continuous wave

DL…………………………………………………………... Downlink

DSCH…………………………………………….Downlink Shared Channel

DTM……………………………………………………Digital Terrain Model

EDGE………………………………Enhanced Data rates for GSM Evolution

EIRP…………………………………………Effective isotropic radiated power

eNB………………………………………………………….Enhanced Node

EPC…………………………………………………....Evolved Packet Core

eSFN……………………………………...Enhanced System Frame Number

ETSI………………………European Telecommunication Standards Institute

EV-DO…………………………………………….EVolution-Data Optimized

EVDO……………………………………………………Evolution data only

EVDV……………………………………...........Evolution Data Voice

EVM…………………………………………………Error Vector Magnitude

FDD……………………………………………….Frequency Division Duplex

FDMA……………………………...Frequency Division Multiple Access

GGSN…………………………………….....Gateway GPRS Support Node

GPRS……………………………………...General Packet Radio Services

GPRS………………………………......General Packet Radio System

GSM……………………………………………...Global System for Mobile

HRPD………………………………………………..High Rate Packet Data

HSDPA…………………………....High Speed Downlink Packet Access

HS-DSCH……………………………..High Speed Downlink Shared Channel

HSPA……………………………………………High Speed Packet Access

HS-PDSCH………………...High Speed Physical Downlink Shared Channel

HS-SCCH…………………………………High Speed Shared Control Channel

HSUPA………………………………………High Speed Uplink Packet Access

ID…………………………………………………………….... Identification

IMSI…………………………………………….Inter Mobile Subscriber Identity

IMT-2000……………………International mobile telecommunications 2000

IP…………………………………………………………......Internet Protocol

IRC…………………………………………....Interference Rejection Combining

ISI…………………………………………………....Inter-symbol-interference

IT…………………………………………………..Information Technology

ITU………………………………...International Telecommunication Union

J-TACS…………………Journal of Theoretical and Applied Computer Science

LTE……………………………………………………..Long Term Evolution

MAC…………………………………………….Medium Access Control

MAC……………………………………………………Medium Access Control

MBMS………………………………Multimedia Broad-cast/Multicast Service

Mbps………………………………………………………Megabits per second

MCS………………………………………Modulation and Coding Schemes

MIMO……………………………………Multiple-Input and Multiple-Output

MME……………………………………….Mobility Management Entity

MME /GW……………..Mobility Management Entity/Gateway (MME /GW)

MSC…………………………………………….....Mobile Switching Centre

MSCs……………………………………...Mobile switching systems

MSISDN………………………………....Mobile Subscriber ISDN Number

MU-MIMO…………………………………………..Multi User - MIMO

NFFT………………………………………………Number of Samples of FFT

NMT………………………………………………… Nordic Mobile Telephony

OBF……………………………………………………… Overbooking factor

OFDM………………………… Orthogonal Frequency Division Multiplexing

OFDMA………………….. .Orthogonal Frequency Division Multiple Access

OPEX…………………………………………………. Operating Expenses

PAPR…………………………………………. Peak-to-Average Power Ratio

PAR……………………………………………………. Peak and Average Rates

PBCH…………………………………………. Physical Broadcast Channel

PDCCH…………………………………. Physical Downlink Control Channel

PDSCCH………………………… Physical Downlink Shared Control Channel

PDSCH……………………………………. Physical Downlink Shared Channel

PDSCH……………………………………. Physical Downlink Shared Channel

PHY……………………………………………………………….. Physical Layer

PS………………………………………………………………. Packet Switched

PSTN……………………………………. Puplic Switched Telephone Network

PUCCH……………………………………. Physical Uplink Control Channel

PUSCH……………………………………… Physical Uplink Shared Channel

QAM…………………………………….. Quadrature Amplitude Modulation

QoS…………………………………………………………. Quality of Service

QPSK………………………………………. Quadrature Phase Shift keying

RAN…………………………………………………… Radio Access Network

RB………………………………………………………….. Resource Block

RLB………………………………………………………….. Radio link budget

RLC……………………………………………………. Radio Link Control

RNC………………………………………………… Radio network controller

RNL……………………………………………………. Radio Network Layer

RRC………………………………………………….. Radio Resource Control

RSCP………………………………………. Received Signal Code Power

RSSI……………………………………… Received Signal Strength Indicator

SAE……………………………………………. System Architecture Evolution

SC-FDMA……………… Single Carrier-Frequency Division Multiple Access

SCTP…………………………………. Stream Control Transmission Protocol

SIMO………………………………………………. Single-input–multi-output

SINR…………………………….. Signal to Interference and Noise Ratio

SISO…………………………………………………. Single Input Single Output

SMS……………………………………………………… Short Message Service

SNR…………………………………………………….. Signal to Noise Ratio

SU-MIMO…………………………………………….. Single User - MIMO

TACS………………………………….. Total Access Communication System

TCP/IP……………………. Transmission Control Protocol/Internet Protocol

TDD………………………………………………….. Time Division Duplex

TDMA……………………………………….. Time Division Multiple Access

TD-SCDMA…. Time Division Synchronous Code Division Multiple Access

TE………………………………………………………… Terminal Equipment

TMA……………………………………………. Tower-Mounted Amplifier

TIA……………………………………………….. Transient Ischemic Attack

TNL…………………………………………………. Transport Network Layer

TTI……………………………………………….. Transmission Time Interval

UE……………………………………………………………. User Equipment

UL……………………………………………………………………. Uplink

UMB………………………………………………. Ultra Mobile Broadband

UMTS………………………….. Universal Mobile Telecommunication System

UPE…………………………………………………………….. User Plane Entity

U-plane……………………………………………………….. User Plane

UTM……………………………………….. Universal Transverse Mercator

UTRAN……………………………. UMTS Terrestrial Radio Access Network

WCDMA…………………………. Wideband Code Division Multiple Access

WGS84………………………………………. World Geodetic System 1984

WiMAX…………………. Worldwide Interoperability for Microwave Access

LIST OF TABLES

LIST OF FIGURES

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ABSTRUCT

Mobile communication is developing very rapidly with passage of time, new technologies are being introduced to facilitate the mobile users more from the technology. The past technologies are replaced by new ones and needs are growing for the new technologies to be developed. One such development is fourth generation networks involving LTE. Also called future generation or Next Generation Networks. The introduction of 4G has widened the scope of mobile communication.

This thesis is based on the newly advanced cellular technology called LTE. It is intended to give a good understanding of LTE radio network planning and optimization of a desired area. The LTE radio network planning involves in coverage estimation, capacity evaluation. In this thesis the coverage estimation and capacity evaluation is done collection of existing parameters and we used those parameters into simulation tool to calculate the desired area. This simulation was perform atoll software version 3.3 to calculate the coverage and the capacity of the desired area and generate simulation result. We propose that by using such scheme we can achieve better QoS during the process of handover

CHAPTER 1

INTRODUCTION

These days, the rapid growth of mobile communication and technologies made an outstanding development not only to ease our daily lives but also to make an important contribution to the persistent computing environments. Starting from the first Generation of cellular network, which is analog communication to the ones that are being developed now like LTE, LTE advance and WIMAX 802.16m, the technology is expanding in higher quality and accessibility. Besides the end user expectations have grown from conventional mobile voice traffic to additional simple text communication and even to live streaming services and internet access which greatly affecting the traffic demands. All these requirements motivated the need for new emerging system architectures and management with issues related to quality of service, capacity and coverage. For this reason, the 3rd Generation Partnership Project (3GPP), which is currently the dominant specifications development group for mobile radio systems in the world, started to work on the upcoming new standard called, the Long-Term Evolution (LTE). LTE is the evolution of the Third generation of mobile communications to the Fourth generation technology that is essentially an all IP broadband Internet system with voice and other services built to ensure 3GPP‟s competitive edge over other cellular technologies. On the contrary to the circuit-switched 3GPP technologies like GSM and WCDMA, which are currently serving nearly 85% of the global mobile subscribers, LTE has been designed to be a high data rate and low latency system supporting only packet switched services. It aims to provide seamless connectivity between two end user equipment (UE) without any disruption to the services in use during mobility. Based on the LTE Rel.‟8 standardization document of 3GPP, the technology enables flexible transmission bandwidth selection between 1.4 MHz and 20 MHz depending on the available spectrum which significantly enhances the service capacity compared to previous cellular technologies.

These and other significant performance achievements rely on recently introduced physical layer technologies, such as Orthogonal Frequency Division Multiplexing (OFDM), Multiple-Input Multiple-Output (MIMO) systems and Smart Antennas. Furthermore, as a result of these technologies minimization to the system and UE complexities; its co-existence with other 3GPP and non-3GPP Radio Access Technologies (RATs) and straightforward planning and deployment approaches were basically achieved. LTE is recently launched technology with improved performance in service delivery and system simplicity. Thus, books, literatures and documentation are available describing the technological advancement, technical standardizations and basic planning and deployment specifications. The planning approach of LTE is divided depending upon the system architecture of LTE as Radio access network and core network planning. LTE Radio access network planning refers to analytical approach which is based on algorithmic formulation and focuses on the radio engineering aspect of the planning process, i.e., on determining the locations, estimated capacity and size of the cell sites (coverage and capacity planning), and assigning frequencies to them by examining the radio-wave propagation environment and interferences among the cells.

1.1 STATEMENT OF PROBLEM

In cellular network, there are sequential steps for radio network planning. These steps start from simple analysis to computer aided mathematical computation; i.e., from nominal planning state to detail planning and then optimization. The system to be deployed is a new technology, the first step in RAN planning, i.e., the nominal planning, is considered as critical point since it gives the first rough estimation to coverage and capacity. LTE nominal radio network planning is done basically using link budget calculation to estimate the cell size and theoretical traffic and throughput calculation for capacity estimation. In most cases, since the simplicity of this stage is needed the coverage estimation is done with a general propagation model which doesn't incorporate the actual geographical information (terrain model). Thus, the major problem in the obtained result is that these results don't represent the real values but in order to make this RAN planning stage more accurate, the inclusion of the terrain model must be considered in simple manners, so that improvement in the result is obtained while the simplicity of the process is still maintained.

1.2 OBJECTIVES

The main aim of this work is to study and describe the nominal radio access network planning and optimization in LTE. It is the intension of the work to understand the different modeling approaches, input and output parameters in LTE dimensioning. Furthermore, seeing how proper the LTE would be for that Kind of terrain exist in Dhaka and see if the results that will be obtained is quality and cost efficient to be done in real and if it will be better than the existed services.

Detailed Objectives

This project specially focuses on:

- ❖ Defining "accurate" or site-based mathematical model of LTE Radio Network planning for capacity and coverage estimation, including environmental information of the selected deployment area to refine the coverage estimation.

- Considering both theoretical simulations and Dhaka Map information of the deployment area which was built on a real statistic from the Bangladesh Telecommunication Limited.

1.3 CONTRIBUTIONS

This research makes contributions to the emerging literature on the convergence to Radio Network planning for Mobile Communication Sectors.

First, this research adopts a methodology enabling the development of insights about radio network planning.
Second, it provides a set of constructs (with their constituent dimensions) that were found sufficient in describing the evolution of and the convergence to Radio Network Planning.
Third, this research formulates research insights helping managers make better decisions in aligning their tools development strategies with emerging to Radio Network Planning.

1.4 SCOPE OF THE PROJECT

This project is a case study and is expected to address features that are necessary for proper implementation of LTE Radio network planning technology in Dhaka. In depth,

- It should estimate the calculation of capacity and coverage and positioning sites process in the area of study.
- From the technical point of view, it should point out the relation between coverage and
- Capacity when planning is performed.
- Optimization is then required to improve the performance of the LTE Radio network planning in that place and how efficient it is to build it in real.

1.5 SERVICES AND APPLICATIONS

Through a combination of very high (downlink and uplink) transmission speeds more flexible, efficient use of spectrum and reduced packet latency, LTE promises to enhance the delivery of mobile broadband services while adding exciting new value-added service possibilities. An overarching objective for LTE is the stabilization and reversal of steadily declining ARPU (Average Revenue per User) that is characteristic of many mobile markets

1.6 HISTORY OF MOBILE TELECOMMUNICATION SYSTEM

1.6.1. The first generation (1G) systems

Mobile telecommunication systems were first introduced in the early 1980s. The first generation (1G) systems used analogue communication techniques, which were similar to those used by a traditional analogue radio. The individual cells were large and the systems did not use the available radio spectrum efficiently, so their capacity was by today's standards very small. The mobile devices were large and expensive and were marketed almost exclusively at business users.

1.6.2. The second generation (2G) systems

Mobile telecommunications took off as a consumer product with the introduction of second generation (2G) systems in the early 1990s. These systems were the first to use digital technology, which permitted a more efficient use of the radio spectrum and the introduction of smaller, cheaper devices. They were originally designed just for voice, but were later enhanced to support instant messaging through the Short Message Service (SMS).

The most popular 2G system was the Global System for Mobile Communications (GSM), which was originally designed as a pan-European technology, but which later became popular throughout the world. Also notable was IS-95, otherwise known as CDMA One, which was designed by Qualcomm, and which became the dominant 2G system in the USA. The success of 2G communication systems came at the same time as the early growth of the internet. It was natural for network operators to bring the two concepts together, by allowing users to download data onto mobile devices. To do this, so-called 2.5G systems built on the original ideas from 2G, by introducing the core network's packet switched domain and by modifying the air interface so that it could handle data as well as voice. The General Packet Radio Service (GPRS) incorporated these techniques into GSM, while IS-95 was developed into a system known as IS-95B. At the same time, the data rates available over the internet were progressively increasing. To mirror this, designers first improved the performance of 2G systems using techniques such as Enhanced Data Rates for GSM Evolution (EDGE) and then introduced more powerful third generation (3G) systems in the years after 2000.

1.6.3. The third generation (3G) systems

The 3G systems use different techniques for radio transmission and reception from their 2G predecessors, which increases the peak data rates that they can handle, makes still more efficient use of the available radio spectrum, enabled faster data-transmission speeds, greater network capacity and more advanced network services. In these systems, the air interface includes extra optimizations that are targeted at data applications, which increase the average rate at which a user can upload or download information, at the expense of introducing greater variability into the data rate and the arrival time. The world's dominant 3G system is the Universal Mobile Telecommunication System (UMTS). UMTS was developed from GSM by completely changing the technology used on the air interface, while keeping the core network almost unchanged. The system was later enhanced for data applications, by introducing the 3.5G technologies of high speed downlink packet access (HSDPA) and high speed uplink packet access (HSUPA), which are collectively known as high speed packet access (HSPA). The final 3G technology is Worldwide Interoperability for Microwave Access (WiMAX). This was developed by the Institute of Electrical and Electronics Engineers under IEEE standard 802.16 and has a very different history from other 3G systems. The original specification (IEEE802.16–2001) was for a system that delivered data over point-to point microwave links instead of fixed cables. A later revision, known as fixed WiMAX (IEEE 802.16–2004), supported point to-multipoint communications between an omnidirectional base station and a number of fixed devices.

1.6.4. The fourth generation (4G) systems

4G is an ITU specification that is currently being developed for broadband mobile capabilities. 4G technologies would enable IP-based voice, data and streaming multimedia at higher speeds and offer at least 100 Mbit/s with high mobility and up to 1GBit/s with low mobility (nomadic). 4G is an IP-based and packet-switched evolution of 3G technologies (such as WCDMA, HSDPA, CDMA2000 and EVDO) that uses voice communications. A number of technologies considered to be 4G standards include Long Term Evolution (LTE), Ultra Mobile Broadband (UMB) and the IEEE 802.16 (WiMax) standard.

1.7 ORGANIZATION

The rest of this thesis is organized into six chapters……..

Chapter 2: Provides the literature review and identifies the lessons learned from it.
Chapter 3: Describes the research methodology.
Chapter 4: Overview of LTE system.
Chapter 5: Brief Idea about Atoll software.
Chapter 6: Overview of LTE Network Planning Process.
Chapter 7: Simulation and Result Discussion.
Chapter 8: Provides the conclusions.

CHAPTER 2

LITERATURE REVIEW

LTE framework basic objectives is to build up a system that meets high data rate demands, low latency and optimization for packet-domain traffic. LTE system is intended to have a peak data rate of 100 Mbps in DL and up to 50 Mbps in the UL **[1].** Dimensioning is a part of the whole planning process, which also includes, detailed planning and optimization of the wireless cellular network. Wireless cellular network dimensioning follows these basic steps:

- Data/Traffic Analysis that gives an estimate of the traffic to be carried by the system.
- Coverage estimation is used to determine the coverage area of each base station
- Capacity evaluation Capacity planning deals with the ability of the network to provide services to the users with a desired level of quality
- Transport dimensioning Transport dimensioning deals with the dimensioning of interfaces between different network elements **[2].**

LTE Capacity Dimensioning **[3]**. Radio Link Budget Calculation**:** Calculating the link budget, one can determine the coverage area and radius of the cell, allowing estimation of the number of base stations needed to cover the area where you intend to offer the service. It is noteworthy that the characteristics of the environment (dense urban, urban, suburban.) in which the network is installed, are determinant for the results of Link Budget, due to propagation loss the signal will **su**ffer **[4].** The awareness of LTE resulted in the designed and deployment of the 4th generation radio technologies commonly refer to as 4G in order to enhance capacity as well as the data rate of the existing 3G radio technology **[5].** A good number of researchers have carried out research on capacity enhancement in WCDMA wireless radio network, but few have been done on Long Term Evolution (LTE**)** **[6].** Power control for utility maximization in wireless networks and cellular communication systems has been intensively studied. There is an extensive body of work on this topic, from the early papers **[7].** The applicability of optimization techniques for ensuring good network performance is quite intuitive, both for planning a network and/or radio resources, and for optimizing them during operation and maintenance, provided that a reasonable trade-off between the model complexity and reality can be found **[8].** Many technical aspects of UMTS networks and some practicedriven optimization and tuning rules are given in **[9].** **[10]** power control and capacity issues are treated in **[10].** Optimization of certain network aspects without site selection is treated in **[11].**

CHAPTER 3

RESEARCH METHODOLOGY

The concept of LTE radio network planning is still an ongoing study with different standardizations. Thus, this project is entirely based on books on LTE, 3GPP standardization documents, different IEEE articles, journals, previous studies on this subject and known simulators and NSN documents and Tools.

The work started with preliminary study on LTE and the general radio network planning. On the process of reviewing related works the statement of the problem had been clearly specified and thus we used the atoll software version 3.3 to generate the simulation results.

CHAPTER 4

LTE SYSTEM

4.1 LONG TERM EVOLUTION (LTE)

In telecommunication, **Long-Term Evolution** (**LTE**) is a standard for wireless broadband communication for mobile devices and data terminals, based on the GSM/EDGE and UMTS/HSPA technologies. It increases 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. LTE is the upgrade path for carriers with both GSM/UMTS networks and CDMA2000 networks. The different LTE frequencies and bands used in different countries mean that only multi-band phones are able to use LTE in all countries where it is supported.

LTE is commonly marketed as "4G LTE and Advance 4G", but it does not meet the technical criteria of a 4G wireless service, as specified in the 3GPP Release 8 and 9 document series for LTE Advanced. LTE is also commonly known as **3.95G**. The requirements were originally set forth by the ITU-R organization in the IMT Advanced specification. However, due to marketing pressures and the significant advancements that WiMAX, Evolved High Speed Packet Access 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".

4.1.1 TARGETS OF LTE DESIGN AND REQUIREMENTS

The initial 3GPP activity on 3G evolution was setting the objectives, requirements and targets for LTE. These targets/requirements are should be noted that the capabilities, system performance, and other aspects are outlined as below and are the targets set out in the initial phase of the LTE standards development. The final capabilities and performance reached are different and do in many cases exceed the targets set at the beginning of the LTE development. The requirements for LTE were divided into seven different areas: Capabilities, System performance, Deployment-related aspects, Architecture and migration, Radio resource management and Complexity. Below, each of these groups is discussed.

4.1.2 CAPABILITIES

The targets for downlink and uplink peak data-rate requirements are 100 Mbit/s and 50Mbit/s, respectively, when operating in 20 MHz spectrum allocation. For narrower spectrum allocations, the peak data rates are scaled accordingly. Thus, the requirements can be expressed as 5 bit/s/Hz for the downlink and 2.5 bit/s/Hz for the uplink. The latency requirements are split into control-plane requirements and user plane requirements. The control-plane latency requirements address the delay for transiting from different non-active terminal states to an active state where the mobile terminal can send and/or receive data.

The user-plane latency requirement is expressed as the time it takes to transmit a small IP packet from the terminal to the RAN (Radio Access Network) edge node or vice versa measured on the IP layer. The one-way transmission time should not exceed 5 ms in an unloaded network, that is, no other terminals are present in the cell. As a side requirement to the control-plane latency requirement, LTE should support at least 200 mobile terminals in the active state when operating in 5MHz. In wider allocations than 5MHz, at least 400 terminals should be supported. The number of inactive terminals in a cell is not explicitly stated, but should be significantly higher.

4.1.3 SYSTEM PERFORMANCE

The LTE system performance design targets address user throughput, spectrum efficiency, mobility, coverage, and further enhanced MBMS (Multimedia Broad-cast/Multicast Service). The LTE user throughput requirement is specified at two points: at the average and at the fifth percentile of the user distribution (where 95 percent of the users have better performance). A spectrum efficiency target has also been specified, where in this context, spectrum efficiency is defined as the system throughput per cell in bit/s/ MHz/cell. The mobility requirements focus on the mobile terminals speed. Maximal performance is targeted at low terminal speeds, 0–15 km/h, whereas a slight degradation is allowed for higher speeds. For speeds up to 120 km/h, LTE should provide high performance and for speeds above 120 km/h, the system should be able to maintain the connection across the cellular network. The maximum speed to manage in an LTE system is set to 350 km/h (or even up to 500 km/h depending on frequency band). Special emphasis is put on the voice service that LTE needs to provide with equal quality as supported by WCDMA/HSPA. The coverage requirements focus on the cell range (radius) that is the maximum distance from the cell site to a mobile terminal in a cell.

The requirement for non-interference-limited scenarios is to meet the user throughput, the spectrum efficiency, and the mobility requirements for cells with up to 5km cell range. For cells with up to 30km cell range, a slight degradation of the user through-put is tolerated and a more significant

degradation of the spectrum efficiency is acceptable relative to the requirements.
However, the mobility requirements should be met. Cell ranges up to 100 km should not be precluded by the specifications, but no performance requirements are stated in this case.

4.1.4 RADIO RESOURCE MANAGEMENT

The radio resource management requirements are divided into enhanced support for end-to end QoS, efficient support for transmission of higher layers, and support of load sharing and policy management across different radio access technologies. The enhanced support for end-to-end QoS requires an improved matching of service, application and protocol requirements (including higher layer signaling) to RAN resources and radio characteristics. The efficient support for transmission of higher layers requires that the LTE RAN should provide mechanisms to support efficient transmission and operation of higher layer protocols over the radio interface, such as IP header compression.
The support of load sharing and policy management across different radio access technologies requires consideration of reselection mechanisms to direct mobile terminals toward appropriate radio access technologies in all types of states as well as that support for end-to-end QoS during handover between radio access technologies.

4.2 LTE SYSTEM ARCHITECTURE

LTE (Long-Term Evolution) of UMTS (Universal Mobile Telecommunications Service) is one of the latest steps in an advancing series of mobile telecommunication systems. The standards body behind the paperwork is the 3rd Generation Partnership Project (3GPP). Along with the term LTE , the acronyms EPS (Evolved Packet System) , EPC (Evolved Packet Core) , and SAE (System Architecture Evolution) are often heard . **Figure 2.1** shows how these terms are related to each other: EPS is the umbrella that covers both the LTE of the Evolved Universal Terrestrial Radio Access Network (E-UTRAN) and the SAE of the EPC network.

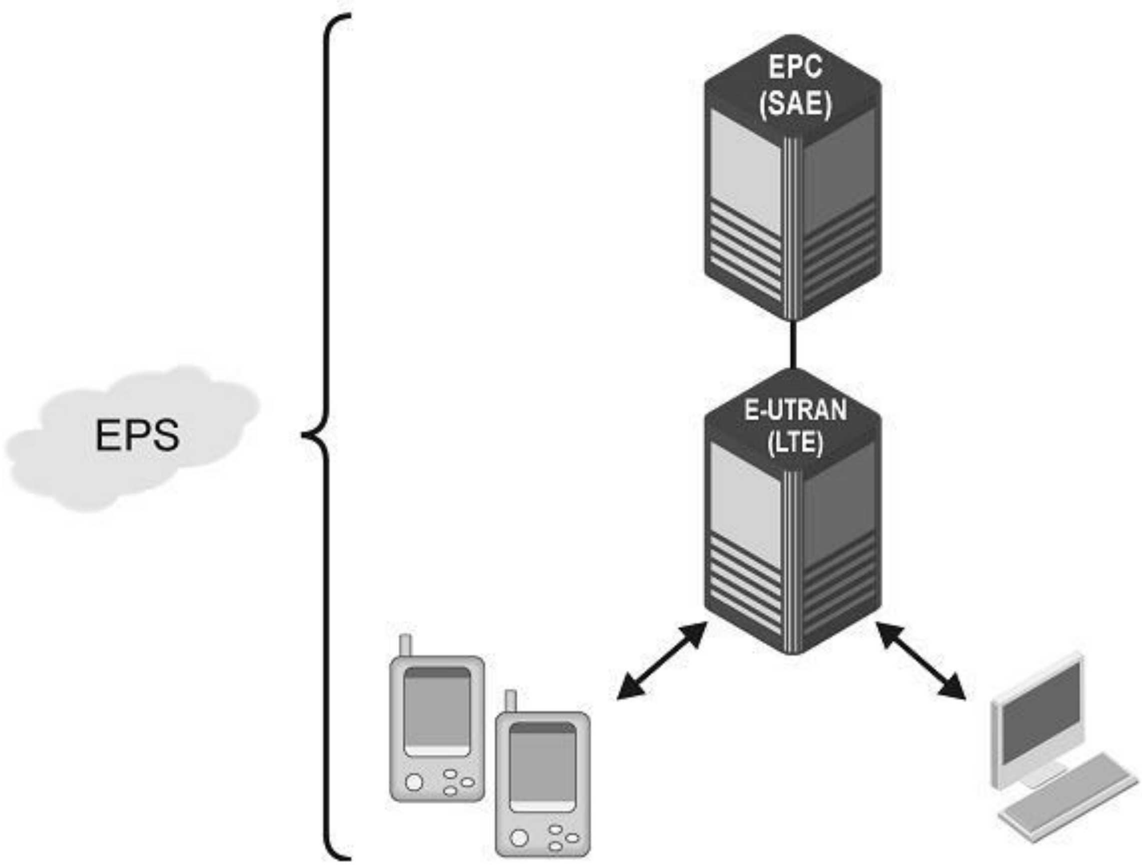

Figure 4.2 EPC and LTE under the umbrella of EPS.

4.2.1. User Equipment (UE) Architecture

As in UMTS, the LTE mobile station is called User Equipment (UE). It is constructed using a modular architecture that consists of three main components (see **Figure 4.2.1**):

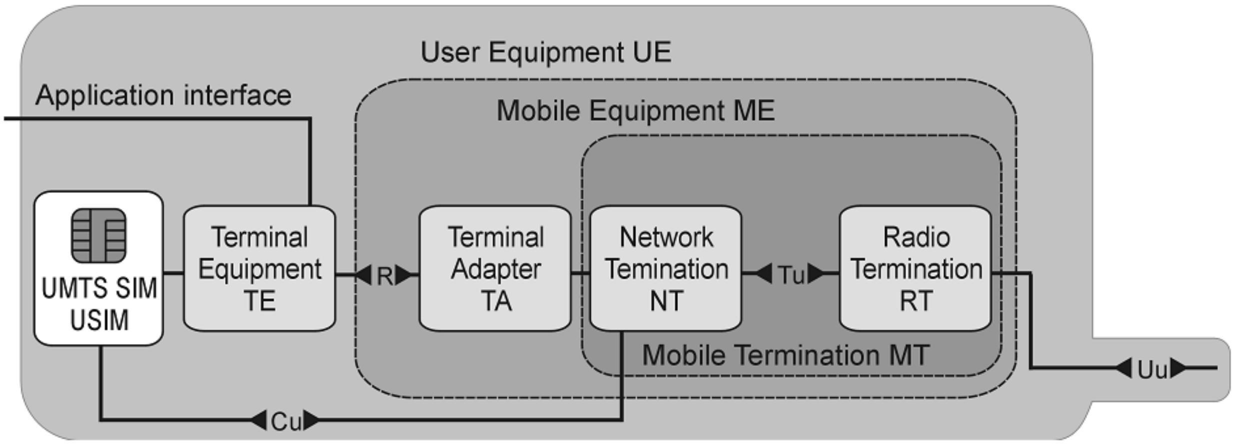

Figure 4.2.1 Modular architecture of a UE.

• Mobile Termination: The MT represents termination of the radio interface. In this entity all the communication functions are handled (the RRC signaling is terminated and RRC messages are sent/received).
• Terminal Adapter: The terminal adapter represents the termination of the application specific service protocols, for example, SIP signaling for VoIP. The terminal adapter might be constructed as an external interface, for example, USB to connect a laptop PC using LTE technology with a mobile network.
• Terminal Equipment: The TE represents termination of the service. Depending on the UE's application capabilities, it may act as the TE or not. For instance, the Apple iPhone with its browser functionalities has full TE capability while a simple USB stick for mobile data transmission has no TE capability at all. In the case of the USB stick, the connected laptop PC is the TE.

UE Categories

The UE categories stand for an abstract grouping of common UE radio access capabilities and are defined in 3GPP 36.306.In particular, the handset-type groups vary in maximum possible throughput (the maximum number of DL-SCH transport blocks bits received within a Time Transmission Interval (TTI)). Assuming a TTI of 1ms for category 1, the maximum possible throughput is 10296 bits/1ms which is approximately 10Mbps of physical layer DL throughput (including the RLC/MAC header information – so the payload throughput will be slightly less). Category 5 mobiles are the only handsets that support 64 Quadrature Amplitude Modulation (QAM)on the UL as highlighted in **Tables(4.2.1a & 4.2.1b)**. The maximum possible bit rate ranges from 5Mbps (Cat. 1) to 75Mbps (Cat. 5).

UE category	Maximum number of DL-SCH transport block bits received within a TTI	Maximum number of bits of a DL-SCH transport block received within a TTI	Approximate maximum bit rate DL (Mbps)
Category 1	10296	10296	10
Category 2	51024	51024	50
Category 3	102048	75 376	75
Category 4	150752	75 376	75
Category 5	302752	151 376	150

Table 4.2.1a UE categories and DL capabilities (according to 3GPP 36.306). Reproduced with permission from © 3GPP ™

UE category	Maximum number of bits of an UL-SCH transport block transmitted within a TTI	Support for 64QAM in UL	Approximate maximum bit rate UL (Mbps)
Category 1	5 160	NO	5
Category 2	25 456	NO	25
Category 3	51 024	NO	50
Category 4	51 024	NO	50
Category 5	75 376	YES	75

Table 4.2.1b UE categories and UL capabilities (according to 3GPP 36.306). Reproduced with permission from © 3GPP™

4.2.2. EVOLVED PACKET CORE (EPC) ARCHITECTURE

Figure 4.2.2 shows the main components of the evolved packet core. We have already seen one component, the home subscriber server (HSS), which is a central database that contains information about all the network operator's subscribers. This is one of the few components of LTE that has been carried forward from UMTS and GSM.

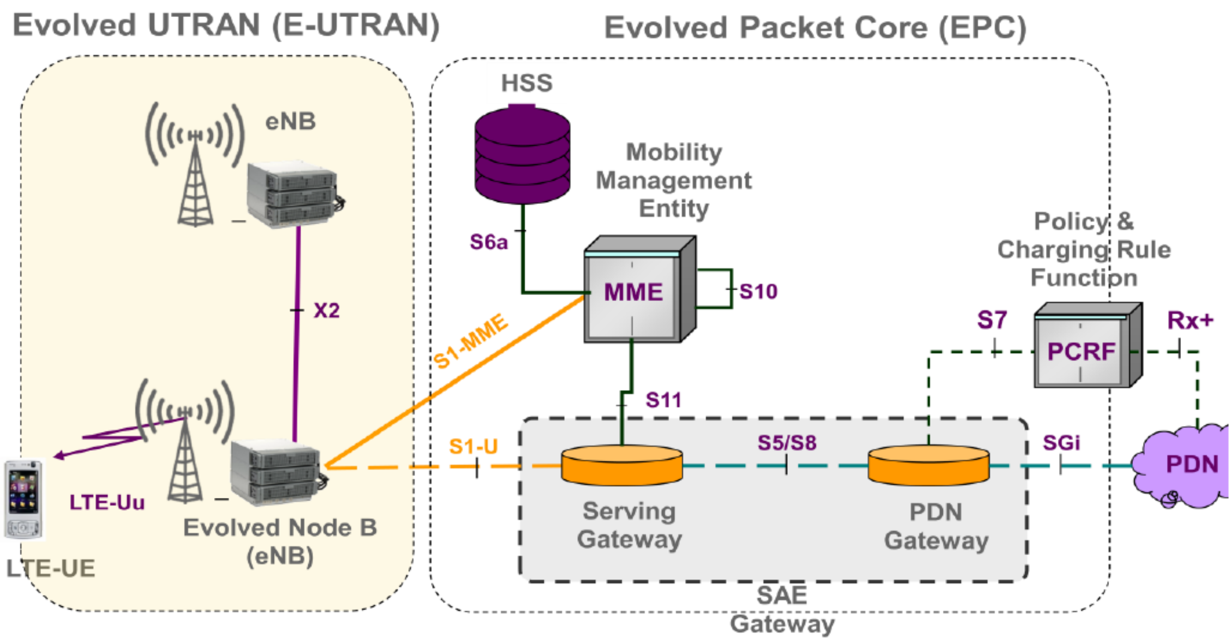

Figure 4.2.2 EPS network elements

Mobility Management Entity (MME) :

The MME is responsible for the NAS connection with the UE. All Non Access Stratum (NAS) signaling messages are exchanged between the UE and MME to trigger further procedures in the core network if necessary. .A new function of the E-UTRAN is NAS signaling security. The purpose of this feature is to protect the signaling messages that could reveal the true subscriber's identity and location from unauthorized eavesdropping. The MME is also responsible for paging subscribers in the EPS Connection Management (ECM) IDLE state (including control and execution of paging retransmission) and is concerned with tracking area list management. The list of tracking areas is the list of locations where the UE will be paged. To route the user plane data streams the MME will select the best fitting PDN-GW and S-GW. It will also connect the E-UTRAN with the 3G UTRAN using the S3 interface (MME to SGSN). When necessary, a relocation of gateways will be triggered and controlled by the MME. As its name suggests, the MME will perform management of handovers by selecting a new target MME or SGSN for handovers to 2G or 3G 3GPP access networks. Also, it is the MME that hosts the connection to the HSS across the S6a interface and, hence, it is responsible for roaming management and authentication of subscribers. Last but not least, the MME sets up, modifies, and releases default and dedicated bearers. This function is commonly known as the bearer management function.

The S-GW (Serving Gateway):

Acts as a router, and forwards data between the base station and the PDN gateway. A typical network might contain a handful of serving gateways, each of which looks after the mobiles in a certain geographical region. Each mobile is assigned to a single serving gateway, but the serving gateway can be changed if the mobile moves sufficiently far.

The packet data network (PDN) gateway (P-GW) :

The (P-GW) is the EPC's point of contact with the outside world. Through the SGi interface, each PDN gateway exchanges data with one or more external devices or packet data networks, such as the network operator's servers, the internet or the IP multimedia subsystem. Each packet data network is identified by an access point name (APN). A network operator typically uses a handful of different APNs, for example one for its own servers and one for the internet .Each mobile is assigned to a default PDN gateway when it first switches on, to give it always-on connectivity to a default packet data network such as the internet. Later on, a mobile may be assigned to one or more additional PDN gateways, if it wishes to connect to additional packet data networks such as private corporate networks. Each PDN gateway stays the same throughout the lifetime of the data connection.

Policy and Charging Rule Function (PCRF) :

For policy control and charging, the PDN-GW can be connected to a (PCRF) via the GX reference point. The PCRF provides guidance on how a particular service data flow should be treated in terms of priority, throughput, and other QoS parameters according to the user's subscription profile.

The Home Subscriber Server (HSS) :

The HSS (Home Subscriber Server) is the concatenation of the HLR (Home Location Register) and the AUC (Authentication Center), two functions being already present in pre-IMS 2G/GSM and 3G/UMTS networks. The HLR part of the HSS is in charge of storing and updating when necessary the database containing all the user subscription information, including (list is no exhaustive):

- User identification and addressing: this corresponds to the IMSI (Inter Mobile Subscriber Identity) and MSISDN (Mobile Subscriber ISDN Number) or mobile telephone number.
- User profile information: this includes service subscription states and user-subscribed Quality of Service information (such as maximum allowed bit rate or allowed traffic class).

The AUC part of the HSS is in charge of generating security information from user identity keys. This security information is provided to the HLR and further communicated to other entities in the network. The EPC has some other components that were not shown in **Figure 4.2.2.** Firstly, the cell broadcast center (CBC) was previously used by UMTS for the rarely implemented cell broadcast service (CBS). In LTE, the equipment is re used for a service known as the earthquake and tsunami warning system (ETWS). Secondly, the equipment identity register (EIR) was also inherited from UMTS, and lists the details of lost or stolen mobiles.

4.2.3. NETWORK AREAS

The EPC is divided into three different types of geographical area, which are illustrated in **Figure 4.2.3** An MME pool area is an area through which the mobile can move without a change of serving MME. Every pool area is

controlled by one or more MMEs, while every base station is connected to all the MMEs in a pool area by means of the S1-MME interface.
Pool areas can also overlap. Typically, a network operator might configure a pool area to cover a large region of the network such as a major city and might add MMEs to the pool as the signaling load in that city increases.
Similarly, an S-GW service area is an area served by one or more serving gateways, through which the mobile can move without a change of serving gateway. Every base station is connected to all the serving gateways in a service area by means of the S1-U interface. S-GW service areas do not necessarily correspond to MME pool areas.

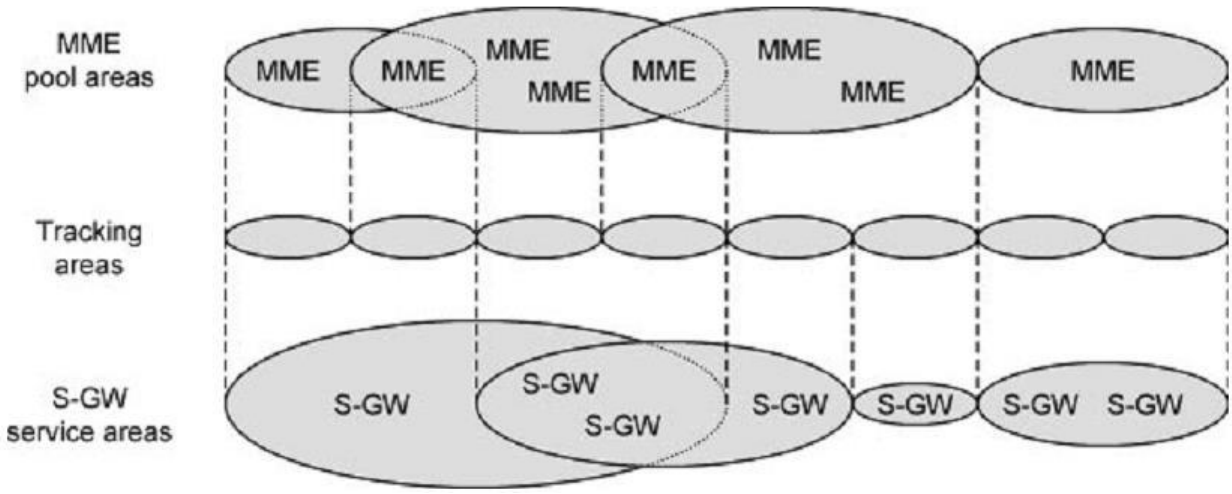

Figure 4.2.3 Relationship between tracking areas, MME pool areas and S-GW service areas.

MME pool areas and S-GW service areas are both made from smaller, non over lapping units known as tracking areas (TAs). Tracking areas (TAs) are used to track the locations of mobiles that are on standby and are similar to the location and routing areas from UMTS and GSM.

4.2.4 NUMBERING, ADDRESSING AND IDENTIFICATION

The components of the network are associated with several different identities.

- **public land mobile network identity (PLMN-ID):**

As in previous systems, each network is associated with a (PLMN-ID). This comprises a three digit mobile country code (MCC) and a two or three digit mobile network code (MNC).For example, the mobile country code for Yemen is 967, while MTN's Yemen network uses a mobile network code of 73.

MME Identities :

Each MME has three main identities, which are shown as the shaded parts of **Figure 4.2.4.** The 8 bit MME code (MMEC) uniquely identifies the MME within all the pool areas that it belongs to. By combining this with a 16 bit MME group identity (MMEGI), we arrive at a 24 bit MME identifier (MMEI), which uniquely identifies the MME within a particular network. By bringing in the network identity, we arrive at the globally unique MME identifier (GUMMEI), which identifies an MME anywhere in the world.

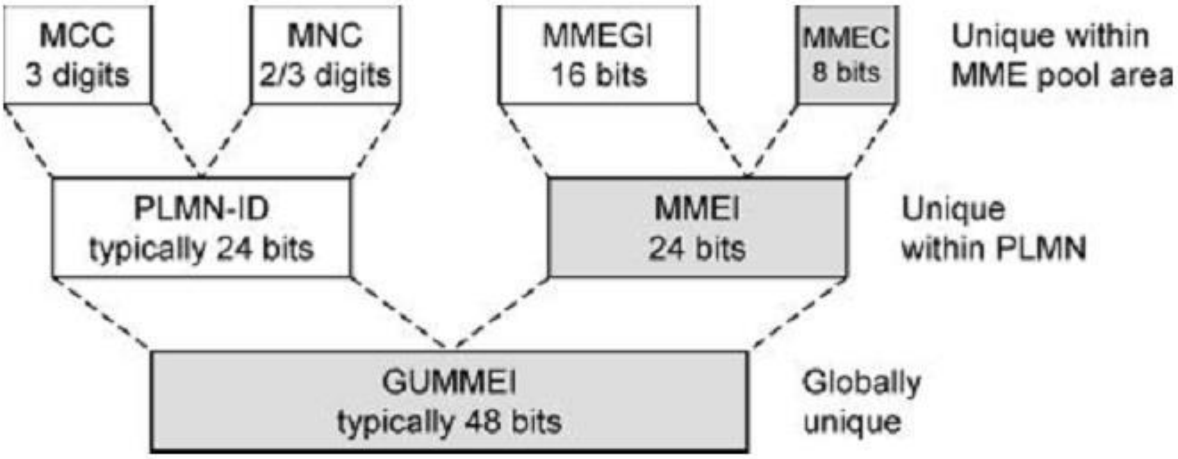

Figure 4.2.4 Identities used by the MME.

Each tracking area has two main identities. The 16 bit tracking area code (TAC) identifies a tracking area within a particular network. Combining this with the network identity gives the globally unique tracking area identity (TAI).

Cells Identities :

Cells have three types of identity. The 28 bit E-UTRAN cell identity (ECI) identifies a cell within a particular network, while the E-UTRAN cell global identifier (ECGI) identifies a cell anywhere in the world. Also important for the air interface is the physical cell identity, which is a number from 0 to 503 that distinguishes a cell from its immediate neighbors.

Mobile Identities :

A mobile is also associated with several different identities. The most important are the international mobile equipment identity (IMEI), which is a unique identity for the mobile equipment, and the international mobile subscriber identity (IMSI), which is a unique identity for the UICC and the USIM.

The IMSI is one of the quantities that an intruder needs to clone a mobile, so we avoid transmitting it across the air interface wherever possible. Instead, a serving MME identifies each mobile using temporary identities, which it updates at regular intervals. Three types of temporary identity are important, and are shown as the shaded parts of Figure 2.8. The 32 bit M temporary mobile subscriber identity (M-TMSI) identifies a mobile to its serving MME . Adding the MME code results in the 40 bit S temporary mobile subscriber identity (S-TMSI), which identifies the mobile within an MME pool area. Finally, adding the MME group identity and the PLMN identity results in the most important quantity, the globally unique temporary identity (GUTI).

4.2.5 LTE PROTOCOL ARCHITECTURE

The Long Term Evolution protocol architecture embraces the first three levels of the ISO/OSI stack. In fact, as we can see from **figure 4.2.5**, two sub-layers of the LTE protocol stack operate at level 3: NAS and RRC. Anyway, they are concerned just with the control plane, so no user traffic passes through them.

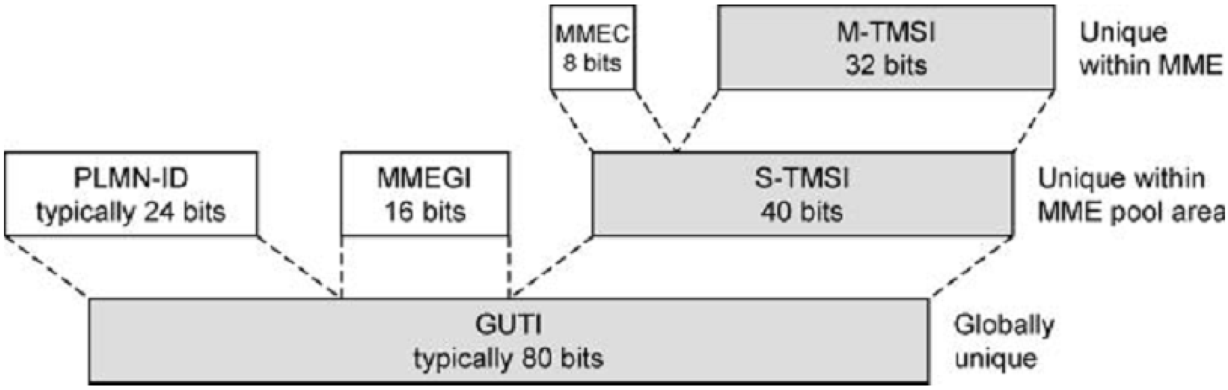

Figure 4.2.5 Temporary identities used by the mobile.

4.2.6 SPECTRUM FLEXIBILITY: FDD AND TDD

Depending on regulatory aspects in different geographical areas, radio spectrum for mobile communication is available in different frequency bands in different bandwidths, and comes as both paired and unpaired spectrum. Spectrum flexibility, which enables operation under all these conditions, is one of the key features of LTE radio access. Besides being able to operate in different frequency bands, LTE can be deployed with different bandwidths ranging from Approximately 1.25MHz up to approximately 20MHz. Furthermore, LTE can operate in both paired and unpaired spectrum by providing a single radio-access technology that supports frequency-division duplex (FDD) as well as time division duplex (TDD) operation. Where terminals are concerned, FDD can be operated in full- and half-duplex modes. Half duplex FDD, in which the terminal separates transmission and reception in frequency *and* time (**figure 4.2.6**), is useful because it allows terminals to operate with relaxed duplex-filter requirements. This, in turn, reduces the cost of terminals and makes it possible to exploit FDD frequency bands that could not otherwise be used (too narrow duplex distance).Together, these solutions make LTE fit nearly arbitrary spectrum allocations. One challenge when designing a spectrum flexible radio-access technology is to preserve commonality between the spectrum and duplexing modes. The frame structure that LTE uses is the same for different bandwidths and similar for FDD and TDD.

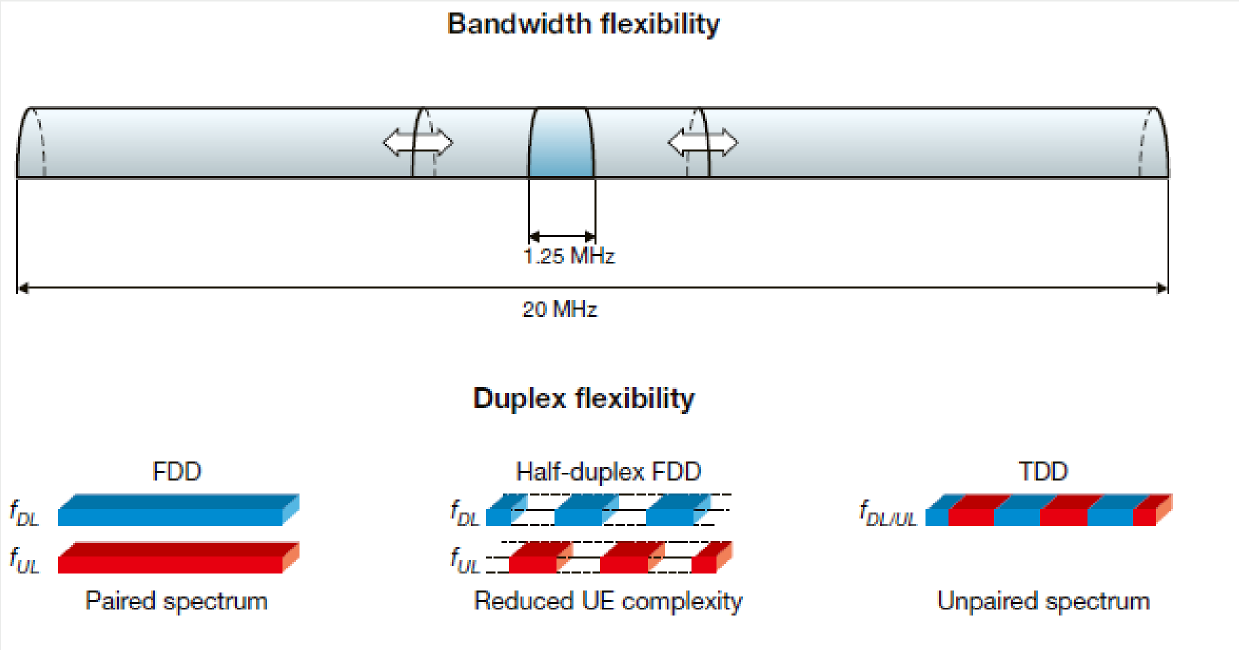

Figure 4.2.6- LTE spectrum (bandwidth and duplex) flexibility Half-duplex FDD is seen.

4.2.7 MIMO TRANSMISSION

MIMO, Multiple Input Multiple Output is another of the LTE major technology innovations used to improve the performance of the system. This technology provides LTE with the ability to further improve its data throughput and spectral efficiency above that obtained by the use of OFDM. Although MIMO adds complexity to the system in terms of processing and the number of antennas required, it enables far high data rates to be achieved along with much improved spectral efficiency. As a result, MIMO has been included as an integral part of LTE.

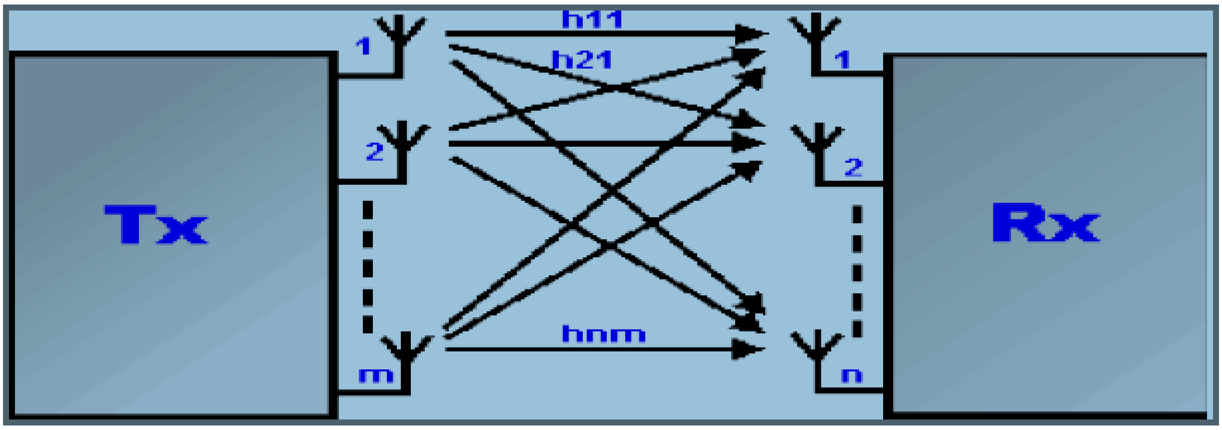

Figure 4.2.7 General Outline of MIMO system

LTE MIMO basics

The basic concept of MIMO utilizes the multipath signal propagation that is present in all terrestrial communications. Rather than providing interference, these paths can be used to advantage. The transmitter and receiver have more than one antenna and using the processing power available at either end of the link, they are able to utilize the different paths that exist between the two entities to provide improvements in data rate of signal to noise. MIMO is being used increasingly in many high data rate technologies including Wi-Fi and other wireless and cellular technologies to provide improved levels of efficiency. Essentially MIMO employs multiple antennas on the receiver and transmitter to utilize the multi-path effects that always exist to transmit additional data, rather than causing interference.

LTE MIMO

The use of MIMO technology has been introduced successively over the different releases of the LTE standards. MIMO has been a cornerstone of the LTE standard, but initially, in releases 8 and 9 multiple transmit antennas on the UE was not supported because in the interested of power reduction, only a single RF power amplifier was assumed to be available. It was in Rel. 10 that a number of new schemes were introduced. Closed loop spatial multiplexing for SU-MIMO as well as multiple antennas on the UE.

LTE MIMO modes

There are several ways in which MIMO is implemented in LTE. These vary according to the equipment used, the channel function and the equipment involved in the link.

Single antenna: This is the form of wireless transmission used on most basic wireless links. A single data stream is transmitted on one antenna and received by one or more antennas. It may also be referred to as SISO: Single In Single Out or SIMO Single In Multiple Out dependent upon the antennas used. SIMO is also called receive diversity.

Transmit diversity: This form of LTE MIMO scheme utilizes the transmission of the same information stream from multiple antennas. LTE supports two or four for this technique. The information is coded differently using Space Frequency Block Codes. This mode provides an improvement in signal quality at reception and does not improve the data rate. Accordingly this form of LTE MIMO is used on the Common Channels as well as the
Control and Broadcast channels.

Open loop spatial multiplexing: This form of MIMO used within the LTE system involves sending two information streams which can be transmitted over two or more antennas. However there is no feedback from the UE although a TRI, Transmit Rank Indicator Transmitted from the UE can be used by the base station to determine the number of spatial layers.

Close loop spatial multiplexing: This form of LTE MIMO is similar to the open loop version, but as the name indicates it has feedback incorporated to close the loop. A PMI, Pre-coding Matrix Indicator is fed back from the UE to the base station. This enables the transmitter to pre-code the data to optimize the transmission and enable the receiver to more easily separate the different data streams.

Closed loop with pre-coding*:* This is another form of LTE MIMO, but where a single code word is transmitted over a single spatial layer. This can be sued as a fall back mode for closed loop spatial multiplexing and it may also be associated with beam forming as well.

Multi-User MIMO, MU-MIMO: This form of LTE MIMO enables the system to target different spatial streams to different users.

Beam-forming: This is the most complex of the MIMO modes and it is likely to use linear arrays that will enable the antenna to focus on a particular area. This will reduce interference, and increase capacity as the particular UE will have a beam formed in their particular direction. In this a single code word is transmitted over a single spatial layer. A dedicated reference signal is used for an additional port. The terminal estimates the channel quality from the common reference signals on the antennas.

CHAPTER 5

ATOLL

5.1 ATOLL OVERVIEW

Atoll is a 64-bit multi-technology wireless network design and optimization platform that supports wireless operators throughout the network lifecycle, from initial design to densification and optimization.

Figure 5.1 : Forsk logo

Atoll 3.2, 3.3 includes integrated single RAN – multiple RAT network design capabilities for both 3GPP (GSM/UMTS/LTE) and 3GPP2 (CDMA/LTE) technology streams. It provides operators and vendors with a powerful native 64-bit framework for designing and optimizing current and future integrated multi-technology networks. Atoll 3.2, 3.3 supports the latest technology advances such as Het Nets and small cells.

Atoll’s integration and automation features help operators smoothly automate planning and optimization processes through flexible scripting and SOA-based mechanisms. Atoll supports a wide range of implementation scenarios, from standalone to enterprise-wide server-based configurations. With 6000 active licenses installed with 300+ customers in 100 countries, Atoll has become the industry standard for radio network planning and optimization.

5.2 LTE IN ATOLL

In 2008, Atoll was the first LTE network planning software available on the market. Atoll is being used by a number of the largest LTE operators worldwide. Atoll 3.2 is a comprehensive framework for operators who need to plan evolution towards LTE and LTE-Advanced. It allows planning and analyzing integrated GSM/UMTS/LTE and CDMA2000/LTE networks.

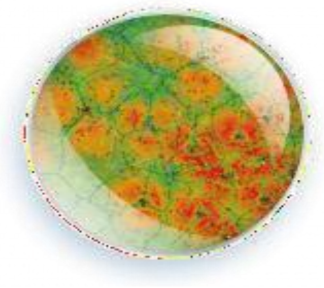

Figure 5.2 Atoll symbol

Atoll 3.2 includes unified multi-technology GSM/UMTS/LTE (3GPP) and CDMA/LTE (3GPP2) traffic models, Monte Carlo simulators and ACP (Automatic Cell Planning) module, as well as support for the latest technology trends such as Het Nets and small cells.

Also Atoll 3.3 is the latest version for Automatic cell planning (ACP), Optimization process and Budget.

CHAPTER 6

NETWORK PLANNING

6.1 DIMENSIONING OF LTE NETWORK:

Dimensioning is the initial phase of network planning. It provides the first estimate of the network element count as well as the capacity of those elements. The purpose of dimensioning is to estimate the required number of radio base stations needed to support a specified traffic load in an area and the specific service to the cell edge users .Dimensioning is an important part of the whole planning process, which also includes, detailed planning and optimization of the wireless cellular network. As a whole, planning is an iterative process covering design, synthesis and realization. The aim of this whole exercise is to provide a method to design the wireless cellular network such that it meets the requirements set forth by the customers. This process can be modified to fit the needs of any wireless cellular network. This is a very important process in network deployment. Dimensioning is based on a set of input parameters and the provided results are relevant for that set of input parameters only. These parameters include area under consideration, expected traffic and required QoS. Dimensioning provides the evaluation of the requirements for network infrastructure and computation of number of sites required to serve certain area while fulfilling the coverage capacity requirements. This is done with the help of dimensioning tool for both access and core networks. Dimensioning uses relatively simpler models for modeling of the actual conditions as compared to the detailed planning. Simpler models and methods reduce the time required for dimensioning On the other hand; dimensioning tool should be accurate enough to provide results with an acceptable level of accuracy, when loaded with expected traffic profile and subscriber base. Wireless cellular network dimensioning is directly related to the quality and effectiveness of the network, and can deeply affect its development. Wireless cellular network dimensioning follows these basic steps:

- Data/Traffic Analysis.
- Coverage estimation.
- Capacity evaluation.
- Transport dimensioning.

A proper set of inputs is vital for dimensioning to yield accurate results. Wireless cellular dimensioning requires some fundamental data elements. These parameters include operator's requirements, operator's existent network sites density and distribution, the frequency band and

Bandwidth available for LTE system, the geographic environment information of the city to be covered and subscriber's population and traffic distribution forecast. Propagation models according to the area and frequency band should be selected and modified (if needed). This is necessary for coverage estimation. System specific parameters like, transmit power of the antennas, their gains, estimate of system losses, type of antenna system used etc, must be known prior to the start of wireless cellular network dimensioning. Each wireless network has its own set of parameters. Traffic analysis gives an estimate of the traffic to be carried by the system. Different types of traffic (voice, data) that will be carried by the network are modeled. Overheads carried by each type of traffic are calculated and included in the model. Time and amount of traffic is also forecasted to evaluate the performance of the network and to determine whether the network can fulfill the requirements set forth at high load.

Coverage estimation is used to determine the required base station must be used to fulfill coverage of area under study. Coverage estimation calculates the area where base station can be heard by the users (receivers). It gives the maximum area that can be covered by a base station. Coverage planning includes radio link budget and coverage analysis. Based on the calculation of RLB, maximum allowed propagation loss is obtained. Maximum allowed propagation loss gives the attenuation of the signal as it travels from transmitted to the receiver. Path loss is converted into distance by using appropriate propagation models. This is the distance from the base station where the transmitter signals can be received by the users (receiver). This distance or the radius of the cell is used to calculate the number of sites required to cover the whole area with respect to coverage estimation. Capacity planning deals with the ability of the network to provide services to the users with a desired level of quality. After the site coverage area is calculated using coverage estimation, capacity related issues are analyzed. This involves selection of site and system configuration, e.g. channels used, channel elements and sectors. These elements are different for each system. Configuration is selected such that it fulfills the traffic requirements. In some wireless cellular systems, coverage and capacity are interrelated, e.g. in WCDMA. In this case, data pertaining to user distribution and forecast of subscriber's growth is of utmost importance .Dimensioning team must consider these values as they have direct impact on coverage and capacity. Capacity evaluation gives an estimate of the number of sites required to carry the anticipated traffic over the coverage area. Once the number of sites according to the traffic forecast is determined, the interfaces of the network are dimensioned. Number of interfaces can vary from a few in some systems to many in others. The objective of this step is to perform the allocation of traffic in such a way that no bottle neck is created in the wireless network. All the quality of service requirements are to be met and cost has to be minimized .Good interface dimensioning is very important for smooth performance of the network.

6.2 LTE ACCESS NETWORK DIMENSIONING:

The target of the LTE access network dimensioning is to estimate the required site density and site configurations for the area of interest. Initial LTE access network planning activities include radio link budget and coverage analysis, cell capacity estimation, estimation of the amount of eNB. This section focuses on the issues related to LTE dimensioning. The calculation of the sites number based on the coverage and the capacity. LTE dimensioning process starts with the Radio Link Budget Calculations, used to determine the maximum path loss. The result of this step depends upon the propagation models used. The estimated cell size, obtained in this step, leads to the maximum allowed size of the cells. This parameter is used to calculate the number of cells in the area of interest. Thus, a rough estimate of the required number of ends is obtained. Capacity calculations follow the above process for coverage estimation. If the coverage estimates for the given configuration, fulfills the capacity requirements, then there is no addition to the previous plan. On the other hand, suitable number of cell sites is added to achieve the capacity targets. If the highest expected traffic is used, then it can lead to an unnecessarily high number of sites. Assessment of eNB capacity comes next, which completes the dimensioning process. We used Dimension Tool structure (v2.3.0) of Nokia Siemens network Excel sheet to calculate the link budget and the traffic and the capacity we discuss it in the next chapter.

Inputs of LTE Dimensioning

One of the basic objectives of this work is to clearly differentiate between LTE dimensioning inputs and outputs. This section discusses all the LTE dimensioning inputs used in the development of methods and models for LTE dimensioning. LTE dimension inputs can be broadly divided into three categories: Traffic, coverage and capacity-related inputs. Traffic related inputs include average cell throughput, number of subscribers and demand traffic for each user in BH. These parameters are the customer requirements to provide a certain level of service to its users. These inputs directly translate into (QoS) parameters. Besides cell edge performance criterion is used in the dimensioning tool to determine the cell radius and thus the site count. Three methods are employed to determine the cell edge. These include user defined maximum throughput at the cell edge, maximum coverage with respect to lowest MCS (giving the minimum possible site count) and predefined cell radius. LTE dimensioning inputs for coverage dimensioning exercise are similar to the corresponding inputs for 3G UMTS networks. Radio link budge (RLB) is of central importance to coverage planning in LTE. Radio link budget (RLB) inputs include transmitter power, transmitter and receiver antenna systems, configuration antennas used, conventional system gains and losses, Cell loading that effect the value of interference margin and propagation models. LTE can operate in conventional frequency bands of 900, 1800 and 2100 MHz as well as extended band of 2600 MHz .Models for all the three possible frequency bands are incorporated in this work. Additionally, channel types (Pedestrian, Vehicular) and geographical information is needed to start the coverage dimensioning exercise. Geographical input information consists of area type information (Urban, Rural, etc) and it related parameters (penetration loss, shadowing margin, etc) and sizes of each area type to be covered. Furthermore, required coverage probability plays a vital role in determination of cell

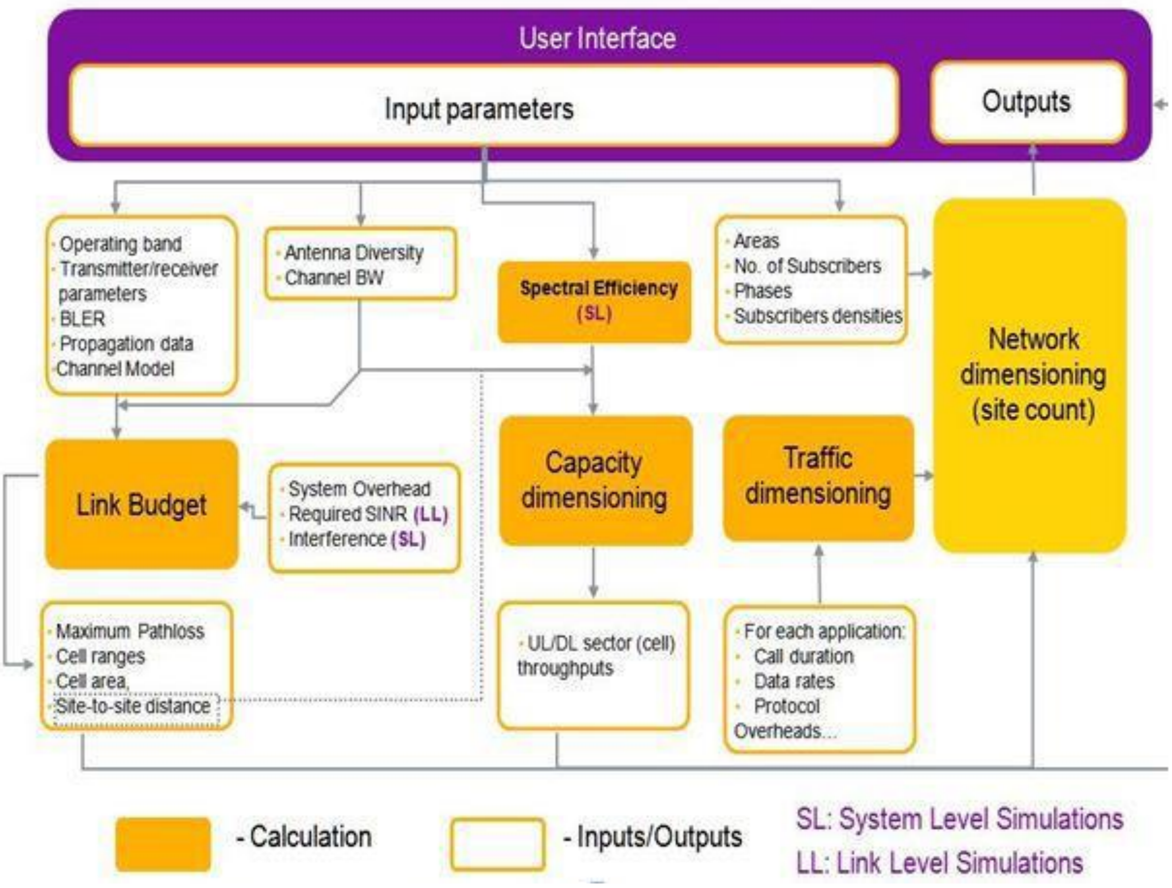

Figure 6.2 The input and output to LTE dimensioning tool

Radio link budget (RLB) inputs include transmitter power, transmitter and receiver antenna systems, configuration antennas used, conventional system gains and losses, Cell loading that effect the value of interference margin and propagation models. LTE can operate in conventional frequency bands of 900, 1800 and 2100 MHz as well as extended band of 2600 MHz .Models for all the three possible frequency bands are incorporated in this work. Additionally, channel types (Pedestrian, Vehicular) and geographical information is needed to start the coverage dimensioning exercise. Geographical input information consists of area type information (Urban, Rural, etc) and it related parameters (penetration loss, shadowing margin, etc) and sizes of each area type to be covered. Furthermore, required coverage probability plays a vital role in determination of cell radius. Even a minor change in coverage probability or other some parameter causes a large variation in cell radius calculation. Capacity dimensioning inputs provides the requirements, to be met by LTE network dimensioning exercise. Capacity planning inputs gives the number of subscribers in the system, their demanded services and subscriber usage level in the busy hour. Available spectrum and channel bandwidth used by the LTE system are also very important for LTE capacity planning. Traffic analysis and data rate to support available services (voice, Data) are used to determine the number of subscribers supported by a single cell and eventually the cell radius based on capacity evaluation. LTE system level simulation results and LTE link level simulation results are used to carry out capacity planning exercise along with other inputs. These results are obtained from Nokia's internal sources. Subscriber growth forecast is used in this work to predict the growth and cost of the network in years to come. Even a minor change in coverage probability or other some parameter causes a large variation in cell radius calculation. Capacity dimensioning inputs provides the requirements, to be met by LTE network dimensioning exercise. Capacity planning inputs gives the number of subscribers in the system, their demanded services and subscriber usage level in the busy hour. Available spectrum and channel bandwidth used by the LTE system are also very important for LTE capacity planning. Traffic analysis and data rate to support available services (voice, Data) are used to determine the number of subscribers supported by a single cell and eventually the cell radius based on capacity evaluation. LTE system level simulation results and LTE link level simulation results are used to carry out capacity planning exercise along with other inputs. These results are obtained from Nokia's internal sources. Subscriber growth forecast is used in this work to predict the growth and cost of the network in years to come.

6.3 LTE COVERAGE DIMENSIONING PROCESS

For LTE systems, the main goal of coverage planning is to estimate the coverage distance of an eNB with parameter settings based on actual cell edge coverage requirements in order to meet network size requirements .The first steps for the initial planning of a cellular network are the selection of an adequate propagation model for the frequency range and type of region considered.

6.4 PROPAGATION MODELS

The radio propagation model plays a key role in the link budget. The coverage radius of a base station is obtained based on the maximum propagation loss allowance in the link budget. Radio propagation models are classified into outdoor and indoor propagation models. These two types of propagation models involve different factors. In an outdoor environment, landforms and obstructions on the propagation path, such as buildings and trees, must be considered. Signals fade at varying rates in different environments. Propagation in free space gives the lowest fade rate. The fading of signals is larger than free space when radio waves propagate in open areas/suburban areas and fading rate is the largest in urban/dense urban areas. Indoor propagation model features low RF transmits power, a short coverage distance and complicated environmental changes.

Empirical /statistical path loss models

Path loss models are important in the RF planning phase to be able to predict coverage and link

Model	Frequency MHZ	Recommended use
Cost-231 Hata	150—2000	$0.02 < d < 5$ km, UMTS, GSM1800, LTE
Erceg-Greenstein	1900—6000	$0.1 < d < 8$ km, Fixed WiMAX
IMT	800-2800	Indoor office, vehicular, outdoor to indoor
ITU-526	30—1000	Fixed receivers
ITU-529	300-1500	$1 < d < 100$ km, GSM900, CDMA2000, LTE
Okumura-Hata	150—2200	$1 < d < 20$ km, GSM900, CDMA2000, LTE
WLL	30—10000	Fixed receivers, Microwave Links, WiMAX

Table 6.4 Commonly used Wireless Channel Propagation Models

IMT: International Mobile Telecommunication.
ITU: International Telecommunication Union
WLL: Wireless Local Loop.

Budget among other important performance parameters. These models are based on the frequency band, type of deployment area (urban, rural, suburban, etc.), and type of application. **Table 6.4** lists the most widely used propagation models in current cellular systems. Most of these models are a fusion of empirical formulas extracted from field measurements and some statistical prediction models. One of the listed models that will be used in LTE are used in our project and discussed in detail in the rest of this section.

Cost231-Hata Model

Path loss estimation is performed by empirical models if land cover is known only roughly, and the parameters required for semi-deterministic models cannot be determined. Four parameters are used for estimation of the propagation loss by Hata's well-known model: frequency f, distance d, base station antenna height and the height of the mobile antenna. Cost231-Hata model can be used in macro cells as the propagation model. The application range is as follows:

- Frequency band: 1500 MHz to 2000 MHz
- Base station height: 30 meters to 200 meters.
- Terminal antenna height: 1 meter to 10 meters
- Distance between the transmitter and receiver: 1 km to 20 km

6.5 LTE CAPACITY DIMENSIONING

With a rough estimation of the cell size and sites count, verification of coverage analysis is carried out for the required capacity. It is verified whether with the given sites density, the system can carry the specified load or new sites have to be added. Theoretical capacity of the network is limited by the number of eNBs installed in the network. Cell capacity in LTE is impacted by several factors, which includes interference level, packet scheduler implementation and supported In LTE, the main indicator of capacity is the SINR distribution in the cell. The SINR distribution can be directly mapped to the system capacity (data rate). The capacity based on the number of sites is compared with the result of the coverage and the larger of the two numbers is selected as

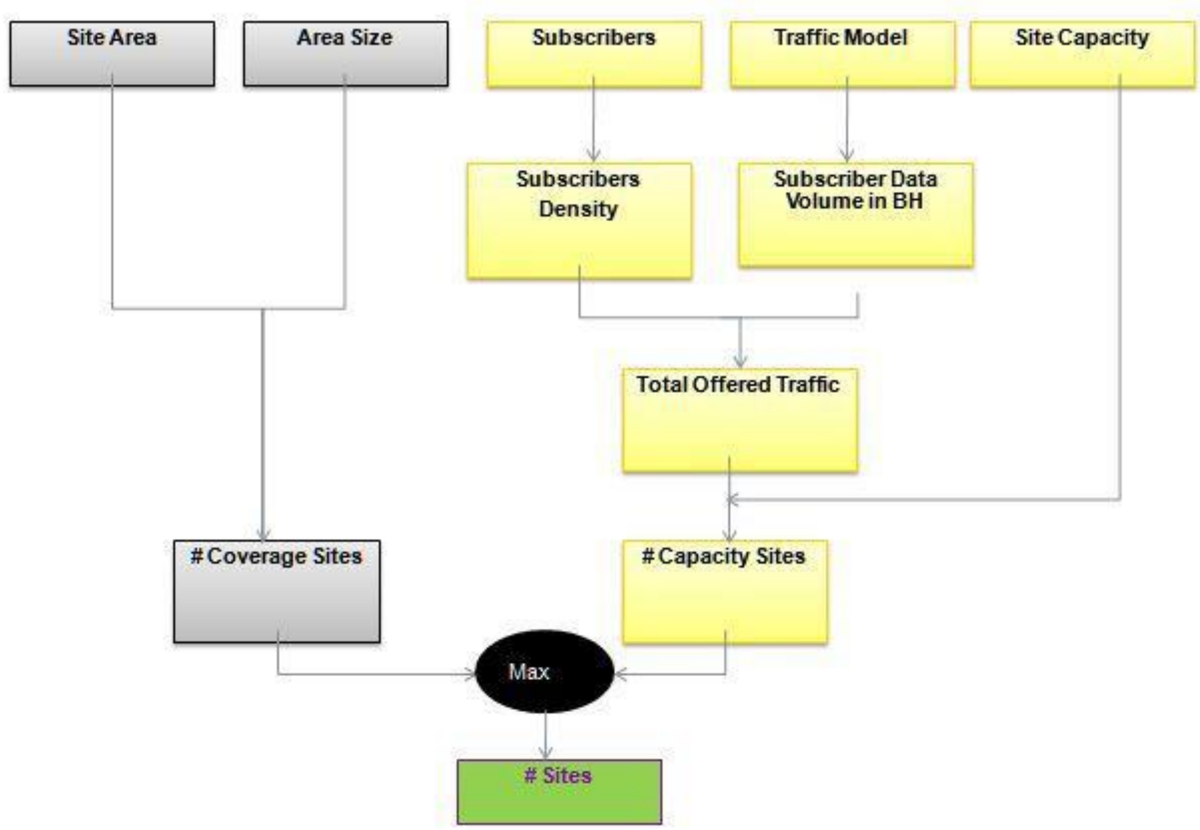

Figure 6.5 Capacity Dimensioning Overview

The number of end sites. The subscriber density and subscriber traffic profile are the main requirements for capacity dimensioning see **figure 6.5** [10].

6.5.1 LTE CAPACITY DIMENSIONING PROCESS:

In this section presents how to convert the cell throughput values to the maximum number of broadband subscribers. Two methods are used: a traffic volume based approach and a data rate based approach.

- **The LTE Cell Capacity (Throughput) depends on:**

1. **Cell Range (Path loss)**: the cell rang considered a variation of the Inter Site Distance (ISD), the larger ISD the less cell capacity because the SINR distribution is bad in larger cells which becomes more & more noise limited.

2. Channel Bandwidth (1.4 MHz... 20 MHz): The best capacity performance can be achieved with wide channel bandwidth due to the maximum frequency diversity gain And Small Bandwidth configuration are characterized by high system overhead.

3. **LTE Features:**

- **MIMO (Multiple Input Multiple Output):**

– **Transmit diversity (Tx diversity)** it results in coverage improvement therefore, it is more suitable to be used at the cell edge.

– **Open / Closed Loop Spatial Multiplexing** Spatial multiplexing on the other hand doubles the subscriber data rate

- **Scheduling: Proportional Fair** or **Round Robin**: From the average cell throughput point of view there is some gain when Proportional Fair (PF) is used, the main reason for the gain is coming from the fact that the SINR distribution in the cell is improved when proportional fair is used. The gain is dependent on the number of users that are scheduled together in the same TTI (1ms): the higher the number of scheduled users per TTI the higher the average cell throughput gain when proportional fair is in use.

6.6 CAPACITY AND COVERAGE OPTIMIZATION IN LTE NETWORKS

Although, it is of primary interest to provide coverage to users during a roll-out, it is equally important to enhance the capacity of the network during operation. The objective of capacity and coverage optimization is to provide optimal coverage and capacity for the radio network. A tradeoff between capacity and coverage needs to be considered.

In this scenario, legacy systems, e.g. 2G/3G/4G provide radio coverage together with E-UTRAN. However, in the first deployment stage of E-UTRAN, unsuitable planning or error parameters settings will lead to coverage holes in some area. In this scenario, there may be too many IRAT HOs. The case of coverage and capacity optimization should enable to detect this kind of problems on network coverage automatically. Another case similar with this is that coverage problems exist between different frequencies in E-UTRAN, i.e. inter-frequency case. For simple reasons, this case is also described here.

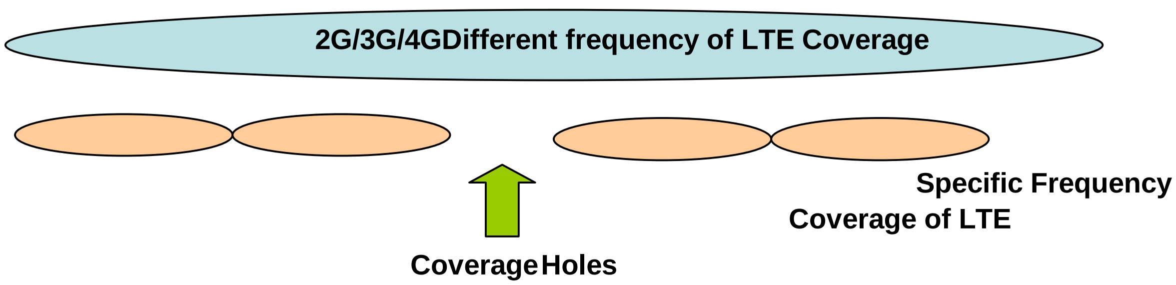

Figure 6.6 Coverage holes with 2G/3G/4G coverage

6.7 AUTOMATIC CELL PLANNING

- Automatic optimization of network parameters to increase coverage & Capacity.
- Site selection and activation for Greenfield and densification scenarios.
- Antenna selection & parameter optimization (height, azimuth & tilt).

6.8 AUTOMATIC SITE POSITIONING

Automatically creation of new site locations according to surface-wise, traffic-oriented and population-based coverage objectives

Site deployment in multiple zones (urban, suburban, rural etc.), along roads and railways, intelligent implementation plan with the selection of the best sites to deploy.

CHAPTER 7

SIMULATION AND RESULT DISCUSSION

7.1 SIMULATION

Simulation is a practical and scientific approach to analyze a complex system. In this project, simulation is used to investigate the RAN nominal planning of LTE networks as it is done using Atoll simulation environment.

The LTE radio network planning simulation is intended to carry out the link budget calculation, propagation modeling using the terrain model, coverage estimation and capacity evaluation.

7.2 PLANNING PARAMETERS

The parameters listed in the **table 7.2** is the inputs what we have used..

Parameter	DL	UL
Frequency	2100 MHZ	
Bandwidth	20 MHZ	
Duplex	FDD	
Propagation Model	Cost-Hata	
Frequency reuse	1	
Scheduling	Proportional Fair	
MIMO Configuration	2x2 MIMO	1x2 MIMO
Tx Power	43 dB	23 dBm
Rx Antenna Gain	18 dBi	0 dB
Body loss	0 dB	0 dB
Feeder Loss	0.5	2.4 dB
Noise Figure	7 dB	
Throughput	1 Mbps	384 kbps

Table: 7.2 The parameters list

7.2.1 DHAKA MAP

This figure 7.2.1 is the Dhaka clutter classes Map which we used for radio network planning involving LTE 4G parameters……..

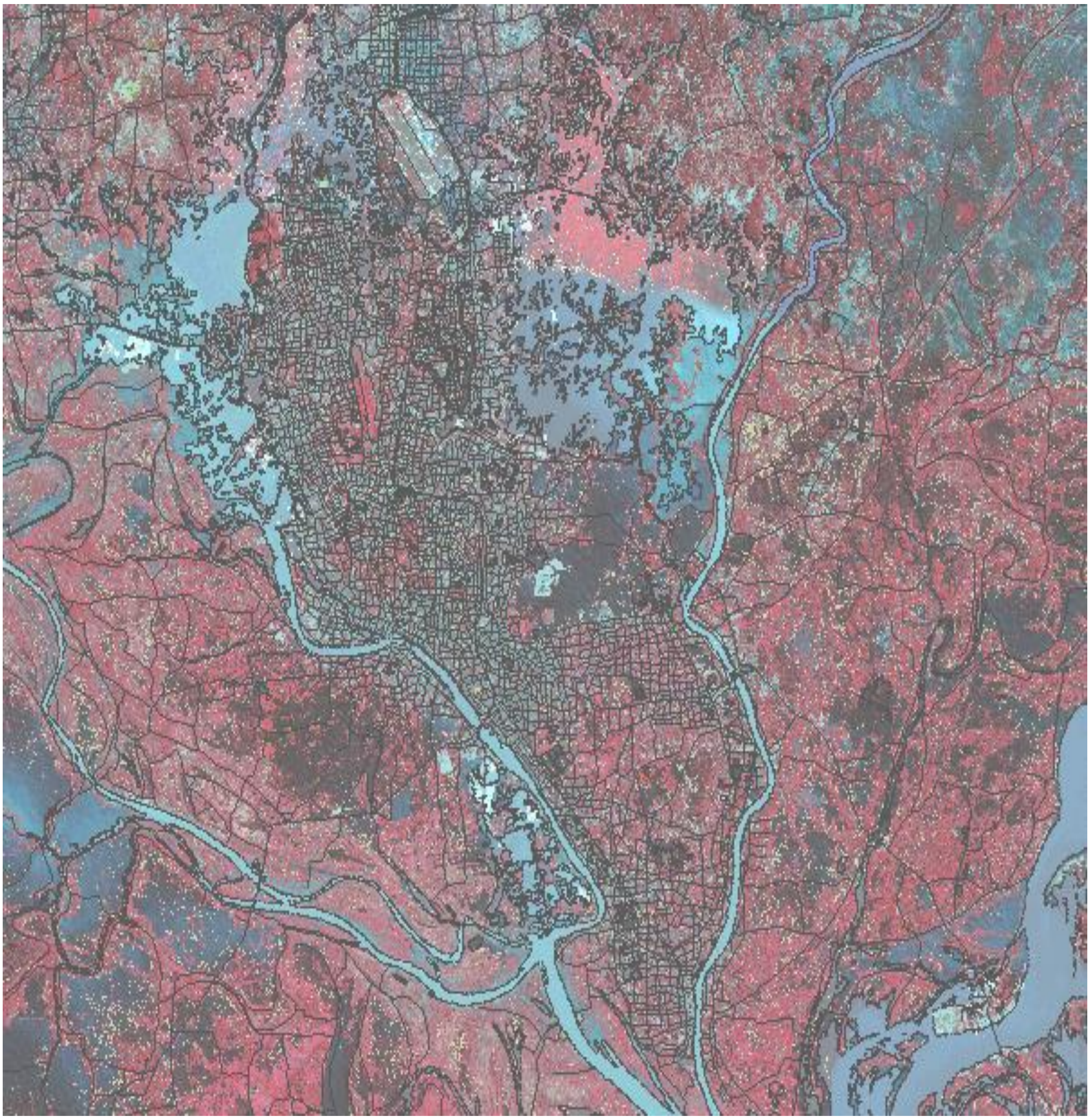

Figure: **7.2.1** Dhaka map

7.2.2 DHAKA AIRPORT AREA

This figure 7.2.2 is the specific Dhaka Airport Map. This selected area is our focus and computation zone which we used for Automatic Cell planning (ACP), Automatic Site Positioning and for optimization.

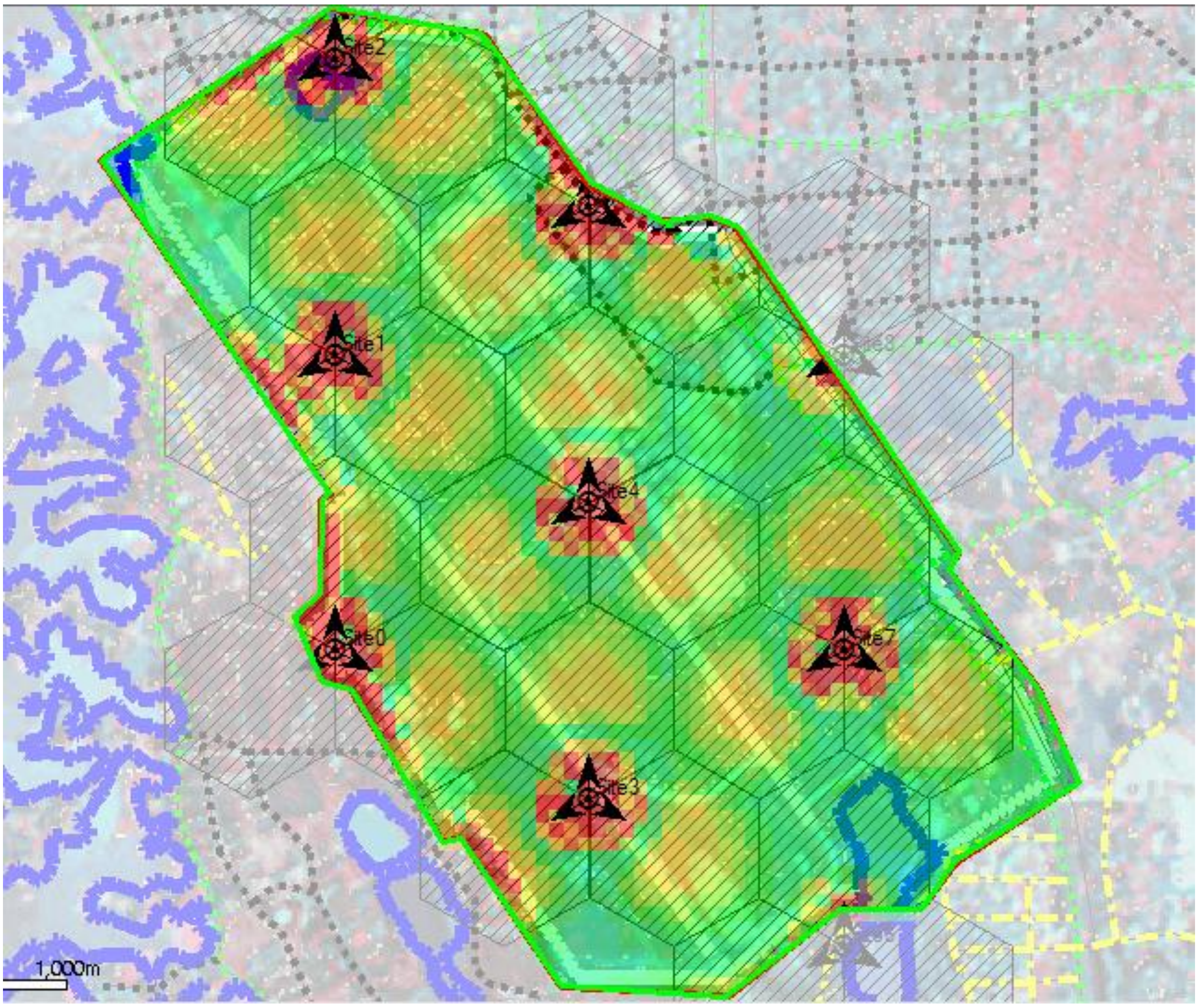

Figure: **7.2.2** Dhaka airport area

7.3 RESULTS BY PREDICTION

In this thesis our main objective is to provide the telecommunication sectors the idea of installing number of Antenna in a desired area or zone and provide good quality of service with minimum cost and profit. So during our research we used the software call Atoll, at the beginning of the work we import Dhaka map into our simulator and start positioning the number of Antennas manually and calculate the area to see if we will achieved out desired output of the signal during the simulation process we did the calculation of various signals **effective signal quality, coverage by quality indicator, coverage by throughput** and we were able to generates some results and on the graph you will see different color indicating the signal strength in every area each color tells you the level of quality of the signal a user's equipment is having been closer to antenna or been farer from the antenna. Below you can see the result we generate manually.

7.3.1 EFFECTIVE SIGNAL ANALYSIS

This figure 4.3.1 is about for analysis of effective signal. We selected our area whole Dhaka map and put 26 site on the map then we calculate effective signal by prediction. From the map near the site signal level is high, accordingly distance increasing from site signal level decrease. And we analyzed signal which is effective or not we can know from figure 7.3.1. We selected Site on the map manually.

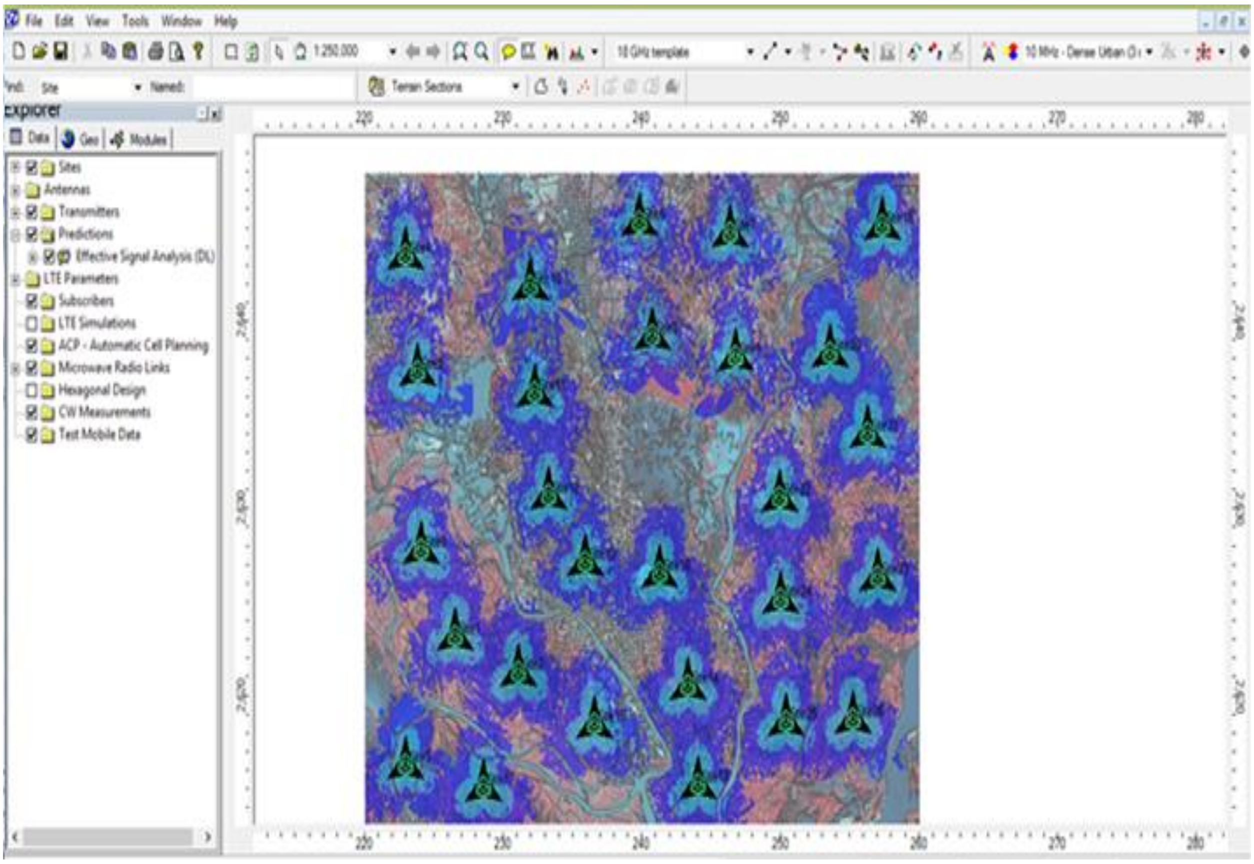

Figure: **7.3.1** Effective signal analysis

7.3.2 COVERAGE BY QUALITY INDICATOR

From this figure 7.3.2 we justified signal quality is good or not with putting site on the map with selected coverage area. We selected site on the map manually.

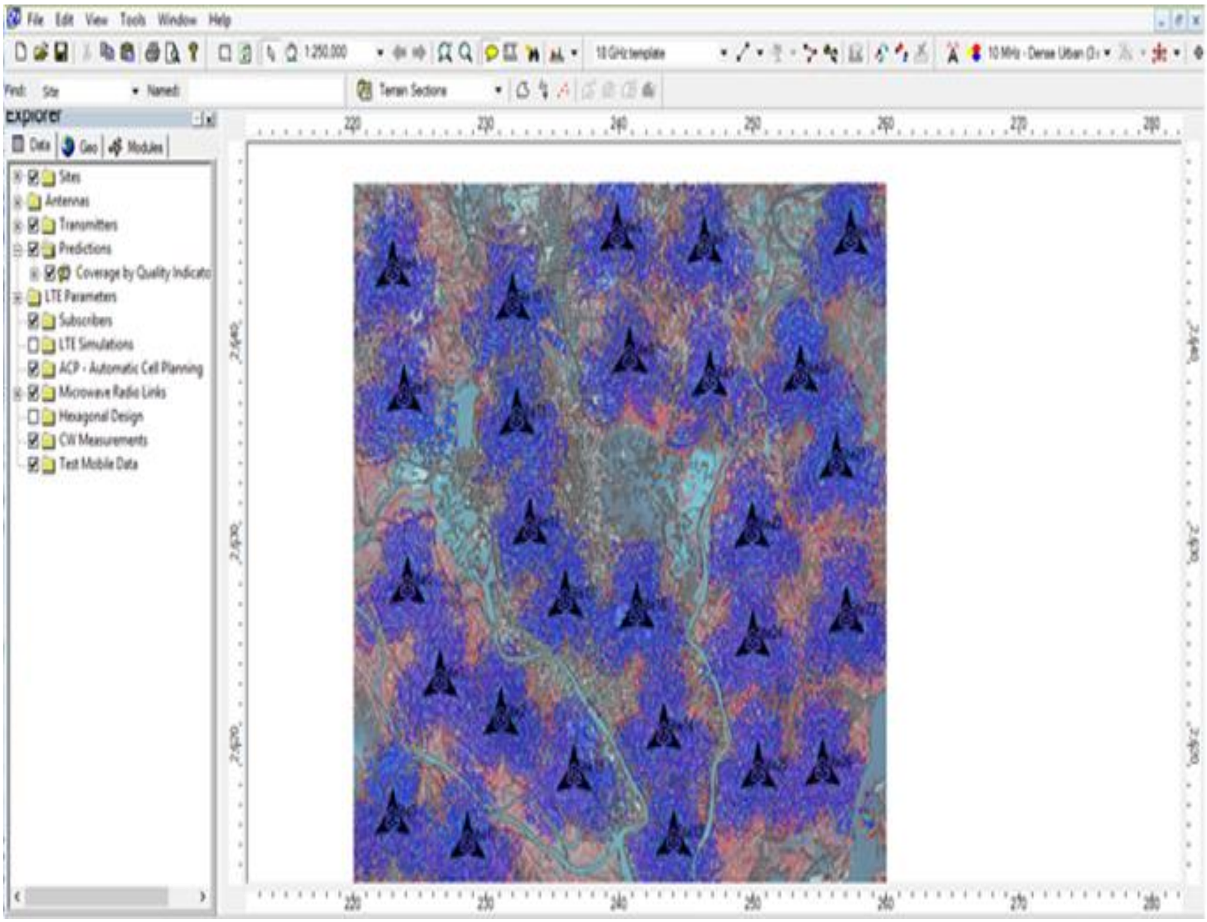

Figure: **7.3.2** Coverage by quality indicator

7.3.3 COVERAGE BY THROUGHPUT

This figure 7.3.3 is about throughput .We observed signal power is covering or not which we selected site on the map with selected area. According to color depth, color depth is higher also throughput is higher.

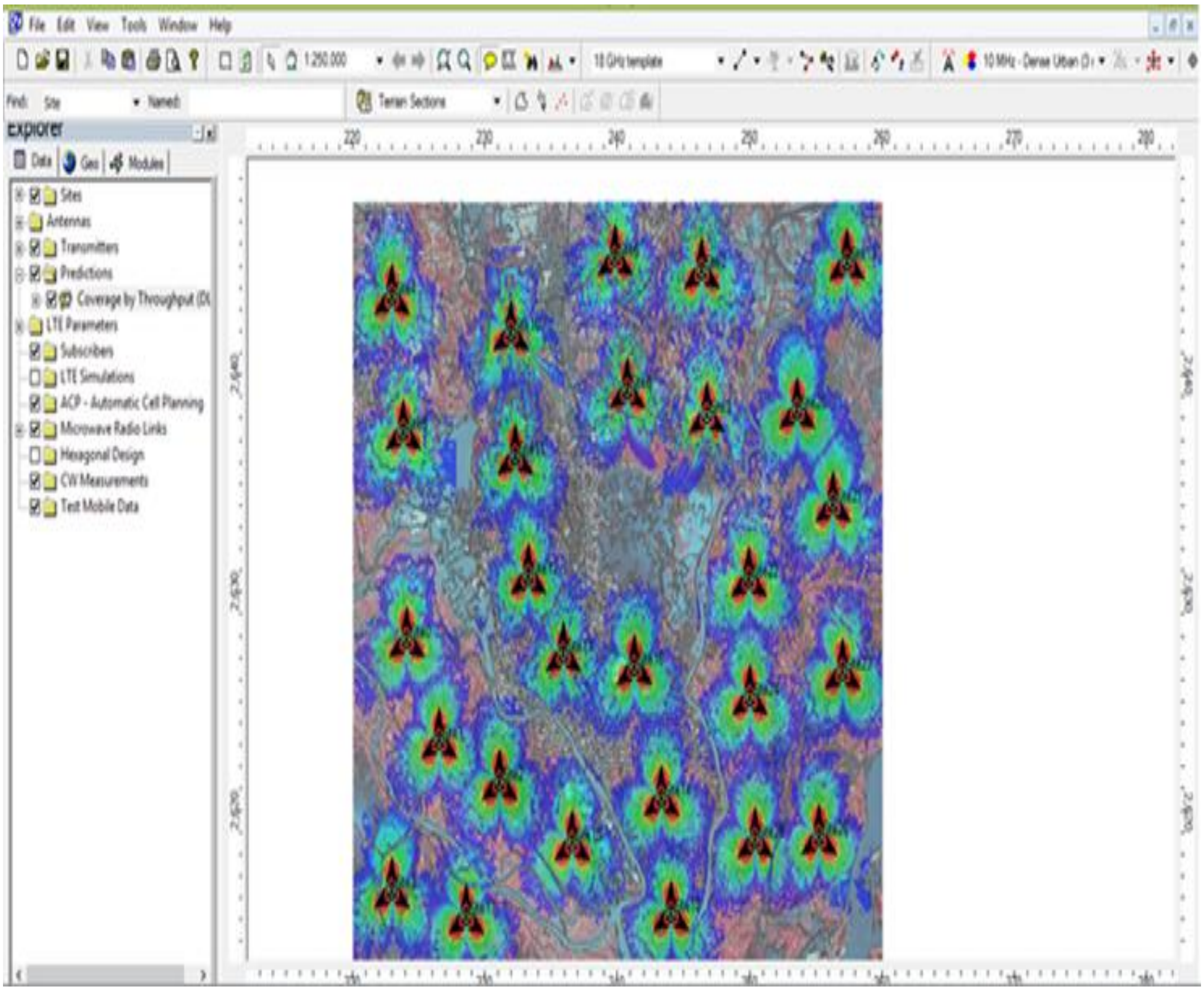

Figure: **7.3.3** Coverage by throughput

7.4 OPTIMIZATION AND BUDGETARY

As we continued in our research, we were not able to find all the result we want due some missing features in out atoll tool, but later we find another advance tool called atoll 3.3. This atoll version is having so many features which help us to achieve our desired output. The atoll has a feature of optimization and budgeting. Budgeting is important in business because we know that we cannot just go in an area and install antenna everywhere without knowing our actual cost as an engineering in the field of business that is not what we want. So thus, in this tool as we are running the simulation is has the advantage of calculation the cost for us from there, we will compare that cost with the actual budget we have to install antennas in that desired area or zone

The tool also has the advantage of optimizing automatically which is it can provide you the information of how many antennas will be needed to be install in that desired area and it can also show you the percentage achievement of the work done. Thus, during our process, we select an area call Dhaka airport and optimized that area and we were able to achieve 95% successive coverage of the area. The calculation was done on two areas which **are reference signal received power (RSRP) and the reference signal received quality (RSRQ).on the graph you will see that it shows different colors indicating the signal strength in different area ranging from -70db to -105db. Below you have the results we generated in the process of optimization and budgetary**

7.4.1 QUALITY OF REFERENCE SIGNAL RECEIVED POWER (RSRP)

This figure 7.4.1 is shown LTE Reference signal Received Power (RSRP) status how much signal is success or fail for selected zone.

From this figure green color showing success and blue color showing fail. Initial LTE RSRP status is more fail for covering signal level, But after tuning final LTE RSRP status is success is more .So here we succeed more received power according to figure.

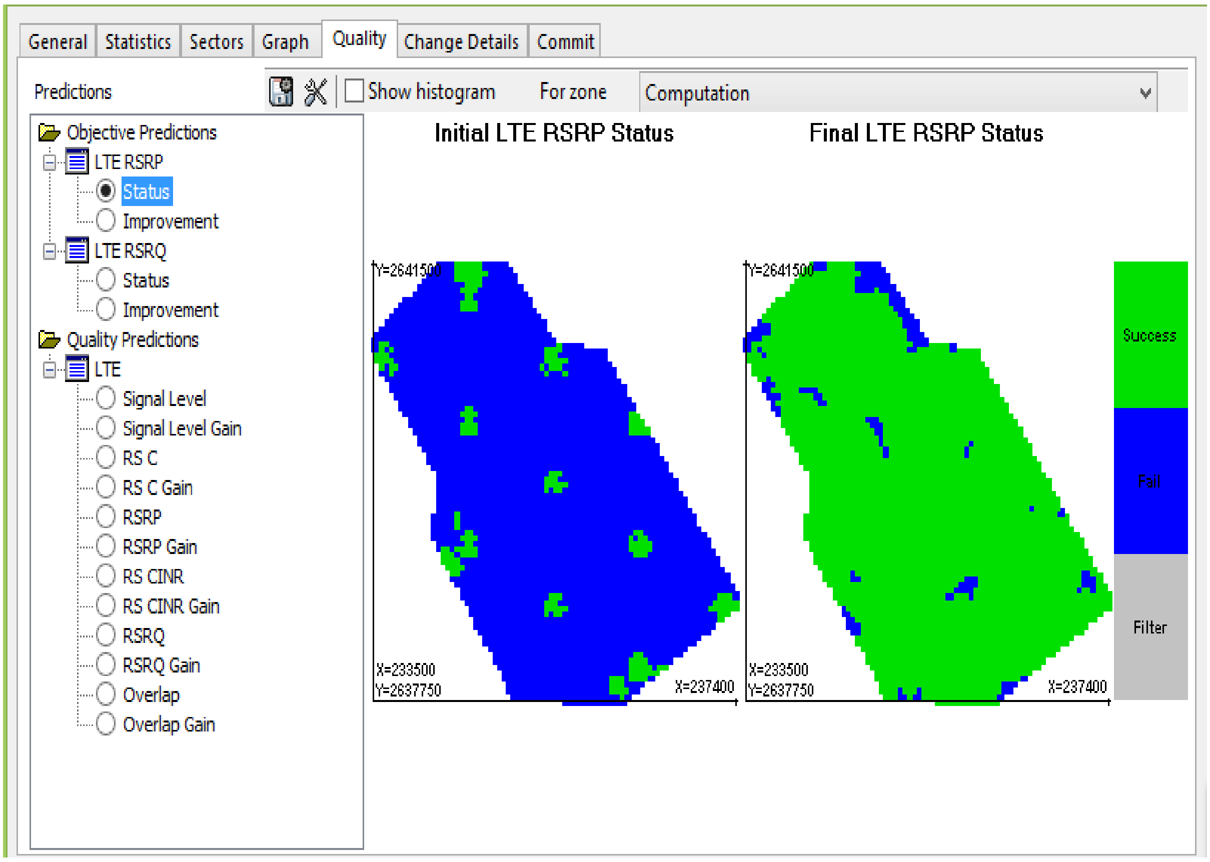

Figure: **7.4.1** Quality of reference signal received power (RSRP)

7.4.2 QUALITY OF REFERENCE SIGNAL RECEIVED QUALITY (RSRQ)

This figure **7.4.2** is shown LTE Reference signal Received Quality (RSRQ) status how much signal is success or fail for selected zone.

From this figure green color showing success and blue color showing fail. Initial LTE RSRQ status is more fail for covering signal level, But after tuning final LTE RSRQ status is success is more .So here we succeed more quality of RSRQ according to figure.

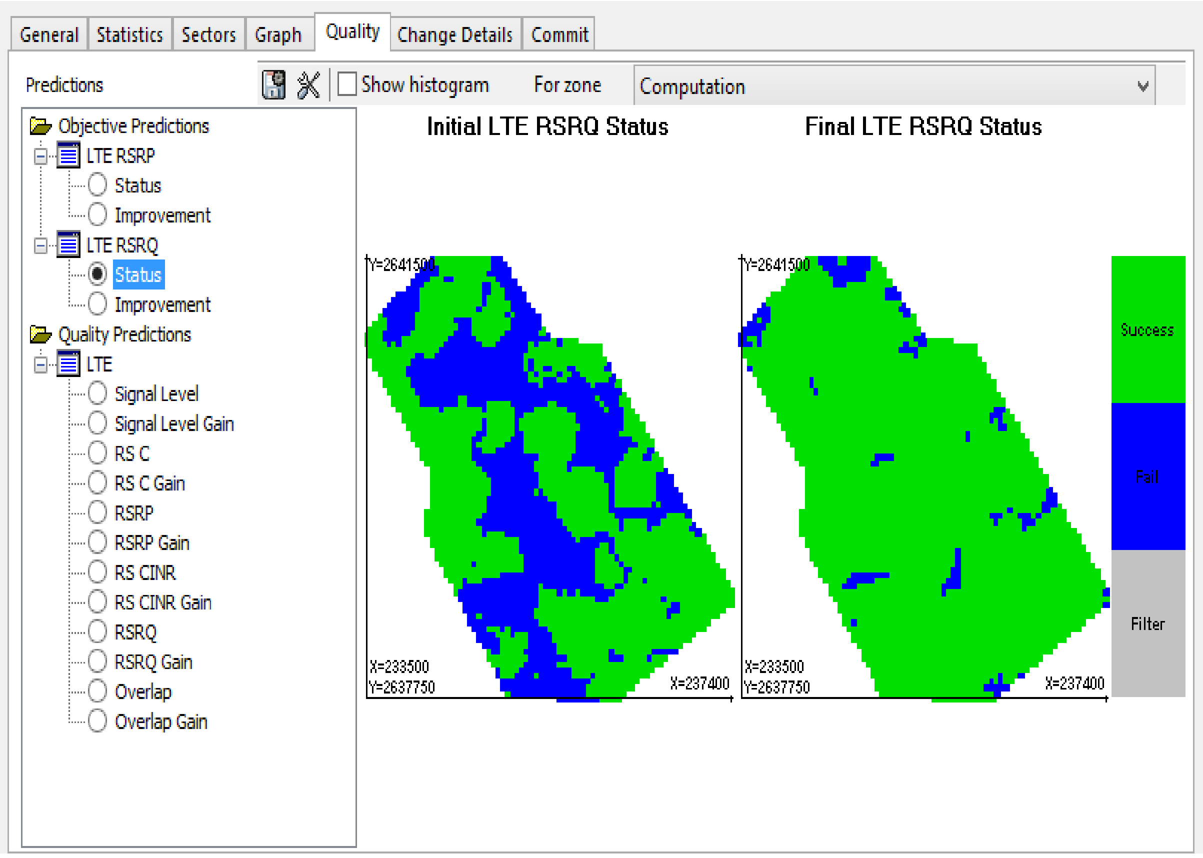

Figure: **7.4.2** Quality of reference signal received quality (RSRQ)

7.4.3 QUALITY OF SIGNAL LEVEL

This figure **7.4.3** shows the quality of the signal Level of the Dhaka Airport and the strength of the signal level in many areas on the map.

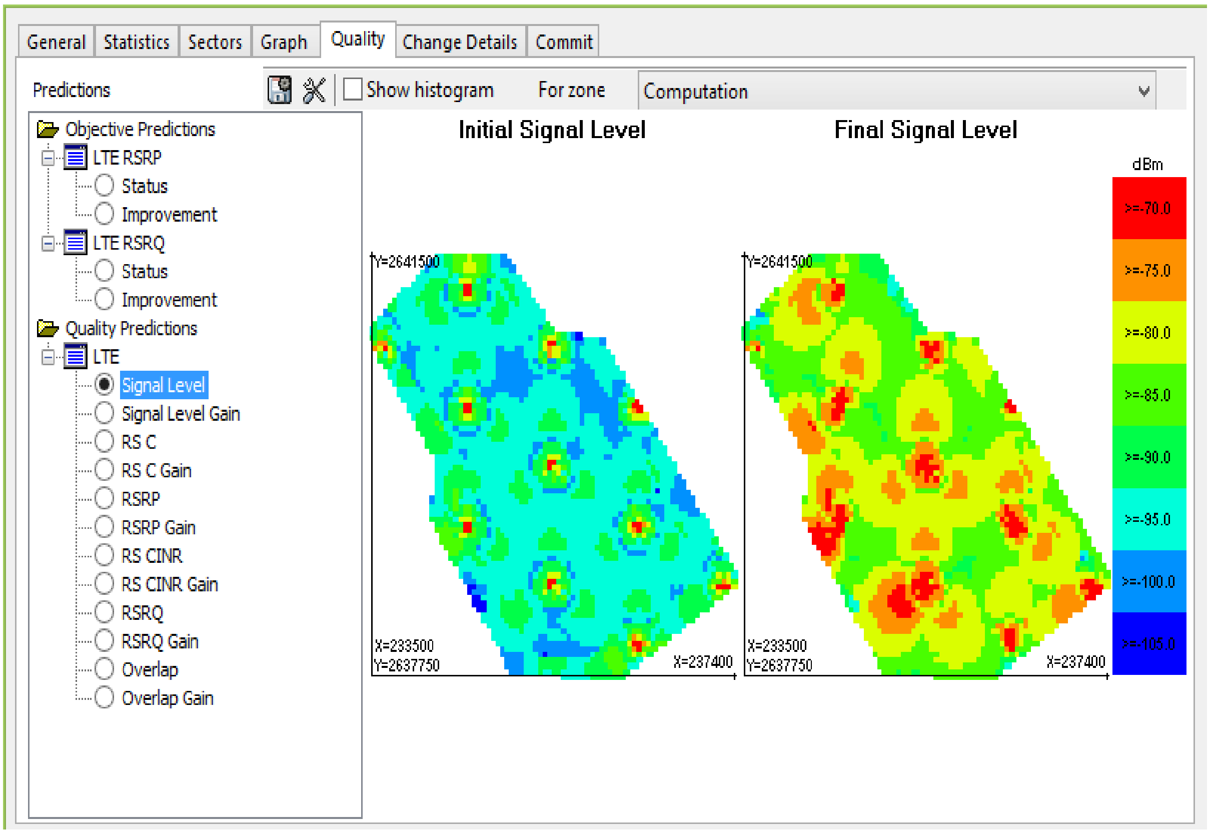

Figure: **7.4.3** Quality of signal level

7.4.4 DIFFERENT SECTORS OUTPUT TABLE INCLUDING (CELL, TOTAL POWER, ANTENNA PATTERN, AZIMUTH)

This Table **7.4.4** about what we have given input like this (selecting site, total power, antenna pattern and azimuth) then after optimization what we get result this is showing about that initial and final values.

General | Statistics | Sectors | Graph | Quality | Change Details | Commit

Cell/Tx Name	Use						Total Power (dBm)		Antenna Pattern		Azimuth	
	Pow	Ant.	Azi.	MTilt	Heigh	Sele	Initial	Final	Initial	Final	Initial	Final
Site11_1(0)	✓	✓	✓	✓		✓	43.00	58.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	0	0
Site11_2(0)	✓	✓	✓	✓		✓	43.00	58.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	120	120
Site11_3(0)	✓	✓	✓	✓		✓	43.00	58.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	240	240
Site12_1(0)	✓	✓	✓	✓		✓	43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	0	0
Site12_2(0)	✓	✓	✓	✓		✓	43.00	58.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	120	120
Site12_3(0)	✓	✓	✓	✓		✓	43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	240	240
Site13_1(0)	✓	✓	✓	✓		✓	43.00	56.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	0	0
Site13_2(0)	✓	✓	✓	✓		✓	43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	120	120
Site13_3(0)	✓	✓	✓	✓		✓	43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	240	240
Site14_1(0)	✓	✓	✓	✓		✓	43.00	58.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	0	0
Site14_2(0)	✓	✓	✓	✓		✓	43.00	58.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	120	120
Site14_3(0)	✓	✓	✓	✓		✓	43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	240	240
Site15_1(0)		✓	✓	✓			43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	0	0
Site15_2(0)		✓	✓	✓			43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	120	120
Site15_3(0)		✓	✓	✓			43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	240	240
Site16_1(0)	✓	✓	✓	✓		✓	43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	0	0
Site16_2(0)	✓	✓	✓	✓		✓	43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	120	120
Site16_3(0)	✓	✓	✓	✓		✓	43.00	58.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	240	240
Site5_1(0)	✓	✓	✓	✓		✓	43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	0	0
Site5_2(0)	✓	✓	✓	✓		✓	43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	120	120
Site5_3(0)	✓	✓	✓	✓		✓	43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	240	240
Site6_1(0)	✓	✓	✓	✓		✓	43.00	58.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	0	0
Site6_2(0)	✓	✓	✓	✓		✓	43.00	43.00	65deg 18dBi 0Tilt 2	65deg 18dBi 0Tilt 2	120	120

Legend: Reconfiguration | TX Added | TX Removed

Table: **7.4.4** Different sectors output table including

(cell, total power, antenna pattern, azimuth)

7.4.5 DIFFERENT SECTORS OUTPUT TABLE INCLUDING (CELL, ANTENNA HEIGHT, LTE RSRP%, LTE RSRQ%)

This Table **7.4.5** about what we have given input like this (selecting site, antenna height, LTE RSRP%, LTE RSRQ%) then after optimization what we get result this is showing about that initial and final values.

General | Statistics | Sectors | Graph | Quality | Change Details | Commit

Cell/Tx Name	Antenna Height (m)		Sector Selection		LTE RSRP (%)		LTE RSRQ (%)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Site11_1(0)	30.00	30.00	✓	✓	2.66	97.43	60.11	98.53
Site11_2(0)	30.00	30.00	✓	✓	3.76	97.00	99.25	100.00
Site11_3(0)	30.00	30.00	✓	✓	3.20	99.00	5.60	97.00
Site12_1(0)	30.00	30.00	✓	✓	26.09	57.14	30.43	28.57
Site12_2(0)	30.00	30.00	✓	✓	5.50	98.56	58.72	94.24
Site12_3(0)	30.00	30.00	✓	✓	9.84	100.00	37.70	50.00
Site13_1(0)	30.00	30.00	✓	✓	5.22	96.53	99.25	100.00
Site13_2(0)	30.00	30.00	✓	✓	43.48	83.33	73.91	83.33
Site13_3(0)	30.00	30.00	✓	✓	18.89	77.78	62.22	22.22
Site14_1(0)	30.00	30.00	✓	✓	3.43	99.55	54.86	90.05
Site14_2(0)	30.00	30.00	✓	✓	4.29	98.08	95.09	99.52
Site14_3(0)	30.00	30.00	✓	✓	3.94	100.00	41.73	100.00
Site15_1(0)	30.00	30.00	✓	✓	12.50	0.00	62.50	0.00
Site15_2(0)	30.00	30.00	✓	✓	15.79	100.00	63.16	100.00
Site15_3(0)	30.00	30.00	✓	✓	7.59	100.00	11.39	50.00
Site16_1(0)	30.00	30.00	✓	✓	12.24	60.00	89.80	100.00
Site16_2(0)	30.00	30.00	✓	✓	100.00	100.00	100.00	50.00
Site16_3(0)	30.00	30.00	✓	✓	11.76	92.71	100.00	97.92
Site5_1(0)	30.00	30.00	✓	✓	15.00	33.33	47.50	33.33
Site5_2(0)	30.00	30.00	✓	✓	5.15	75.00	52.58	100.00
Site5_3(0)	30.00	30.00	✓	✓	80.00	100.00	100.00	100.00
Site6_1(0)	30.00	30.00	✓	✓	6.62	95.98	100.00	100.00
Site6_2(0)	30.00	30.00	✓	✓	3.13	100.00	56.88	100.00

Legend: Reconfiguration | TX Added | TX Removed

Table: **7.4.5** Different sectors output table including (cell, antenna height, lte rsrp%, lte rsrq%)

7.4.6 OBJECTIVE ACHIEVED BY GHRAPH

The figure **7.4.6** shows the total achievement of the reference signal received power (RSRP) and reference signal received quality (RSRQ) of the calculated area or zone.

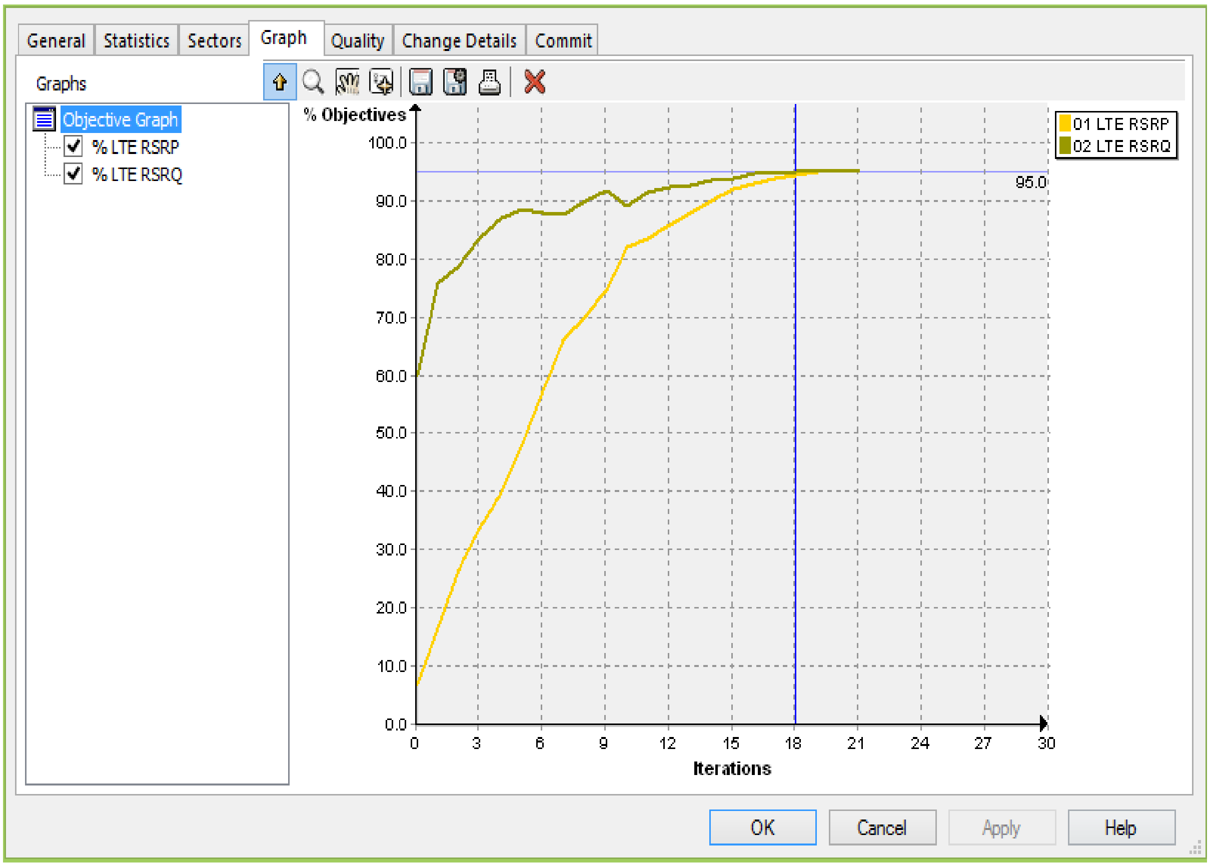

Figure: **7.4.6** Objective achieved by Graph

7.4.7 OBJECTIVE ACHIEVED BY COVERAGE AREA

This table **7.4.7** shows the achieved coverage area of the desired zone and also showing the total amount of cost requires to install the number of antennas in that area or zone.

Duration of optimisation: 9.19 s

Objective *LTE RSRP* (Coverage >= 95.0%)

	Evaluation Zone
Initial	5.79%
Final	95.44%
Improvement	***89.65%***
Objective	**ACHIEVED**

Objective *LTE RSRQ* (Coverage >= 95.0%)

	Evaluation Zone
Initial	86.66%
Final	95.63%
Improvement	***8.97%***
Objective	**ACHIEVED**

Total Cost: 233000

Table **7.4.7** Objective achieved by coverage area

7.4.8 DETAILED ZONE RESULTS

This table **7.4.8** The objective is to calculate the reference signal received power (RSRP) and reference signal received quality (RSRQ) of a desired area or zone and expect to generate a result of 95% focus and computation.

Detailed Zone Results

Objective: LTE RSRP		
Zone	*Initial*	*Final*
Focus	6.74%	95.29%
Computation	6.77%	95.16%
Objective: LTE RSRQ		
Zone	*Initial*	*Final*
Focus	59.76%	95.14%
Computation	59.83%	95.13%

Table: **7.4.8** Detailed zone results

CHAPTER 8

CONCLUSION

The ultimate objectives of the present study of LTE radio network planning guidelines are to introduce the relevant LTE features, to define the basic models for radio propagation planning, to estimate coverage and network element count. The prepared guideline may assist in the development of various tools used in Radio Network Planning (RNP). Obtained result of coverage and capacity analysis has been used in nominal and detailed radio planning stage with Atoll taking Dhaka digital map as input. In detail Atoll simulations have been run on Dhaka digital map containing both coverage predictions and traffic simulations. Again, performance evaluation has been done using point analysis tool. For initial network deployment, at the very beginning only a small number of subscribers are considered for coverage and capacity calculation. So, there remains the challenge for future capacity enhancement. But still it can be considered as a standard radio planning platform for the densely populated South-Asian city Dhaka.

REFERENCES

1. *“Partnership Project Description”, Slide set, available at ‘http://www.3gpp.org/About/3GPP.ppt*

2. *Jaana Laiho, Achim Wacher and Tomas Novosad, “Radio Network Planning and Optimisation for UMTS”, John Willey and Sons, 2002*

3. *L10A Radio Network Design © Ericsson 2009 © Ericsson 2009LTE*

4. Dimensioning of LTE Network Description of Models and Tool, Coverage and Capacity Estimation of 3GPP Long Term Evolution radio interface by Abdul Basit, Syed

5.*Deepak, S. and N. Sachdeva.” Performance Analysis of Conventional Diversity Combining Schemes in Rayleigh Fading Channel “International Journal of Advanced Research in Computer Science and Software Engineering Vol.2 No 6, (2012),197-201*

6. *Jaafar, A., A.Yahya, R.B. Ahmab, A.S. Md Zain, M.K. Salman and Riad Edan. “On Coverage Analysis for LTE-A Cellular Networks”.School of Computer andCommunication Engineering, (2013), 492-497*

7. *G. J. Foschini and Z. Miljanic, “A simple distributed autonomous powercontrol algorithm and its convergence,”IEEE transactions on vehicularTechnology, vol. 42, no. 4, pp. 641–646, 1993.*

8. *L. Bao and J. J. Garcia-Luna-Aceves. Topology management in ad hoc networks. InProc. of the Fourth ACM Intl. Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc ’03), pages 129–140, June 2003*

9. *J. Laiho, A.Wacker, and T. Novosad, editors. Radio Network Planning and Optimization for UMTS. John Wiley & Sons Ltd., 2001*

10. *D. Catrein, L. Imhof, and R. Mathar. Power control, capacity, and duality of up- and downlink in cellular CDMA systems. Technical report, RWTH Aachen, 2003.*

11. *A. Gerdenitsch, S. Jakl, M. Toeltsch, and T. Neubauer. Intelligent algorithms for system capacity optimization of UMTS FDD networks. In Proc. IEEE 4th International Conference on 3G Mobile Communication Technology, pages 222–226, London, 2002.*