DEBRE TABOR UNIVERSITY

GAFAT INSTITUTE of TECHNOLOGY (GIT)

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING(Stream of communication)

PLANNING AND DIMENSIONING OF LTE NETWORKFOR GONDAR CITY USING ATOLL SOFTWARES

HOSTING COMPANY:

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DEBRE TABOR: ETHIOPIA

Declaration

We are 5th year electrical and computer engineering students. Here by we declare that this final evaluation report have been submitted to Debre Tabor University in partial fulfillment of the requirements of engineering internship program in ECE. The objective of this report is to explain what we did and learned that is our practical skills, theoretical knowledge, interpersonal communication skills, team working skills, leadership skills, work ethics and entrepreneurship skills during internship period .In our hosting company Ethio Telecom we spent three consecutive months for the internship program.

We would like to declare that this internship report is our true and original work done by us depending on our internship experience and knowledge that we have gained in our three-month internship time at the hosting company, Ethio telecom, without any plagiarism. Additionally, this report was carried out in accordance with the rules and regulations of Debre Tabor University.

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First and for most we are grateful to thank DTU, UIL for forming linkages with Ethio telecom, and providing this opportunity for us. Secondly, we want to thank our Advisors Mrs. Bizuayehu T.who advised us to do our work in well manner. They were also with us and informed us to prepare this document .Thirdly, we would like to thank the head of human resource management Mr.Worku T. who accepted and advised us how to follow our internship training. Our fourth gratitude thanks goes to the supervisor of NNWR Mr. Nursien who assigned us in each section. He also followed our day to day activities .Not only this he also regularly assigned his coworkers to tell and show us the theoretical and practical concepts together. We would also like to expand our deepest gratitude for all Ethio telecom workers who helped us directly or indirectly in our theoretical and practical training with good respect and kindness. Finally, we would like to thank our families for their moral and economical support in order to attended this internship program.

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List of Abbreviations

2G……………………………………… Second Generation

3G ……………………………………… Third Generation

3GPP ……………………………..…….... 3rd Generation partnership projection

4G…………………………………..…..... Fourth Generation

ATN…………………………………… Aeronautical Telecommunication Network

BBU…………………………………..……Baseband Unit

BSC…………………………………..….Base Station Controller

BSS……………………………..………Base Station Subsystem

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

BS…………………………………….. Base station

BTS……………………….……….. Base transceiver station

CPRI…………..…………………….. Common Public Radio Interface

CDMA ……………………….…….. Code Division Multiple access

DCDU……………………..……. Direct Current Distribution Unit

DL………………………………….. Downlink

EIRP…………………..….…….. Effective Isotropic Radiated Power

EPC……………………….…….. Evolved Packet core

E-UTRA…………………..…… Evolved Universal Terrestrial Radio Access

E-UTRAN ……………………………Evolved Universal Terrestrial Radio Access Network

GSM ……………………………… Global System for Mobile Communication

HSS ……………..………………… Home Subscription Server

HL…………………………..……..Home Location

IF……………………..……………..Intermediate Frequency

IP ……………………..………..… Internet Protocol

IJSR……………………………..….. International journal of science and research

LAN……………………...…………Local Area Network

LTE…………..Long Term Evolution

MAPL……………………………..… Maximum Allowable Path Loss

MHZ……………………………………..Mega hertz

MIMO ……………………………… Multiple Input Multiple Output

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

MS …………………..……….……… Mobile station

MW………………………………………Microwave

NAAZ……………………..……..……North Addis Ababa Zone

NNWR…………………….……….......North North West Region

NSS……………………………………Network Switching Subsystem

ODU……………………….……………Outdoor Unit

O&M……………………………………..Operation and Maintenance

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

OFDMA………………….……….. Orthogonal Frequency Domain Multiple Access

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

P-GW ………………………………… Packet Data Network Gateway

PL ……………………………………….. Path Loss

PSTN…………………………….………..Public Switched Telephone Network

PS……………………….……………… Packet-Switched

QoS ……………………………….…………. Quality of Services

RRU…………………………………..…..Remote Radio Unit

RTN…………………………………..…….Real Time Network

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

RB……………………………….….…. Resource Blocks

RF……………………………….………… Radio Frequency

RLB ……………………………………Radio Link Budget

RN……………………………………… Relay node

SAAZ……………………..……….…..South Addis Ababa Zone

SWAAZ………………………..……..South West Addis Ababa Zone

S-GW……………………………………. Serving Gateway

SINR……………………………..… Signal to Interference plus Noise Ration

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

TMC…………………………………………Transmission cabinet

UE …………………………………..……..User Equipment

UL…………………………..……………… Uplink

UMTS…………………………………….….. Universal Mobile Telecommunications System

UTRAN……………………………………... Universal Terrestrial Radio Access Network

UIL…………………………………….…..University Industry Linkage

VLR……………………………………..…..Visitor Location Register

VPN-……………………………………….....Virtual Private Network

WAAZ……………………………...……...West Addis Ababa Zone

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

Abstract

This report introduces several new concepts and terms that will be used through the internship Program and practical application of Electrical & computer Engineering and that internship program is mainly concerned in Wireless and Transport network (O&M) operation and maintenance and to create productive, skilled and knowlegible generation. The report is an outcome of the practice we conducted during our internship period at ethio telecom Gonder. This bring to us a great opportunity to realize our theoretical knowledge by practical works, which we gained for the last four years of study in Debre Tabor University. The purpose of this report is to put in paper the work experience we had performed and the knowledge obtained from performing specific tasks while working in a professional environment in this program.We develop theoretical knowledge through practical work. This thing makes Us to be active and confidential. This report is divided in to different parts starting from briefly Describing the back ground of Ethio telecom, including its history, objective, vision, mission and any others. While the other part is describes the overall internship experience we had gained during the practical periods, including how we get in to the company, the section of the company like; Rollout planning ,RAN, IP backhaul and Optimization sections we have been working in the procedure.

Part One

Internship Report

Chapter One

1. Introduction

The development of telecommunication industry is one of the important indicators ofsocial and economic development of our country. In addition to this, the development of communication sector plays a vital role in overall development of all sectors related to social, political and economic affairs. This sector is very dynamic in its nature of innovation and hence, it needs Proper regulation like other critical economic sectors. The Government of Ethiopia establishedthe Ethiopian Telecommunication Agency by Proclamation No. 49/1996, as a regulatory body for Telecommunication Services.The Agency is institutionalized with the objectives of promoting the development of high quality, efficient, reliable and affordable telecommunication services in the country. The Ethiopian Telecommunication Agency (ETA) started its operation by giving license in four areas of services, namely, Public Switched Telecommunication Network (PSTN), Cellular Mobile,Internet and Data communication services to Ethiopian Telecommunication Corporation (ETC),which was established by Council of Ministers regulation No 47/1999 as an incumbent state owned operator. Currently, Ethio telecom is providing all types of services in all parts of the country.

The government of Ethiopia has aggressively been moving and implementing development strategies aimed at reducing the poverty prevailing in the country. In this line, telecommunication plays a key role in facilitating the poverty reduction and development strategy being implemented by the government. To this end, the government has designed strategies to expand telecommunication national network infrastructure, and other infrastructures (Roads and power) to increase socioeconomic development of the country.

1.1. Background and Brief History of Ethio Telecom

Telecommunications service was introduced in Ethiopia in 1894 during the rule of Emperor Menelik II. The first major telephone line construction spanned a total distance of about 477 kilometers and connected Harare a major trade center in the eastern region with Addis Ababa. Immediately after the telephone line, a telegraph line was installed following the construction of the first and only rail way line in Ethiopia. With a construction period of two years 880km North to South telephone line connecting Asmara with Addis Ababa was constructed and made operational in 1904. The verbal repeater" system was used to facilitate long distance calls,makinguse of the several intermediate stations opened at the small towns and villages along the route. By 1930 a route distance of 7000 km was completed and over 170 towns were being served by the telephone network. International communication service, however took long to develop. Until 1930 Asmara and Djibouti are the only cities connected. Later, in 1932, Ethiopia became a member of the International Telecommunications Union (ITU) immediately before the Italian invasion of 1935 and radio communication was introduced following the establishment of radio circuit links with Djibouti, Aden, Cairo and London. By 1934 Ethiopia has established direct radio telephone links with Cairo, Djibouti, Aden and London and soon after radio communications training sectors for Ethiopians in order to replace the expatriates handling the nation's traffic. Administratively the country telecommunication sectoris run by an office in imperial palace.

1.2. Values and principles of Ethio Telecom

- **Human-centric:** provide quick response to our customers and employees in line with their interest and values
- **Integrity:**are trustworthy, responsible and accountable to do business centering ethics at the heart of our business.

- **Excellence:**are committed for quality ,excellence and professionalism .take every challenges as an opportunity using innovative approaches and centering digitalization for a better result.
- **Socially responsible:** care and protect environment contribute for the overall development of our society and do engage in ethical business and do business ethically.
- **Togetherness:** always perform in synergy and team work internally and work in collaboration with ecosystem players so as to grow together.

1.3. Objective, Vision, Mission & Strategy of Ethio Telecom

1.3.1. Objectives

Ethio Telecom has ambitious goals:

- To improve the international telecommunications service by increasing direct links to additional countries in keeping with Ethiopia's economic and culture
- Being a customer centric company
- To improve the quality of service by upgrading as many switching offices as was economically viable from manual to automatic operation and maintainingthe fault rate at a realistic minimum
- Meeting world-class standards
- Building a financially sound company
- To provide telephone connections to as many urban customers as would helpnarrow the existing demand/supply gap
- Implementing control standard processes to extend basic telecommunications services to as many rural communities as possible

To reach these goals, all Ethio telecom divisions will focus on:

- ✓ Developing and enhancing network and information system
- ✓ Ensuring easy access and coverage to the whole population
- ✓ Creating a strong brand
- ✓ Developing human resources management

- ✓ Implementing control standard processes
- ✓ Improving financial, sourcing and facilities processes

1.3.2 Mission

- ❖ Connect every Ethiopian through information communication network.
- ❖ Provide telecommunication service and product that enhance the development of our nation.
- ❖ Build reputable brand known for its customers' consideration.
- ❖ Build its managerial capability that enables Ethio Telecom to operate an international standard.

1.3.3 Vision

- ❖ World wide solution provider change to : A leading digital solutions provider

1.3.4. Ethio Telecom Strategy

Ethio-telecom will achieve its goal of both providing a reliable network and of improving Customer Services through a range of different levers that are part of its development. Ethio-telecom will develop and enhance the information system. This will help to decrease the delay for provision, sales and activation as well as to provide more reliable information to Customers. It will develop a world-class human resources management. This will help to improve employees‟ ability to meet the needs and expectations of Customers. Ethio-telecom will implement control standard processes. This will help to increase reactivity and to faster Customer access to services. It will also develop better sourcing & facilities processes. This will help to faster delivery and repair and will offer more transparency to Custom.

1.4 .The main product or service of ethio telecom

Ethio Telecom is institutionalized with the objectives of promoting the development of high quality, efficient, reliable and affordable telecommunication services in the country. Its services can be broadly classified as:

- Mobile service
- Fixed line service
- Internet service

1.4.1. Mobile products and Services of Ethio telecom

Mobile service includes mobile roaming, satellite mobile, GOTA service, Business mobile, machine to machine, Vanity number, Voice, GPRS and SMS new package and hybrid business mobile.

1. **Mobile Roaming**

Mobile roaming is a service that helps subscribers automatically to make and receive voice calls, send and receive data, or access other services when travelling outside the geographical coverage area of ethio telecom, by means of using a visited country's operator's network.

a) Outbound Roaming: It is a service given to ethio telecom customers who wants to use their mobile phone abroad (out of ethio network coverage).

b) Inbound Roaming: It is a service given to customers of foreign operator who has a roaming agreement with ethio telecom (like tourists, foreigner investors …). Currently, this service is provided only for GSM post paid subscribers.

figure 1. 1 mobile roaming

2. GOTA (Global Open Trucking Architecture)

GOTA (Global Open Trucking Architecture) is a service given using the CDMA2000 wireless network for the purpose of group communication. It allows two or more individuals to communicate and also use for private and group calls using push to talk. The service also allows the subscriber to make external calls after subscribing to the mobile wireless service.

GOTA Service Benefits are affordability, can be used as GSM mobile, one-to-one private calls and one-to-many group calls, the ability to set the user's priority, the ability toperform forced insertion/ forced release based on the user's priority, the ability to classify the groups,inwhich the group members can be managed by the user.

Figure 1. 2 gota service

3. Satellite Mobile

Satellite mobile telephone is mobile phone that connects to orbiting satellites instead of terrestrial network. It enables customers in every part of the globe to be beneficiaries of telecom services through satellites stationed on the universe. Satellite phone is one of the greatest innovations in communication. The satellite mobile telephone provides similar features of communication services to that of earthly mobile telephones such as; voice, SMS and low-band width internet access. Satellite phone vital communication tool in remote area where local telecom are unreliable and this kind of service needs special telephone apparatus and SIM.

Figure 1. 3 Satellite mobile

4. Business Mobile

Business mobile Service with/without CUG is a bundled postpaid mobile service that allows enterprise customers to make calls at a discounted rate compared to the normal mobile tariff rates.BM with CUG (Closed User Group) option, in addition to the business mobile bundles, any calls out of the bundle made within the group are treated at a much discounted rate. To subscribe CUG there should be at least five defined internal users within the group for each organization. All services supported by GSM are also supported by Business mobile.

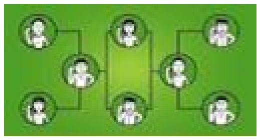

Figure 1. 4 Business mobile

5. Packaged Services

Packaged services are a service that could be provided in the form of voice off pick package, GPRS package and SMS package. Special target of customers for all packages include students, night shift workers, big Hotel workers and Taxi drivers.

6. Vanity Numbers

Vanity numbers are Mobile numbers which are memorable and easy to dial. Vanity numbers are classified into four categories based on their easiness to remember. These are:

Platinum numbers: 0911111111, 0922222222, 0933333333 …

Gold numbers: 0911121314, 0915161718 ….

Silver numbers: 0912345678, 0901234567 ….

Bronze numbers: 0912331233, 0911121112 …….

7. Machine to Machine

Machine to Machine is a wireless technology that enables machines to talk to each other, and which customers can access directly from their office or home computer. It combines telecommunication and information technology in order to connect remote devices and locations, system and people. It is the utilization of different types of mechanical devices to establish a communication and exchange of information. M2M used a data enabled SIM card.

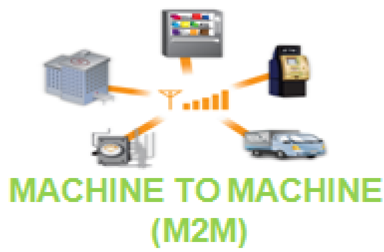

Figure 1. 5 Machine to machine service

1.4.2. Fixed line service

It includes Wired Fixed line, Wireless Fixed line (CDMA), Short code, Bulk SMS and ISDN/E1. Landline: is a telephone line that travels over terrestrial circuits. A landline can be copper wire, fiber optics or microwave.

Wireless Fixed line: is much similar to the ordinary fixed telephone service; it uses Fixed Wireless Terminal (FWT) which enables it to give a voice, data and other value added services. It works where ever CDMA network is available. ISDN/E1 service: Integrated services digital network (ISDN) is an international communications standard for sending voice, video, and data over digital telephone lines or normal telephone wires.

1.4.3 Internet service

1. Fixed broadband internet Broadband is a relatively fast Internet service provided through wired and wireless connections with a speed level from 256 Kbps.

- ✓ Fixed wired broadband internet is provided through copper or fiber with different access methods like ADSL, VDSL, EPON and GPON.
- ✓ Fixed wireless BB internet wireless is device or system used to connect different fixed locations with a radio or other wireless link.
- ✓ Wireless broadband internet is an Internet service which can be given through different access methods like, AIRONET, supports up to 54 Mbps downloading capacity, VSAT (supports up to 2Mbps downloading capacity), EVDO and 3G.

2. Asymmetric Digital Subscriber Line (ADSL) Internet Fixed Broadband Internet service is an Internet service with wired access. It can be provided through copper or fiber depending on the speed requested and other factors. Ethio Telecom provides this service in two options:

- ✓ Limited ADSL: is a packaged service based on volume; mainly targeting residential customers.
- ✓ Unlimited ADSL: It is unlimited in volume and sold with a fixed monthly rent with different access speed options.

3. 3G Internet Ethio telecom’s 3G Internet package service is a broadband internet service. The package is designed to meet the demand of both residential and enterprise customers.

4. Evolution Data Only (EVDO) EVDO is a Broadband mobile Internet service with high speed using CDMA technology. The service works wherever CDMA network is available. The service is available in Addis Ababa and more than 200 cities and town throughout the country. It is provided in three alternative packages: 1GB, 2GB and 4GB for both prepaid and postpaid customers.

1.5. Main Customers or End Users of Ethio-Telecom

Ethio telecom offers a wide range of products and services tailored made for Enterprise customers and non-enterprise customers (Residential).Generally, the customers of Ethio Telecom are the entire people of Ethiopia where the company network is covered. The reason behind this is that everyone can use the network of Ethio Telecom where ever the network is there as much as he/she has fulfilled the requirements to use the services.

The customers or end users of Ethio telecom include:

- ❖ Government organizations like educational institutions, health centers, etc.
- ❖ Private and commercial companies.
- ❖ International institutions.
- ❖ Individuals.

1.5.1. Stake Holder of Ethio Telecom

Stakeholder is defined as those at groups without those supports the organization cease to exist. Then it has gained wide acceptance in business practice and in theorizing relating to strategic management, cooperate governance, business purpose and cooperate social responsibility (CSR).

The stake holders of Ethio telecom are: -

- ZTE company
- HUAWEI company
- Ericsson company
- Customers
- Government

1.6. Over All Organizational Structure

The EthioTelecom Company has been organizational structured by one head quarter, six zonal offices, and twenty three regional offices

The six zonal offices

- EAAZ(East Addis Ababa Zone)
- NAAZ(North Addis Ababa Zone)
- CAAZ(Central Addis Ababa Zone)
- WAAZ(West Addis Ababa Zone)
- SAAZ(South Addis Ababa Zone)
- SWAAZ(South West Addis Ababa Zone)

The regional offices have twenty three main offices:

- ER,CWR,EAAZ,NAAZ,WAAZ,EER,CNR,NWR,NER,NEER,NNWR,CER,SAAZ,SWAZ,SER,SSWR,SWR,SR,WR,WWR,NR,

1.6.1. Organization structure and work flow of the company

Organizational structure of ethio telecom has four divisions.under each division it has sub division:

1. **Technical division**
    - ❖ Network
    - ❖ Information system(IS)
2. **Commercial division**
    - ❖ Residential sales
    - ❖ Marketing and communication
    - ❖ Enterprise
    - ❖ Customer service
3. **Support division**
    - ❖ Finance
    - ❖ Human resource
    - ❖ Sourcing and facility
    - ❖ Legal
    - ❖ Quality and process
    - ❖ Security
    - ❖ Internal audit
4. **Other**
    - ❖ Women, children and youth affairs
    - ❖ Ethics and anticorruption
    - ❖ Corporate communication
    - ❖ Strategic planning

Ethio Telecom organizational structure includes different functional divisions that are under direct administration of Board of Directors. As the figure above shown the organizational structure of Ethio telecom depends on functional structure. The company has six major significant divisions, which is led by chief officer, departments led by officer and section led by managers. Even if this is create divisional rivalries it is best suit the company for the easy implementation of Enterprise solutions applications. To grasp on our target divisions, Residential division is responsible for the sales generated from residential people.

Enterprise division is responsible for all enterprises like government organization, profit and nonprofit organizations. Marketing and communication division take care of marketing related activities like tariff revision, new product or service launch and sales guides' different sales analysis including market research. Customer servicedivisions undertake after sales and presales activities mainly 994, 980 for VIP customers. Technical Division the core division of the company which is responsible for entire network management of the company. Information system division facilitates and ensures the automation part of the company as well as provides necessary detailed and summarized information for managers depending on their request. When we see this all the board of directors is the final controller of the company.After the transition from France Telecom (FT), the overall organizational structure and work flow of Ethio Telecom was under the control of Ms. FrehiwotTamiru, CEO and Mr. TeferaDerebew, Chairman of the Board, Currently in Ethio-telecom.

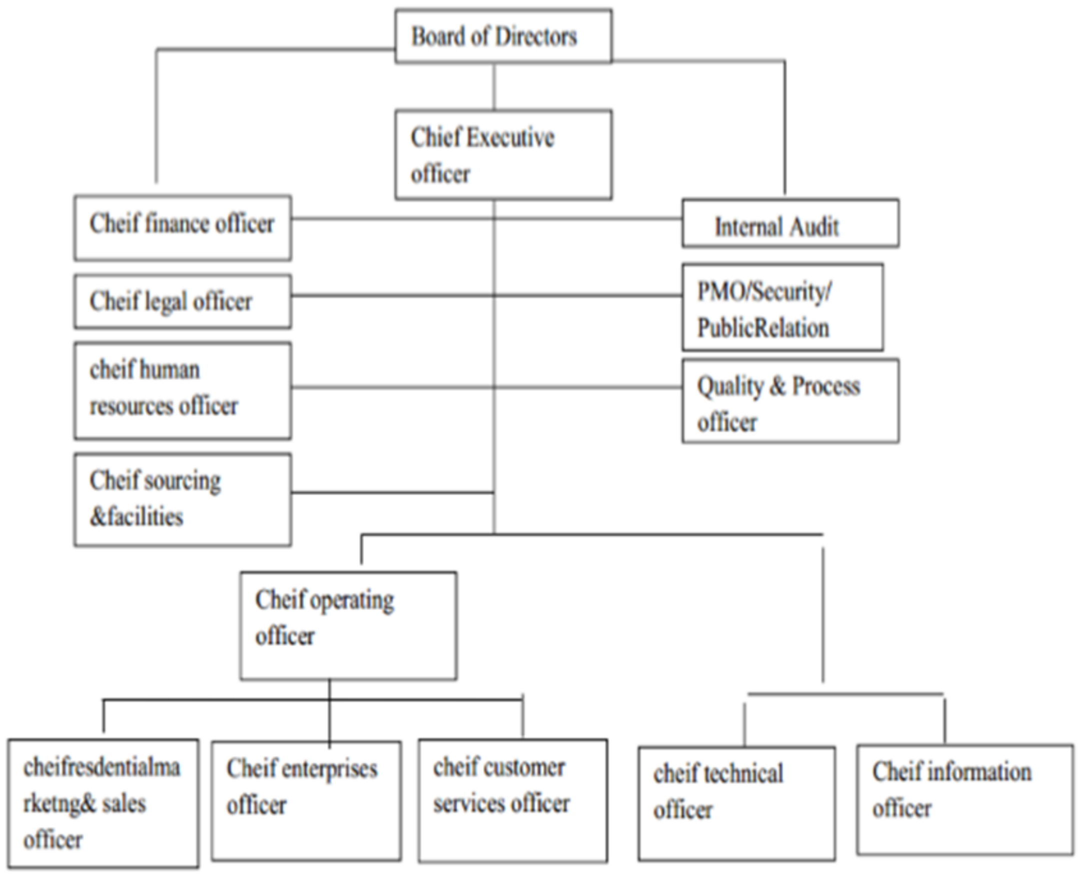

Figure 1. 6 Work flow of the organization

Chapter Two

2. The Overall Internship Activities and Experience

2.1 Objective of the internship

2.1.1 General Objective:

- ✓ The general objective of this internship program is to enable engineering students under the institute to reflect and upgrade their theoretical knowledge practically in the real world.

2.1.2 Specific Objective:

- ✓ The specific objective during the internship is aimed to improve the student's practical and theoretical knowledge, interpersonal communication and team playing skill, and understanding about work ethics and related issues, and also to develop an idea for final project from duration of internship.

2.2 How we did get the company

To get in to the company, firstly the UIL sent a list of students, which are interested to join Ethio telecom. Ethio telecom accepted the paper. Then Minister of Education has placed the students to different regions of Ethio telecom. After we have placed to different regions of Ethio telecom, the UIL office coordinator announce all of us through notice to attend a one-day induction training hosted by the company in Gondar. We attended the training at the specified place and got some information about Ethio telecom's background, mission and vision, work ethics, products and services provided, and end user of Ethio telecom. After finishing the training, we joined to the NNWR of Ethio telecom, which was our choice whenever we registered and joined to different section.

2.3. The Way of Entrance to the ethio telecom

Debre Tabor University is implementing/applying the curriculum by which engineering students take an internship (industry placement) based on their department course sequence schedule. So Electrical and Computer Engineering department students are taking an internship on 5th year, 1st semester of their regular program. According to the program, the students want for practice at related companies for a period of three months.

At the time 2022/2023 (communication engineering stream) 5th year student, andhave took an internship (industry placement). We were ordered to find the host company on which we would feel comfort and satisfied to relate the theoretical lessons that we learnt in the past 4th-years to practical ones which have been performed.

2.4. Working sections of company

The section that we have been working for the allocated time is.

Wireless and Transport network (O&M) operation and maintenance

Then we got a chance to join the Engineering departmentdivision has also four sections in NNWR:

- Rollout planning subsection
- RAN subsections
- IP backhaul subsections
- Optimization subsection

Rollout planning:

Network Rollout Plan means a plan describing the rollout of the distribution system of the proposed distribution system of the applicant, as the case may be, including geographical coverage of such distribution system, phasing of the rollout and such other details as may be required by the Commission.

The study of the Proposed Network Plan should necessarily include a broad range of factors, from the expected national socio-economic development, government policy to resource availability of particular importance are demands of the various services, including those services not available at present, and the extent of financial resources. Other important considerations include the existing network, transition strategies, interworking with other networks, operation and maintenance, administrative structure, numbering, signaling and other fundamental plans.

The Network Rollout Plan is proposed considering:

- ✓ The network is designed considering economical deployment and ease of operation and maintenance.
- ✓ The proposed network will be deployed utilizing the latest technologies at present.
- ✓ The network will be able to accommodate expected demand of existing and new application of basic telephone and non-telephone services that interface to the conventional networks.
- ✓ The network should facilitate the development of ICT (Information and Communication Technology) covering the major areas of Ethiopia.

Radio access network (RAN):

The radio access network section is governed under engineering department and it’s the core and centralized section out of all. Its main job is to support the company’s technical goals, provide a radio access radio network with a great capacity and quality.it always come with a continuous proposal for a better wireless telecom technology choices.in general, radio access network section do the planning, surveying, designing and optimizing functions updating its self with current global tools.in addition.it works on preparation of technical specification and bill quantity related to its section.

Ethiotelecom in recent time use three mobile communication technologies in NNWR those are: -

- ❖ 2G (Second generation) technology
- ❖ 3G (Third generation) technology
- ❖ LTE (Fourth generation) technology

2G is the second generation of cellular networks, based on the Global System for Mobile Communication (GSM). Designed to accommodate the growing number of mobile phones, 2G introduced cellular services like SMS, multimedia messaging, and digitally encrypted voice conversations.2G networks based on GSM use 850/900 MHz and 1800/1900 MHz bands.

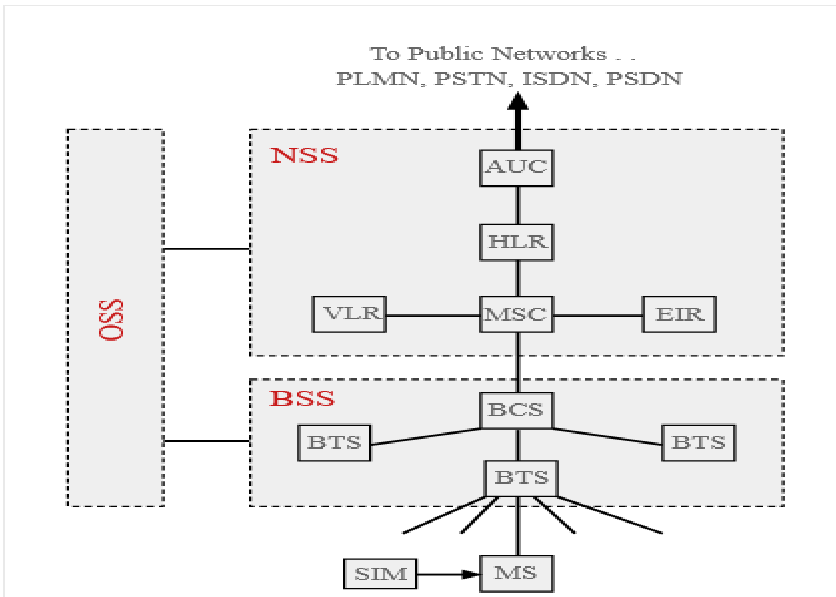

Figure 2. 1 GSM architecture

3G is the third generation of wireless mobile telecommunications technology. It is the upgrade over 2G(GSM) networks, offering faster data transfer, and better voice quality.It used Wide Band Wireless Network that increased clarity. It operates at a range of 2100 MHz .

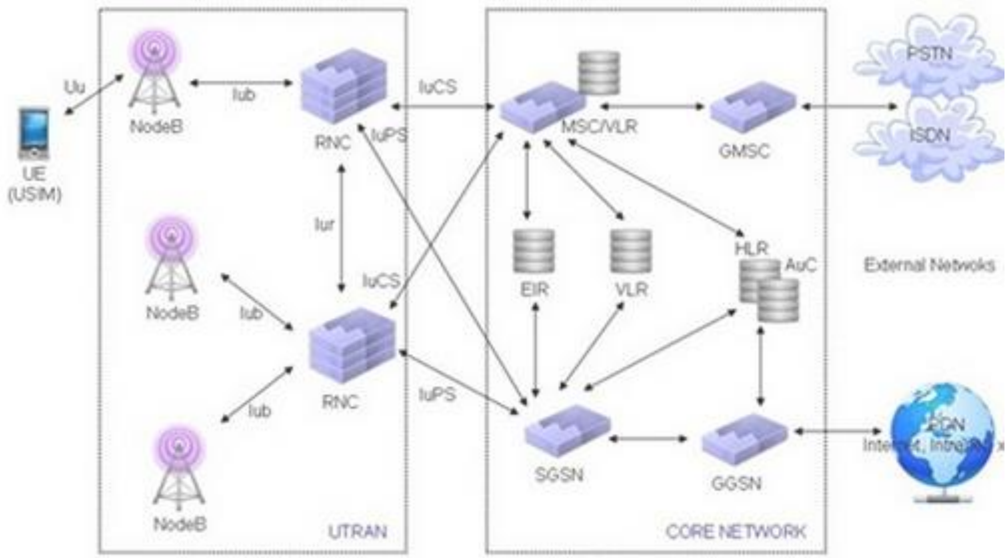

Figure 2. 2 3G (CDMA) architecture

LTE stands for Long Term Evolution and is sometimes referred to as 4G LTE. It's a standard for wireless data transmission that allows you to download your favorite music, websites, and video really fast—much faster than you could with the previous technology, 3G.

It is the upgrade over 3G(CDMA) networks, offering broadband data transfer. It operates at a range of 2600 MHz and also use recycling the 2G frequency’s.

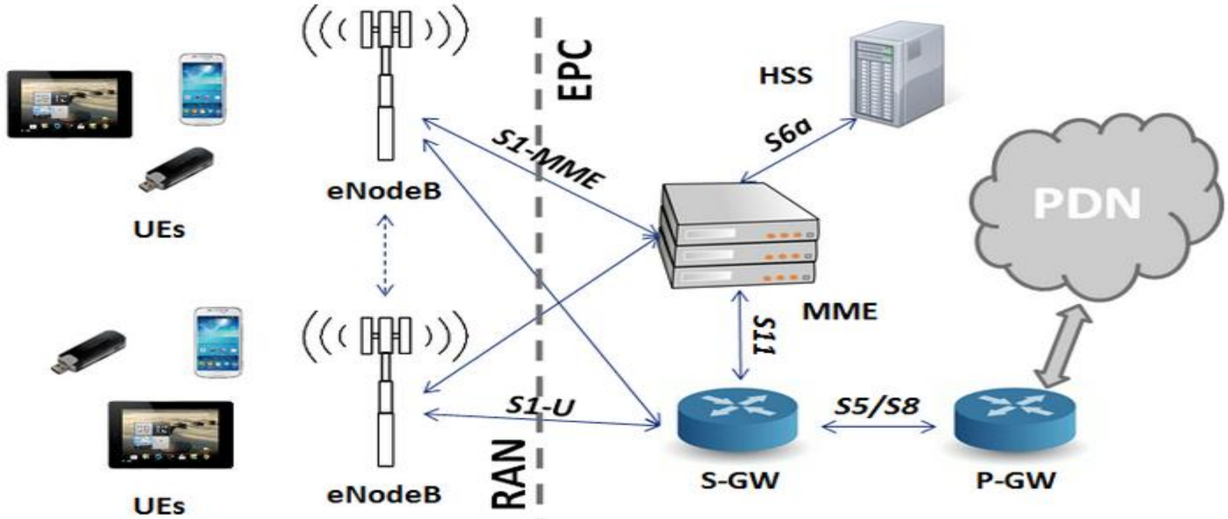

Figure 2. 3 Architecture of LTE

The three technologies has two main parts such:

- ➢ Base station subsystem

- Network switch sub system

The Base Station Subsystem is responsible for managing the radio network, and it is controlled by an MSC. Typically, one MSC contains several BSSs. A BSS itself may cover a considerably large geographical area consisting of many cells (a cell refers to an area covered by one or more frequency resources).

The BSS consists of the following elements:

- ✓ BTS Base Transceiver Station
- ✓ BSC Base Station Controller

BTS (Base Transceiver Station):The BTS houses the radio transceivers that define the cell and handles the radio network protocols with the mobile station. In large Urban area, a large-numbers of BTS may be deployed.

BTSis base transceiver stations a piece of equipment that facilitates wirelessommunication between user equipment (UE) and a network. UEs are devices like mobile phones (handsets), WLL phones, and computers with wireless Internet connectivity.

N.B. BTS for GSM (2G) and NodeB For UMTS (3G) BSC for GSM RNC for UMTS/WCDMA and eNodeB for OFDM (LTE).Each BTS,NodeB,eNodeB serves as a single cell.

Functions of BTS ,NodeB,eNodeB

- Encoding, encrypting, multiplexing, Modulating, and feeding the RF signals to the antenna.
- Time and frequency synchronizing
- Voice through full rate or half rate services
- Decoding, decrypting, and equalizing the received signals

BTS ,NodeB and eNodeBequipment:

1. RF Antenna
2. **2.** RRU
3. **3.** TMC
4. **4.** Connection cable
5. **5.** MW
6. **6.** ODU
7. **7.** Power cabinet

1. RF Antenna: is a transducer, which converts electrical power to electromagnetic waves and vice-versa. Every antenna is two way or is bidirectional i.e. it can both transmit and receive signals.

Transmitting antenna is one, which converts electrical power to electromagnetic waves and radiates them.

Receiving antenna is one, which converts electromagnetic waves from the received beam to electrical signal. In two-way communication, the same antenna can be used for both transmission and reception. Antenna is the key element for wireless technology.

Figure 2. 4 RF antenna

2. RRU (Remote Radio Unit) :is the distributed and integrated frequency unit that connects to an operators network with the User Equipment's (UE's) like Cell Phone and mobile devices.

The logical term **"distributed and integrated"** is because traditionally the radio architecture for cellular system is based on a single-standalone system(Base Stations) usually installed indoor but now, the cellular architecture is divided.

Figure 2. 5 RRU

RRU Functions:

- Receives downlink baseband data from the baseband unit (BBU) and sends uplink baseband data to the BBU.
- Receives RF signals from the antenna system, down-converts the signals to intermediate frequency (IF) signals, amplifies the IF signals, performs analog-to-digital conversion, and up-converts RF signals to the transmit (TX) band.
- Multiplexes receive (RX) and TX signals on the RF channel so that these signals can share the same antenna channel, and filters the RX and TX signals
- The RRU can be powered by the AC/DC power module. In this case, this RRU is called AC RRU.

RRU can be mount in antenna pole in tower site and main pole and in roof top site.

Figure 2. 6 Tower and roof top site

RRU Hardware Description:

1) CPRI Port: There is 2 port generally named as CPRI0 and CPRI1. However there may be 1's in some model. The name at suffix may vary. Its function is to connect to BBU.

2) RF Port: We say it as a Jumper port. The number of jumper port may vary with model and company's architecture. At least there is 2 jumper port, one of which is for Tx and another for Tx/Rx. The RF port is connected to the Antenna via Jumper Cable.

3) RET Port: There is at least one RET port for connection to RCU. The connector is mostly DB9 in Huawei and may vary with other company's. RCU is connected to the Antenna. RET cable connects the RCU and RRU.

4) Power Supply Port: There is one port for powering the RRU. Mostly blue and black. Blue is for negative (-) and black is for zero(0). Generally all RRU operates in -48V.

5) Ground Port: There is two OT port for the grounding. The ground cable: mostly copper wire, one end is connected to RRU and another end into Bus Bar near by RRU. Thus it provides the surge and high voltage protection of RRU and thus keeping safe from natural weather and climates.

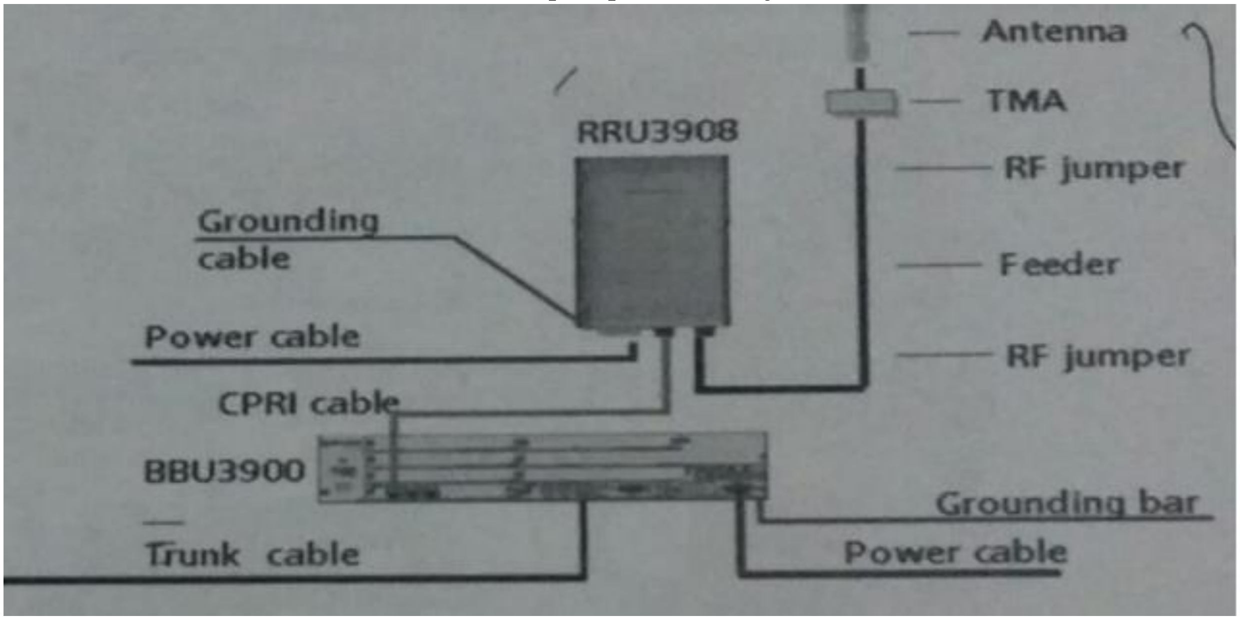

Figure 2. 7 RRU each port

3. **TMC (Transmission cabinet)**:is a device that contains BBU, RTN, ATN,and DCDU

Figure 2. 8 TMC

Baseband unit (BBU)is a unit that processes baseband in telecomm systems. A typical wireless telecom station consists of the baseband processing unit and the RF processing unit (remote radio unit - RRU). The baseband unit is placed in the equipment room and connected with RRU via optical fiber. The BBU is responsible for communication through the physical interface. A BBU has the following characteristics: modular design, small size, low power consumption and can be easily deployed.

A BBU in a cellular telephone cell site is comprised of a digital signal processor to process forward voice signals for transmission to a mobile unit and to process reverse voice signals received from the mobile unit. The digital signal processor also serves to produce a first supervisory audio tone (SAT) for transmission to the mobile unit by generating successive digital SAT samples which are decoded into a continuous tone. Finally, the digital signal processor detects the presence of a second SAT generated by the mobile unit by sampling and processing successive samples of the second SAT and measuring the power.

Base band unit (BBU) processes the signal of original frequency before it is modulated. To clarify, in base band – Frequency is not shifted to some other frequency band by means of modulating.

BBU have DSP (Digital signal processor) that process the conversion of signals between analog and digital signals. Above all, it is known as heart of communication because it serves for communication link between two end users.

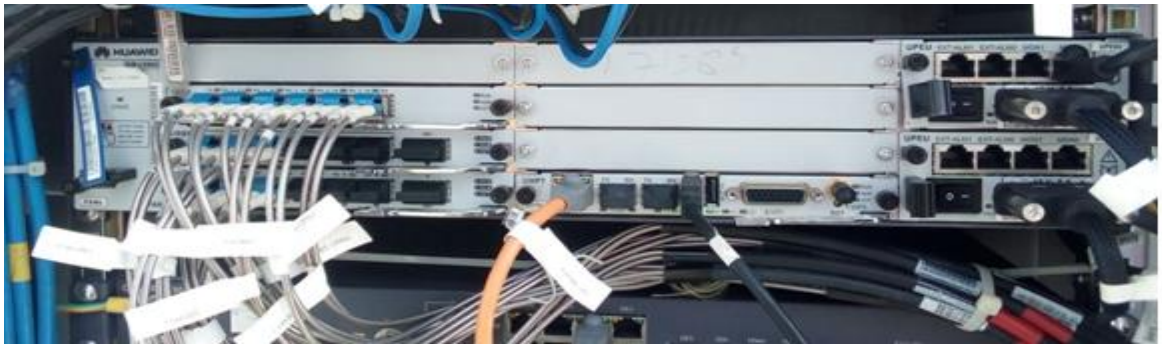

Figure 2. 9 BBU

Functions of BBU:

1. Provides clock ports for clock synchronization, alarm monitoring ports for environment monitoring, and a Universal Serial Bus (USB) port for commissioning using a USB flash drive.
2. Manages the eNodeB through operation and maintenance (OM) and signaling message processing.
3. Provides common public radio interface (CPRI) ports or optical links for communication with RRUs and processes uplink and downlink baseband signals etc.

Commonly BBU consists of FAN, UBRI, UMPT, UPEU and other slots. Where necessary cards is inserted for needed operation. This all slots commonly works as the function of bbu in telecom. While, brief description of each above components is given below:

Figure 2. 10 BBU card board

FAN any fan inside BBU Connected, or attached to BBU Slot number 16 Constant slot it used for active cooling, and may refer to fans that draw cooler air into the case from the outside, expel warm air from inside, or move air across a heat sink to cool a particular component Cool For all BTS Cards.

WBBP is a WCDMA baseband processing unit and can be installed in a BBU3900.This Card Function For 3G network. There are 2 TYPES of WBBP Bored WBBP F1and WBBP F3 based on the capacity. WBBPF1 has 192 (Uplink) and 256 (Downlink). WBBPF3 has 384 (Uplink) and 512 (Downlink).

UBRI Universal Baseband Radio interface board; It is applicable for GSM mode.

- ✓ Provides extended CPRI optical or electrical ports Performs convergence, distribution, & multi-mode transmission on the CPRI.
- ✓ When the UBRI is working in GSM mode, the RF module processes baseband signals
- ✓ The UBRI can only be installed in a BBU3900
- ✓ One UBRI supports 6 CPRI interfaces & one RRU needs one CPRI interface
- ✓ Maximum board number = 2; optional

UMPT it is the brain or central processing unit of the BTS and is the Universal Main Processing & Transmission unit that is installed in a BBU3900.

The UMPT performs the following functions:

- Performs configuration management, device management, performance monitoring,
- Signaling message processing, and active/standby switchover.
- Controls all boards in the system.
- Provides the reference clock for the entire system.

UPEU

- Universal Power & Environment Interface Unit
- It is a power module in a BBU3900 or BBU3910
- Maximum board number = 2, mandatory

UEIU

- Universal Environment Interface Unit
- An environment monitoring unit in a BBU3900 or BBU3910
- Max board no = 1, optional
- The UEIU transmits monitoring & alarm signals to the main control unit
- works on water sensor, smock sensor, temperature sensor.

UBBP

- Universal baseband process unit
- It works for both 2G and 3G.
- It has two versions UBBPd1 and UBBPe4, UBBPd1 has 384 (UL) and 512 (DL) and UBBPe4 has 1024 (UL) and 1024 (DL).

RTN(Real Time Network): Real-Time Network is a satellite-based positioning system using a network of ground receivers (also called continuously operating reference stations (CORSs)) and

a central processing center that provides highly accurate location services to the users in real-time over a broader geographic region. Such systems can provide geospatial location data with centimeter-level accuracy anywhere within the network. Geospatial location services are not only used in measuring ground distances and mapping topography; they have also become vital in many other fields such as aerospace, aviation, natural disaster management, and agriculture, to name but a few. The innovative and multi-disciplinary applications of geospatial data drive technological advancement towards precise and accurate location services available in real-time.its current applications in transportation-related fields, and a perspective on the future use of this technology in advanced transportation applications.

RTN is a new generation integrated microwave transmission system developed by Huawei, which can be installed easily and configured flexibly.

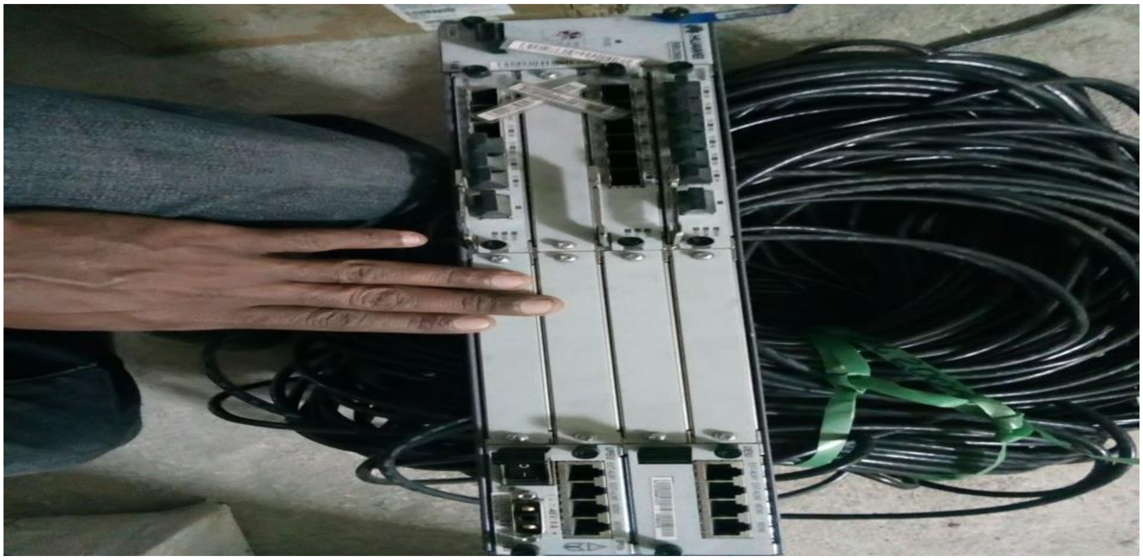

Figure 2. 11 RTN

Aeronautical Telecommunication Network (ATN) is being defined within the International Civil Aviation Organization (ICAO) as a digital data communications network for the aeronautical community. ATN routers will link the diverse networks and technologies within the aeronautical environment into an internetwork. The routers provide intelligence to select the best communications path for each pair of users. Mobile routing is the key element that makes ATN unique from most networks. Mobile routing allows a ground system to communicate to an aircraft, without interruption, as it flies in and out of coverage of various air/ground subnetworks.

Figure 2. 12 ATN

DCDU (Direct Current Distribution Unit): The DC distribution unit is a device or distribution of direct current.The DC power required by many power-required devices, including RRU, RTN, ATN, BBU, and many others, is distributed through it. A direct current distribution unit provides -48 V DC power for other components in a cabinet (in the rectifier).

Figure 2. 13 DCDU

4. Connection cable

- If cable
- RF cable
- LAN cable
- CPRI cable

Intermediate frequency (IF) cable, which connects the RF processing unit with the IF and baseband processes unit and supplies power to the RF processing unit.

RF(radio frequency) cable ,which connects the RF antenna within the RRU.

LAN(local area network) cable, which connects RTN to BBU.

CPRI (Common Public Radio Interface) is a specification for wireless communication networks that defines the key criteria for interfacing transport, connectivity and control communications between Baseband units (BBUs) and remote radio units (RRUs).

5. **Microwave** is a line-of-sight wireless communication technology that uses high frequency beams of radio waves to provide high speed wireless connections that can send and receive voice, video, and data information.

Figure 2. 14 MW

6.**Outdoor Unit (ODU)** is part of the digital microwave transmission system. It supports a point-to-point digital fixed radio service and works together with the Indoor Unit (IDU) to provide multiple types of service interfaces.

Figure 2. 15 ODU

7.Power cabinet is the house of power storage that sends powerwith in the DCDU.

Base station controller (BSC) is a network element that controls and monitors a number of base stations and provides the interface between the cell sites and the mobile switching center (MSC).it use in GSM of the generation technology.

RNC is a functional element of the UMTS RNS (Radio Network System) which controls a number of Node Bs. Responsibilities of the RNC include radio resource management and control, air interface security, mobility procedures and system synchronization.

Network switching subsystem (NSS) (or GSM core network) is the component of a GSM system that carries out call out and mobility management functions for mobile phones roaming on the network of base stations.It contains the elements Mobile Services Switching Center (MSC), Home Location Register (HLR), Visitor Location Register (VLR), Authentication Center (AC), Equipment Identity Register (EIR).

MSC (mobile switching center)

- Call processing
- Interface management
- Operation and maintenance supports
- Blink

HLR(home location register)

- Subscriber ID
- Current subscriber
- Subscriber status
- Store permanent data

VLR (visitor location register)

- ✓ Location area identity
- ✓ Temporary mobile subscriber identity

- ✓ Allocating the roaming number
- ✓ Mobile status

EIR (equipment identity register):isa globally standardized, hierarchical system for identifying these stolen and counterfeit devices on a mobile network – for automatically blacklisting them; and for prohibiting them to connect to the network.it focus on the equipment not the subscriber.

Authentication center (AuC) is a function to authenticate each SIM card that attempts to connect to the gsm core network (typically when the phone is powered on). Once the authentication is successful, the HLR is allowed to manage the SIM and services described above.

IP backhaul subsections

The Internet Protocol (IP) is the method or protocol by which data is sent from one computer to another on the Internet. Each computer (known as a host) on the Internet has at least one IP address that uniquely identifies it from all other computers on the Internet.

IP backhaul :is the link between the network serving as the backbone for other networks and other sub-networks . Also, the transportation of data or network between access points to the public is backhaul. Backhaul connects the central network to the individual networks or publicnetworks. Topology of IP backhaul is show below the figure.

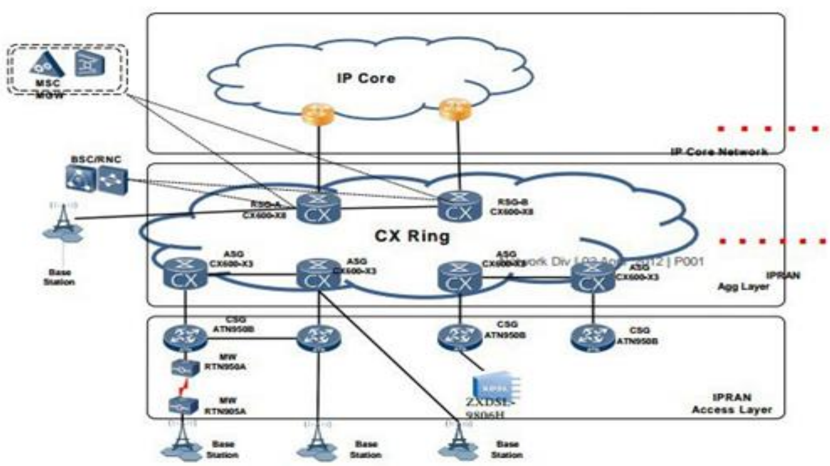

Figure 2. 16 IP backhaul topology

Optimization subsection

What Is Network Optimization?

Network optimization is an umbrella term that refers to a range of tools, strategies, and best practices for monitoring, managing, and improving network performance. It is an act, process, or methodology of making something (such as a design, system, or decision) as fully perfect, functional, or effective as possible .

What Are the Benefits of Network Optimization?

Managed effectively, network optimization is capable of helping organizations build more effective and efficient internal and external networks. This carries with it a number of distinct advantages, including the following:

Increased Network Throughput

Network optimization removes the hurdles that stand in the way of optimal data transmission speeds. This means decreased latency and jitter, faster response times, and a better-connected IT ecosystem, and, as a result, increased throughput.

Enhanced Employee Productivity

Latency, packet loss, and downtime in internal networks prevent employees from being able to access and use vital tools and information when and how they need them most. Network optimization keeps data flowing properly, so your workforce doesn't have to sit on its hands waiting for your network to catch up.

Improved Analytics and Security Posture

An important element of network analytics and security is traffic visibility. By keeping a close eye on what traffic is moving through your network, where it's going, and what it's doing, you'll gain the benefit of being able to more quickly identify and respond to threats, and track various crucial metrics, including those outlined above.

Armed with this information, organizations using network performance monitoring and diagnostic (NPMD), application performance monitoring (APM), and security tools can analyze captured data and turn it into valuable, actionable insights. These tools can be further enhanced with advanced metadata, including attributes from the application layer, to solve more advanced use cases. Network analytics can likewise be employed in predictive modeling, providing accurate forecasts of future network usage.

Enriched Customer Experience

Customer-facing networks likewise benefit from network optimization, with faster, more available services. When customers enjoy full functionality without having to wait longer than expected, they are more likely to want to continue doing business with your company.

Greater Overall Network Performance

Obviously, the overall goal of network optimization is to optimize your network's operation. This means better performance across the board and improved returns from any and all services and systems that rely on network performance.

Optimization parameter adjustment

To limits the effect of over heading one channel to another channel as optimization we use an action. i.e.

- ❖ Physical parameter adjustment of optimazation

It is used to adjust the antenna with in tilt.

What is tilt?

Tilt represents the inclination or angle of the antenna to its axis when we apply a tilt, we change the antenna radiation.

There are two possible types of tilt (which can be applied together):

Mechanical tilt: it is the adjustment of antenna in down tilt for consider of the coverage area.

- ✓ will decrease coverage lengthwise from the sector, but in width, the coverage will stay the same, more like an ellipse shape type coverage on the ground.
- ✓ Is used on tall sites, typically on top of hills, because electrical tilt is not enough.
- ✓ Decrease coverage and Does not add Interference as in case of Electrical tilts.
- ✓ Sector overlaps are increased

Electrical tilt: where there is adjustment of phase of the control signals given to individual segments of the antenna. As a result, the virtual distance between the antenna back-plate and each single segment varies so that an apparently tilted surface of the antenna front plate is resulting.

- ✓ Decreases both length and width, like a circle on the ground which is getting smaller and smaller, but stays a circle
- ✓ Recommended for sites which are not tall and inside city limits.
- ✓ Decrease coverage and does not increase overlap in sectors
- ✓ Increases interference, as portion of energy based on electrical tilts is transmitted in the upper side lobe reducing the energy in lobe facing towards ground hence reducing coverage.

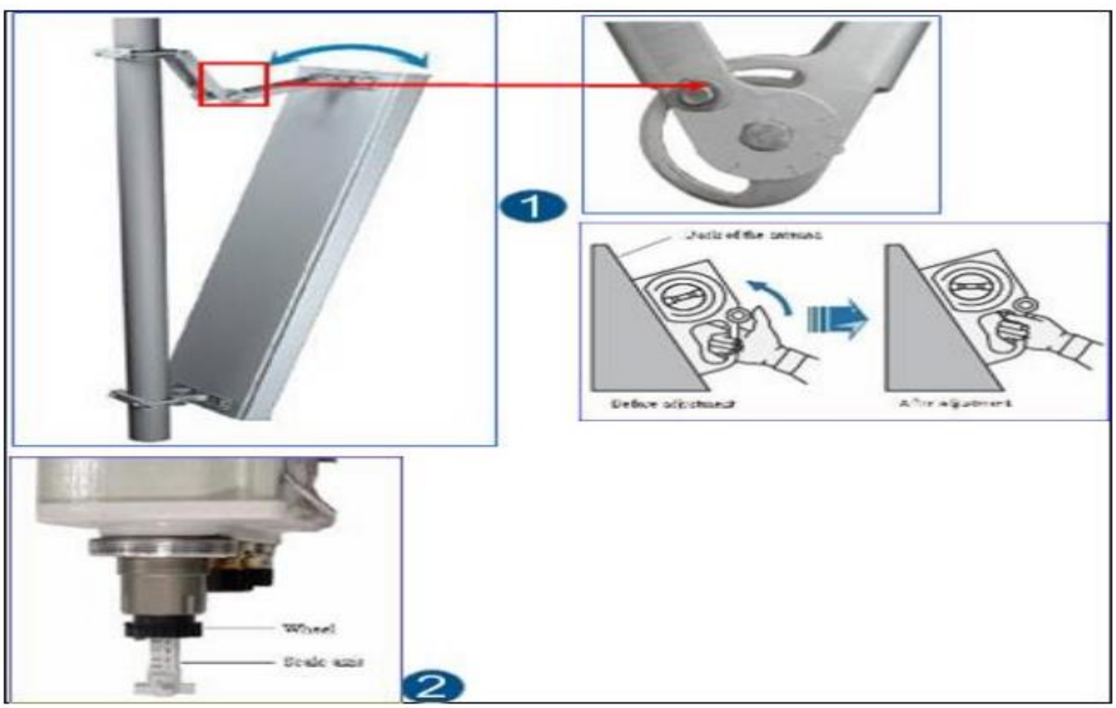

Figure 2. 17 mechanical and electrical tilt

Where 1 is mechanical tilt and 2 is electrical tilt

Antenna Azimuth: Azimuthal antenna configuration is the difference between each antenna positions. Each antennain a tower is called sector. Sector 1 antenna must cover 0 to 120 degree from north in clock-wisedirection. Sector 2 antenna must be in the angle between 121 to 240 degree and sector 3 antenna covers the remaining 241 to 360-degree angle**.**

- Soft parameter adjustment of optimization: this adjustment is includes
  - utilization
  - up link and down link rejection(up and down rejection <500 per sum)
  - power resource
  - code recourse
  - traffic

Types of tools in optimization process:

- Pre processing : like NEMO out door,NEMOhandy,GPS,liecsence,team investigator, genx probe.
- Post process : like actix analyzer, team discovery.

2.5 Our Major Duties

Internship provides the opportunities to know more about practically working environments.Knowing the duties of an employ helps one on how to perform tasks accordingly. It gives the information about how to behave and work together with other fellow workers in company. In Ethio-telecom, we understand that our duties include the following;

- To be punctual
- Willingness to know
- Obey the rules of the company
- To have good communicative skill
- To participate actively in teamwork
- To respect the staffs and our friends
- Incentive to do what is expected from us
- Fulfill wearing formality

2.6 Challenges We Faced During the Internship

During our three month stay in Ethio telecom, we faced different challenges. Some of the challenges we faced are listed below.

- ✓ There were lack of infrastructures like computers, chairs, training manuals, and accesseslike Wi-Fi in both sections.
- ✓ In O&M section, the technicians allowed us only to observe while they maintained a fault. We were not able to maintain a fault by ourselves.
- ✓ The workers were usually busy, so they had not enough time to train and guide us.
- ✓ The equipment are installed by professionals from the vendor companies and there are no equipment that are reserved for training. Hence, we were only allowed to observe the equipment's. The nature of the work is very sensitive that a simple fault, for example, disconnecting a single cable, can cause a great network failure. This makes the internship theoretical which were not our expectation.

2.7 Measurements Taken to Overcome the Challenges

In order to overcome the above challenges, we took the following measurements.

- We shared the available limited resources, like computer and chairs, with the staff members and among ourselves. In addition, we were sharing ours laptop among ourselves and filling our gap using Wi-Fi service in our campus.
- In order to have a deep understanding of telecom concepts, we ask the supervisors at their free time, we were usually studying the resources we got from different websites and seeing video tutorials.
- We were discussing among ourselves on a regular basis to share what we have read and understood.
- We told the O&M Manager to have a meeting with him and supervisors per month to discuss on ideas which were confusing and need to be discussed. He accepted our idea and we had had a meeting monthly.

Chapter Three

3. Overall Benefits Gained From Internship

The internship program is useful to students not only in terms of practical and theoretical knowledge but also to skills like improving practical skills, up grading theoretical knowledge, improving interpersonal communication, improving team work, understanding work ethics relative to issue, improving leadership and entrepreneur ship skills.

Anyhow among different types of benefits that can be got from our internship host company Ethio telecom, the following are most important:-

- ✓ Improved Practical Skills
- ✓ Upgraded Theoretical Knowledge
- ✓ Upgraded Interpersonal Communication Skill
- ✓ Improved Team Playing Skills
- ✓ Improved Leadership Skills
- ✓ Understanding Work Ethics and Related Issues

3.1. Improved Practical Skills

By doing an internship, students join a new learning environment. They apply their theoretical knowledge to real practical applications. Interns in telecom companies are expected to understand how the technology works, the function of basic components, interconnection of different modules and the wiring schemes. During our stay in the training program, we have developed certain practical skills.

- We have gained basic knowledge regarding to what precautions to be taken when we touch or come closer to some equipment and the safety measurements that should be considered.
- We are able to understand how the telecom devices are interlinked together. Telecom devices are modular. So that, it is easy to maintain, replace and install the

components. Most telecom boards contain microprocessor units that control certain functions.

- We have seen different type of devices that are applicable in Ethio telecom; their physical appearances.
- We have developed understandings on how communication problems (failures) are identified remotely and how they are corrected. Some correction mechanisms are so risky that they can cost the lives of workers. Antenna men have ever died falling from towers when fixing antenna failures.

3.2 Upgraded Theoretical Knowledge

Internship lets the interns evaluate their priori knowledge based on the training. From their internship experience, students may gain new knowledge or they may update their previous knowledge so as to correct their theoretical misconceptions.

At the onset of our internship, we were pretty much confused. The equipment and their names, the acronyms used, and generally, the technologies implemented were new for us. This confusion let us know that we had to read more and spend a lot of time in digging out new concepts. It was easy to get more theoretical knowledge by asking our mentors. In a short period of time they could share what they developed in their longtime experience.

The theoretical knowledge we acquired in Ethio telecom is reinforcement to what we had developed in the university. We could grasp more knowledge on:

- How multiple users share telecom resources
- Different generations of mobile communications system
- Different telecom vendors and their products
- Types of networking technologies

3.3 Upgraded Interpersonal Communication Skills

Interpersonal communication skills are of vital importance in an organizational environment. Good communication skills enable people to interact in harmony. Communication is a means to share information, feelings and experience with other people.

The internship program played a crucial role in enhancing our communication skills. Our communication with officials of the company and co-workers improved through time. We developed the following major communication behaviors that are applied at workplace.

- Greeting others in a respectful manner; flavor interpersonal communication.
- Listening to the feelings of others before starting to speak to them.
- Speaking in an understandable way and in a plain language.
- Listening attentively to what others are saying.
- Trying to solve disagreements in a peaceful way.
- Saying goodbye in a respectful manner.

4.2Improved Team playing Skills

Teamwork is co-operation between those who are working on a task. Teamwork is generally understood as the willingness of a group of people to work together to achieve a common aim.We did our internship in a group of three students. It helped us realize that working in group has an advantage over working individually as different ideas may arise from different people in the team. These different ideas and suggestions can be evaluated and the best ones are considered. As a member of the team each student was expected to make the following activities.

- Actively participating in sharing information.
- Rising brainstorming topics and make broad group discussion.
- Forwarding suggestions to make the training environment better

3.5 Improved Leadership Skills

Leadership skills are an essential component in positioning executives to make thoughtful decisions about their organization's mission and goals, and properly allocate resources to achieve those directives. Valuable leadership skills include the ability to delegate, inspire and communicate effectively and fluently. Other leadership traits include honesty, confidence, commitment and creativity.During the internship period, we have met different workers of Ethio telecom and we observed their daily activities. It enabled us to understand the general behavior of workers. We tried to capture when workers can perform their tasks responsibly and with great satisfaction.From our stay experience, we dictate that a good leader has to keep in mind the following means of inspiring the workers to achieve the objectives of a company.

- A leader should be an exemplary to others in all traits.

- A leader should have good communication skills to inspire his/her workers.
- Incentives are important in motivating workers.
- Outstanding workers should be rewarded.
- Career improvement and salary increment are vital.
- Inviting workers for dinner at home in order to strengthen the relationship among themselves and with the leader.

3.6 Understanding Work Ethics and Related Issues

In our internship program we developed a lot of professional work ethics in order to success our goals. Generally the work ethics we developed are expressed as;

- Punctuality
- Honesty
- Reliability
- Responsible
- being loyal and honest when doing professional judgments on issues
- Cost vs benefit analysis
- Safety
- Quality when doing any project or assignment

Chapter Four

4. Conclusion and Recommendation

4.1 Conclusion

The history of the Ethio-telecom shows that it requires enormous resources and strong determination to build and operate an efficient and modern telecommunication infrastructure. For three months duration, we have been working in Ethio-telecom in North North West Region. The internship program can be seen as an introduction to the real world work, and gain field experience and knowledge that couldn't be attained from the theoretical concepts. The task gets further complicated from day to day as demand increases continuously and the system is timely updated & modified as world technology grows and new services are expected by the increasing number of users. It helps us to know about Ethio-telecom in detail such as services delivered, organizational structures, the technologies used such as microwaves, satellites and optical fibers, and also we gain some information about the generations of networks. Beyond Ethio telecom, this internship period played a great role in building our confidence for other workplaces. We have learnt how to act and communicate in workplace. We also grasped the concept of transmission of services (signals). The theoretical concepts that we were dealing with are practically implemented in Ethio telecom.

Completing this internship has various advantages, including the growth of strong teamwork abilities balanced with the exercise of individual responsibility. In addition to learning theoretical and applied knowledge, the workplace enables us to develop a variety of skills, including leadership, teamwork, and communication skills, entrepreneurship, and personal abilities.

In general, it expands our theoretical and practical knowledge, aids in our self-preparation for the demands of office job, and exposes us to the real world. Consequently, this internship program is offered in order to serve as a link between us and the world of work.

4.2 Recommendations

4.2.1 Recommendation to Ethio telecom

Ethio telecom as a hosting company has many limitations that hinders the training of the interns under it. During our internship period, we faced some problems in the company and based on that we greatly recommend the following solutions.

- Ethio telecom should announce the accepted intern's list as quick as possible. Because it poses a problem for those who haven't got acceptance in it.
- As Ethio telecom in NNWR is a huge company, it shouldn't fulfill infrastructures like chairs, computers, and services like Wi-Fi to host interns in a good way.
- During the training, Ethio telecom as a huge company should assign technicians for interns to have a practical work, but shouldn't have a full prepared manual that guides the interns during the period.
- Ethio telecom has its own period for internship that is not consistent with our university period. Hence, we recommend Ethio telecom to host its period on the time consistent with the university.

4.2.2.Recommendation to Our Faculty and UIL

- During the apparent period of time as huge organization DTU have not paid cost share at the exact time .

Abstract

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. The fourth generation mobile networks are being developed with the aim to overcome the shortcomings and limitations of third generation, one is the issue of available bandwidth. The third generation specifications have been defined to offer maximum bandwidths of 2 Mbps. However, fourth generation mobile networks offer higher bandwidths, up to a value of 100 Mbps. Besides the bandwidth limitation of third generation, other shortcomings of third generation are related to the issue of global roaming and network scalability. Our work will focus on planning and dimensioning of fourth generation radio network by using Atoll planning software by taking Gonder city as case study. The planning process aims to maximize the coverage and the quality of service and allow the maximum number of users sending and receiving adequate signal strength in a cell signal level ≥ -70 dBm it shows better signal and the signal level>-105 dBm that shows the poor coverage signal on the target area , overlapping b/n each sites and there transmitter of signals .

Keywords: planning and dimensioning, long term evolution, digital Mapping, atoll software

Part Two

Internship Project

Chapter Five

5. Planning and Dimensioning of LTE Network For Gondar City ATOLL soft ware

Introduction

The rapid growth of technologies and mobile communications has contributed to the improvement of our daily lives. 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[1]. For this reason, the 3rd Generation Partnership Project, 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 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 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 [2]. These and other significant performance achievements rely on recently introduced physical layer technologies, such as Orthogonal Frequency Division Multiplexing, Multiple-Input Multiple-Output 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 and straightforward planning and deployment approaches were basically achieved [3] [4]. 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.

5.1 Background of LTE

LTE, commonly known as 4G ,LTE is a standard given for wireless communication of high-speed data for mobile phones and data terminals. Initially the 4G technology commercially introduced in two forms as Mobile WiMAX standard (in 2006 in South Korea) and Long-Term Evolution standard (in 2009 in Oslo, Norway)[5]. Mobile WiMAX or LTE was not available to all continents with same year of its invention due to the different frequency bands, but the starting point for this standard was the workshop held in November 2004 for 3GPP RAN evolution in Toronto Canada. The study was started one month later, in December 2004, with the objective of developing a framework for the evolution of the 3GPP Radio Access Network with the intention of reducing cost per bit, increased service provisioning, flexible use of new and existing frequency bands, reasonable terminal power consumption, and simplified architecture with open interfaces. Here in Ethiopia Ethio telecom has launched the Fourth-Generation service on 21 March 2012 in line with the help of the Chinese company HUAWEI[6].

5.1.1 LTE Architecture

LTE is the evolution of the radio access Universal Mobile Telecommunications System known as Evolved UTRAN, whereas the evolution of the non-radio part including the Evolved Packet Core network[7].

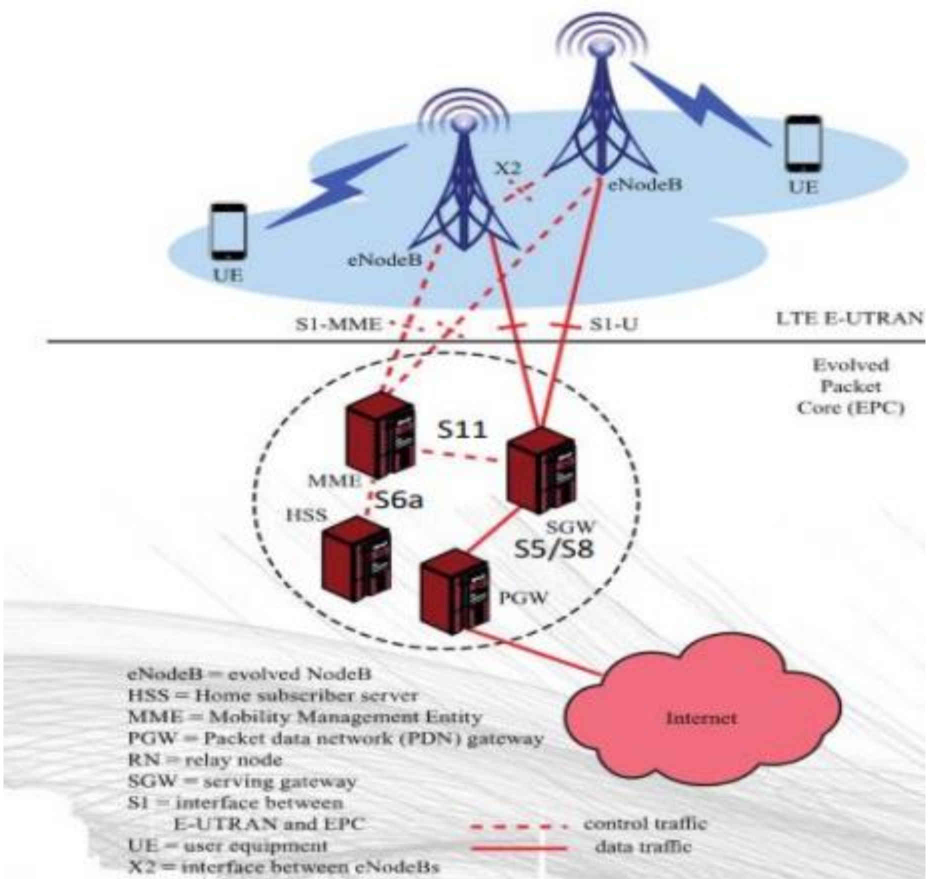

Figure 5. 1 LTE Network Architecture

EPC Components

A. Mobility Management Entity: Supports user equipment context, identity, authentication, and authorization. It mainly performs Non-Access Stratum procedures, which consist of two main groups[12].

B. Serving Gateway: Receives and sends packets between the eNodeB and the core network. It Perform packet routing and forwarding within EPC. It is Anchor point for intra LTE-mobility.

C. Packet Data Network Gateway: Connects the EPC with external networks. Is a router that performs UE IP assignment, per user packet filtering. Anchor point for mobility with non 3GPP access network.

D. Home Subscriber Server: Database of user-related and subscriber-related information. Is Similar to HLR in GSM architecture.

S1: Interface between the E-UTRAN and the EPC. For both control purposes (connect MME to eNodeB) and for user plane data traffic (connect SGW to eNodeB)

S5/S8: Connects MME with PGW

S11: Connects SGW with MME network was first called the System Architecture Evolution.

S6: currently referred to as S6a connects the MME and the HSS.

E-UTRAN: Mainly consist of eNodeB and user equipment.

X2 Interface: The E-UTRAN architecture consists of a network of eNodeBs that are interconnected with each other by this interface.

UE: it is any device used by an end user such as a smart phone or other mobile device, laptop, or tablet equipped with a mobile broadband adapter.

eNodeB: Are used to connect the User Equipment to the network. It is the only logical node in the E-UTRAN.

MME: Supports user equipment context, identity, authentication, and authorization

5.1.2 Specification comparison of 3G&4G

Table 1 comparison of 3G&4G

Specifications	3G	4G
Frequency band	1.8-2.5 GHZ	2.8-8 GHZ
Band width	5-20MHZ	5-20MHZ
Date rate	Up to 2Mbps	20Mbps
Access	Wideband CDMA	Multi-carrier-CDMA or OFDM(TDMA)
Peak download rate	100Mbits	1Gbit/s
Data through put	Up to 3.1mbps	3to5mbps but potential estimated at a range of 10to 300mbps
Frequency band	1.8-2.5 GHZ	2-8 GHZ
Service and application	CDMA 2000, UMTS, EDGE etc	Wimax2 and LTE –Advance
Network architecture	Wide area cell based	Integration of wireless LAN and Wide area
Peak upload rate	50Mbits/s	50Mbits/s
Switching	Circuit/packet switching	Packet switching

5.1.2 Features Provided by 4G

The main features of 4G services which are of interest to users are application adaptability and high dynamism users' traffic, radio environment, air interfaces and quality of services.

- Support for interactive media, voice and video streaming, gaming, internet and other broadband services.
- IP based mobile system.
- High speed, high capacity and low cost per bit.
- Global access, service portability and scaling mobile services.
- Avoidance of congestion.
- Seamless network of multiple protocols. Since 4G will all IP, it will be compatible with all common network technologies.
- Infrastructure to handle pre-existing 3G systems, along with other analog wireless technologies

5.1.3 Advantage of LTE

- Reduced delays for both connection establishment and transmission latency.
- Increase user data throughput.
- Increased cell edge bit rate.
- Minimized cost per bit employing enhanced spectral efficiency.
- Simplified network architecture.
- Seamless mobility including between different radio access technology.
- Reasonable power consumption for the mobile device.
- Minimizes equipment cost as it abolishes need of costly frequency equalizer at receiver.
- It provides integral security server.

5.2 Problem statement

Due the increasing usage of smart devices in the city, mobile users are demanding to use the data service all over the places. To meet this ever-increasing demand, recently Ethio Telecom has made telecom infrastructures expansion for the existing 2G & 3G networks and introduces a new LTE network. In Gonder city there is currently national higher meetings, conferences, national festivals and building markets, tourism, private and government buildings, hotels and lodges. Related to this the subscribers that enter the city are increasing hence adding to the existing 3G network's poor quality of data services in addition to voice coverage limitation and QoS problem. To solve these data and voice capacity, quality and coverage limitations for Gonder city, we are going to plan and dimension LTE network to give multi service technology and also to minimize investment cost on the existing network infrastructure that can be integrated to the new LTE technology.

5.3 Objective

5.3.1 General Objective

.Planning and Dimensioning of LTE network for Gondar city using atoll software

5.3.2 Specific Objective

- ❖ Simulating the LTE planning using ATOLL commercial software.
- ❖ To measure the optimal performance of LTE

5.4 Methodology of the project

The methodology we have followed during the development of this paper which starts from the project title selection up to the complete thesis submission is presented in the following section diagrammatically.

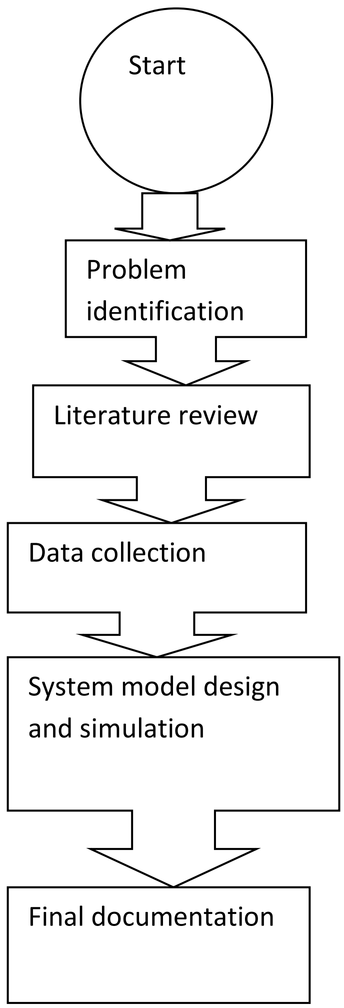

Figure 5. 2 methodology of the project

5.6 Scope and limitation

5.6.1 Scope of the project

This project covers the software part at which that we develop the system design using Atoll software.

5.6.2 Limitation of the project

The LTE planning in this project is done by using assumptionof simulation. Thus, the actual on sites conditions and issues related to land are not taken to consideration.

5.6.3 Significance of the project

- Increase user data throughput.
- Increased cell edge bit rate
- Simplified network architecture

Chapter Six

Literature Review

There have been several works done on the area of GSM, UMTS and LTE dimensioning and planning. Some of the recently published articles related to this work and we took as a reference are reviewed as follows:

Abdul Basit, Seid "Dimensioning of LTE Network," 2009.The dimensioning of LTE radio access networks presented in [5]. This thesis covers coverage and capacity estimation in radio network dimensioning. Radio link budget is used to investigate coverage planning. Theoretical work is put for into the development of an excel based dimensioning tool which is designed to keep the interface simple and to set the functional parts clearly distinguishable. The final thesis result gives the number of sites required in order to support a certain subscriber with a given capacity, but the thesis has not taken the full spectrum capacity for all subscribers within the area.

Betelehem Seifu, "LTE Radio NETWORK planning, Modelling Approches for the case of addisababa," 2012.LTE radio network planning by considering Addis Ababa as a case study presented in[6]. The ultimate target of this work is to give a good understanding of LTE radio network planning in order to improve the existing network deployment. The study addressed the LTE radio network planning to do coverage estimation, capacity evaluation and frequency planning.

Bekele Mulu "LET Radio Network Planning modeling approches for case the case of Bahir dar city," in 2012. LTE radio network planning modelling approaches for the case of Bahir Dar city [7]. It covers LTE radio Network dimensioning and planning, but the final site layout and simulations is done future development but its traffic analysis is only considered current population.

Marwa Elbagir Mohammed & Khalid Hamid Bilal, 2012: LTE Radio Planning Using Atoll Radio Planning and Optimization Software”,[8] International Journal of Science and Research. They carried out coverage and capacity estimation in radio network dimensioning. Radio link budget is investigated for coverage planning.

Anteneh Temesgen, 2015: WCDMA Radio Network Dimensioning and Planning for the case of Bahir Dar City [13]. He covers WCDMA radio coverage and capacity dimensioning and planning.He took demographic data for capacity estimation and he considered cell load and calculated throughput in detail for capacity dimensioning.

There are also literature that deal with 2G, 3G and 4G, but the above we mentioned are the literatures that helps us in planning this 4G network.

Chapter Seven

System Design and Parameter

7.1 System design

The design process for any wireless system could have some common steps that will be followed during the planning and design for the LTE network, the design process can be shown as:

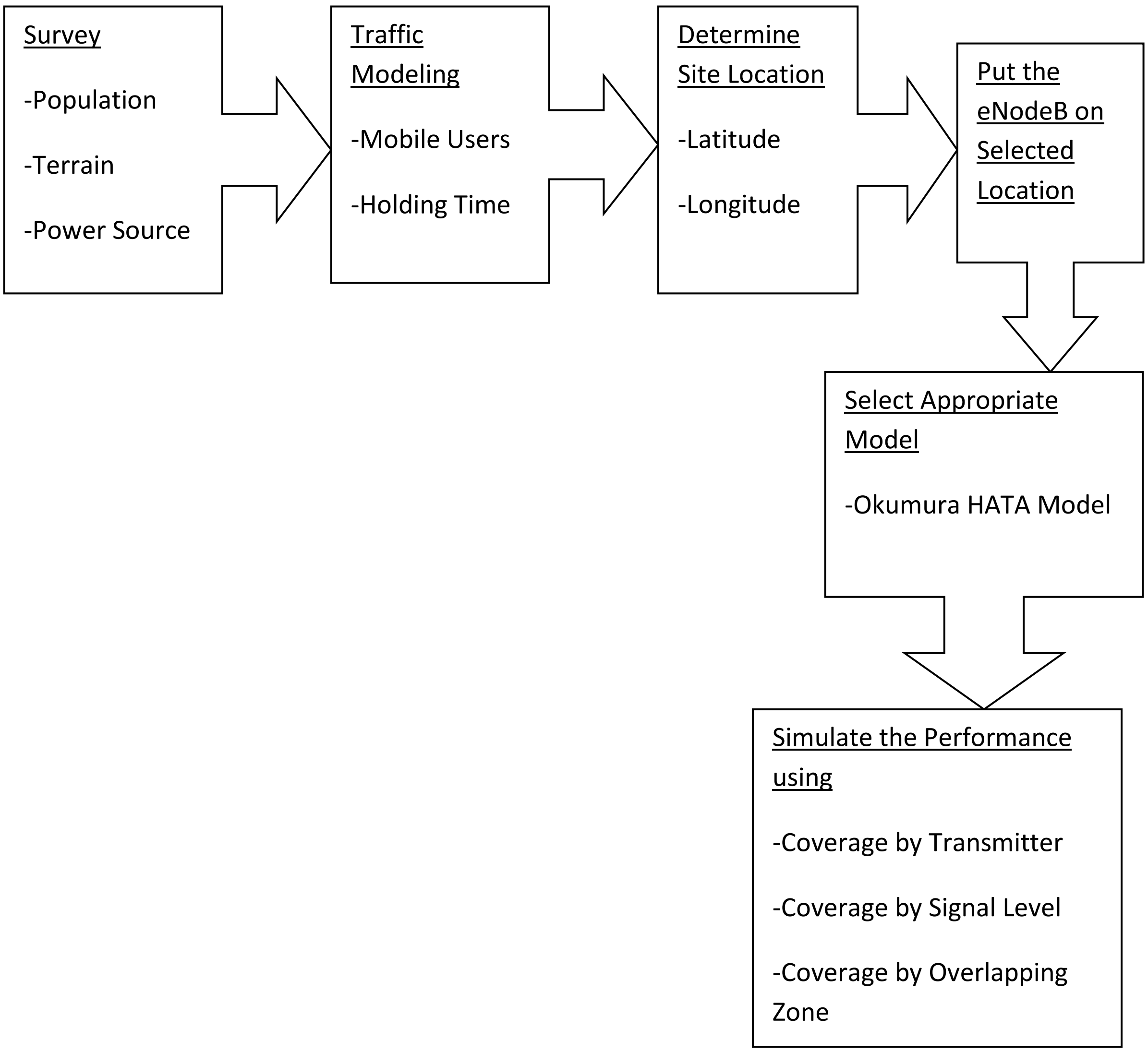

Figure 7. 1 System Design

1.survey: In this stage the population of the city that we have taken should be considered. The next thing that we should have to consider is the power source. The area at which we are going to deploy the base station must have enough power source.

2.Traffic modeling: Number of mobile users, holding time and calling frequency should be considered in this stage.

A. Mobile users: A smart phone or tablet user, a traveling user with a laptop computer.

B. Holding time: Average call duration in seconds, denoted by H Depends on users and operator's tariff.

C. Calling frequency: Average number of calls per unit time, denoted λ seconds-1.Typically taken to be at the busiest time of day.Depends on type of user’s community like Office, residential, call center.

3.Determine site location and select the model: purpose of site selection is to select a site that can cover the target area and has the lowest interference to another site.

Principles of site selection

- The position of a new site should be place with convenient power supply.
- when the site is near the lake, sea, in a mountain or building with glass wall, the effect of signal reflection should be considered.
- The site should not be built besides broadcasting station or other interference source.Site Selection in dense urban area
- The antenna should be lower than the average height of buildings in the area.
- The antenna should not be blocked by any nearby building.
- The antenna should be installed at the edge of the building.Site selection in urban area
- The antenna should be slightly higher than the average building in the area.
- Line of sight links may exist in the most portion of the area covered by the BS.Site Selection in the suburb

- The antenna should be 5m to 10m higher than the average building in the area.

- Line of sight links should be available in the most portion of the area covered by the BS.
- Only some line of sight links crosses the cell boarder

This is all about the theoretic location, latitude & longitude and other parameter of sites. Based on this theoretic location of sites, a sites survey activity will be carried out to confirm site location, site type & location, antenna type, height, direction angle.

4. Set base transceiver station on selected location: Once the area where we want to place the series of stations is drawn on the digital map of assumption of Gondar city, we can set the base transceiver station.

5. Select appropriate model: in wireless cellular communications system information is transmitted by using electromagnetic waves between transmit and receive antennas. Theelectromagnetic waves signal strength difference from transmitter antenna to receiver antenna is called Path Loss.

A good coverage planning requires appropriate selection of path loss model. In order to determine the PL models are used. Propagation model Okumura-Hata's considered in this work to predict path loss between the transmitter and receiver.

Okumura-Hata Model: is used for the frequency range of 150 MHz to 1500 MHz to predict the path loss for the distance d from transmitter to receiver antenna up to 20 km, and transmitter antenna height (BTS antenna height) is considered 30 m to 200 m and receiver antenna height is 1 m to 10 m. PL predictions based on Okumur-Hata can be done by using the following formula:

$$PL = A + B\log(f) - 13.82\log(h_{bs}) - \alpha(h_m) + [44.9 - 6.55\log(h_{bs})]\log(d) + L_o \quad \ldots\ldots\ldots\ldots\ldots (7.1)$$

Path loss for urban clutter

$$LP(urban) = 69.55 + 26.16\log(f) - 13.82\log(h_{bs}) - \alpha(h_m) + (44.9 - 6.55\log(h_{bs}))\log(d) \quad \ldots\ldots\ldots\ldots (7.2)$$

Where, f is frequency in MHz, hbs is the BTS antenna height in meter (m), α(hm) is a function of the mobile station antenna height(hm).The distance between the BTS and MS Is given by d in kilometer(km) and Lo give the attenuation due to land usage classes.α(hm) has different values depend on the size of the area given by the general formula as:

For small/Medium-sized city:

$\alpha(hm)=(1.1\log(fc)-0.7)\,hm-(1.56\log(fc)-0.8)$ ……………………………………..(7.2a)

For large-sized city:

$\alpha(hm)=8.25[\log(1.54hm)]^2-1.1$, for $f_c \leq 200MHz$ ……………………………….. (7.2b)

$\alpha(hm)=3.2[\log(11.75hm)]^2-4.97$, for $fc \geq 200MHz$ …………………………… (7.2c)

The constants A&B varies with frequencies:

For 150-1000MHz, A=69.55, B=26.16

For 1000-2000MHz, A=46.3 and B=33.9

The models for dense urban, urban and suburban areas result different path loss. The size of the city is classified during the survey work.

6. Simulate the performance using Atoll simulation software: coverage signal level, path loss and signal interference ratio are some of the performance parameters used to evaluate the work[8].

7.2 Parameters

7.2.1 Parameters in coverage planning

Coverage estimation is used to determine the required base station and the maximum area that can be covered by a base station. Coverage planning is done by evaluating the DL and UL radio link budget to get the maximum allowable pathloss based on the required Signal-to-Interference level at the receiver and by putting interference into consideration. Both downlink and uplink

MAPL used to calculate the cell radius for different morphologies based on the appropriate propagation model for the deployment area. The effective cell radius must be taken into account to determine the cell area and the total sites count[9].

A. Radio link budget parameters and formulas

The objective of the RLB is to identify the MAPL between the transmitter and receiver for both the UL and DL direction. By comparing the MAPL with the PL of the appropriate propagation model, the cell radius can be calculated for different terrain morphologies. The RLB considers many factors that affect the final cell coverage. These factors include building penetration loss, feeder loss, antenna gain, and the interference margin of radio links to calculate all gains and losses. The main parameters to calculate MAPL are:

- Maximum Total Transmitter power: Refers to transmit power value per transmitting path. Typical value is either 43dBm (20W) or 46dBm (40W).
- UE Maximum Total Transmitter power: It refers to the UE transmit power which depends on the power class of the UE. Currently only one power class is defined in 3GPP TS 36.101; class 3 with maximum transmitter power of 23 dBm.
- eNodeB Antenna Gain: The selection of antenna gain depends on clutter type and coverage requirement. The low gain antenna (15-17dBi) can be used in dense urban and urban clutters while a high gain antenna (18-20dBi) can be used in rural areas and high ways to extend the RF coverage.
- UE Antenna Gain: Based on the specifications of 3GPP, UE(s) are assumed to have an integral antenna only with a gain of 0dBi for each antenna port(s).
- Body Loss (dBm): occurs at the user's equipment side. It is a loss generated due to signal blocking and absorption, when UE antenna is close to body of user. Its value depends on usage habit of the user. In the link budget calculation, the default setting of body loss is 3dB for speech service and 0dB for data services.
- Feeder Loss (cable loss): feeder loss considers the loss due to RF feeder, RF jumpers and connectors in the path between the antenna and the eNodeB. In a distributed eNodeB the

typical value of feeder loss is 0.5dB. On the other hand, if eNodeB is not distributed type feeder loss may be 3dB or more according to the feeder and its connector's characteristics.

- Receiver Sensitivity: Receiver sensitivity determines the signal level at which the RF signal can be detected with a certain quality. It refers to the antenna connector and should take into account the further demodulation and the required output signal quality. The receiver sensitivity per subcarrier can be calculated as follows:

Rxs(sc)=SINR+NF+NP+10Log(sc)…………………….(7.2)

Where SINR is the threshold of the receiver that can demodulate the signal, NP is the density of the thermal white noise power which is - 174 dBm/Hz, SC is the subcarrier and is 15 KHz in LTE, and NF is the noise figure in dB.

- SINR: Is commonly used in wireless communication as a way to measure the quality of wireless connection. These can be determined by,

$$\text{SINR}=\frac{P}{1+\text{N}}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(7.3)$$

Where P Is the power of incoming signal of interest, I is the interference power of the other (interfering signals), and N is some noise term.

- Noise Figure: It is a key factor to measure the receiver performance it is defined as the ratio of the input SINR at the input end to the output SINR at the output end of receiver. It depends on the capability of eNodeB capability. Atypical value of noise figure is between 6 to 8 dB.

$$\text{F}=\frac{S_i/S_0}{N_i/N_0} \text{ and NF=10logF}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(7.4)$$

- Penetration Loss: Indicates the fading of radio signals due to building obstruction from an indoor terminal to the eNodeB and vice versa. It depends on the nature of the buildings and the clutter type of the targeted coverage area. For dense urban clutter type the penetration loss varies in between 19 and 25 but its typical value is 19.and its is 15 for urban, 14 for sub urban, and 8 for rural area.

- Minimum Signal Reception Strength: can be formulated by adding the receiver side losses such as body loss, cable loss, interference margin, receiver sensitivity and subtracting the antenna gain. It is calculated by the equation

Minimum Signal reception Strength= RS + IM + LRS – GRX …………….(7.5)

Where: RS =Receiver Sensitivity (dB), IM = Interference Margin (dB),

LRX =Reception losses (connector, cables and body) (dB),

GRX = Reception Gain (dB)(receiver antenna gain).

- Equivalent isotropic radiated power: Is obtained by adding the gain to the power emitted by the transmitter and subtracting the losses due to cable, connector and the human body.

The equation of the EIRP is given by:

EIRP=D+AGeNB-F……………………………………. (7.6)

Where A is maximum transmitter power, D is subcarrier power=A-10log(c),C is subcarrier to distributed power=12*B, B is RB to distributed power, and PUE(SC) are power per subscriber in DL and UL respectively, AGeNB is the eNodeB antenna gain, CL is feeder loss(cable loss).

Shadow Fading Margin: Indicates the fading due to obstruction like building. Shadow fading changes slowly, and is thus called “slow fading”. Statistics repeatedly show that the median levels of received signals follow log-normal distribution with the time and location at a certain distance. Fading caused by location mainly from obstruction far exceeds fading caused by time. Therefore, the major concern for shadow fading is those caused by location changes.

Table 2 LTE Link Budget UL and DL Parameter

Parameter	formula
Transmitter (eNodeB)side link budget parameter	
Max total Tx power(dBm)	A
RB to distribute power	B
Subcarriers to distribute power	C=12*B
Subcarriers power(dBm)	D=A-Log(C)
Tx antenna gain (dBi)	E
Tx cable loss (dB)	F
EIRP per subcarrier(dBm)	G=D+E-F
Receiver (UE/eNodeB)side link budget parameter	
SINR(dB)	H
Rx noise figure(dB)	I
Receiver sensitivity(dBm)	J=H+I-174+10*Log_{10}(15KHZ)
Receiver antenna gain(dBi)	K
Receiver cable loss(dB)	L
Receiver body loss(dB)	M
Interference margin	N
Min signal reception strength (dBm)	O=J-K+L+M+N
Path loss and shadow fading margin	
Penetration loss(dB)	P
Shadow fading margin	Q
Maximum allowable path loss(MAPL)	
MPL(dB)	R=G-O-P-Q

B. Cell Area and Site Count

Once the MAPL value is calculated for both UL and DL based on Table 3, the next step in the coverage planning is to determine the cell radius by using the appropriate propagation model.

With the assumption that cell coverage area as being hexagonal in shape, the cell area can be calculated using the cell radius found from the MAPL.

Cell area depends on the site configuration. It can be omni -directional, 2-sector, or 3-sector sites and thus the cell radius is calculated for each configuration.

Site coverage Area for Omni Site:

$$A=\frac{3\sqrt{3}*R^2}{2} \quad (7.7)$$

Site coverage Area for two sector Site:

$$A=\sqrt{3}*R^2 \quad (7.8)$$

Site coverage Area for three sector Site:

$$A=\frac{9\sqrt{3}*R^2}{8} \quad (7.9)$$

Finally, the site count based on coverage is calculated:

$$\text{Total number of site} = \frac{\text{Target area to be covered}}{\text{site area}} \quad (7.10)$$

7.2.2 Parameters in Capacity Planning

Capacity planning deals with the ability of the network to provide services to the users with a desired level of quality[10]. After the site coverage area is calculated using coverage estimation, capacity related issues are analyzed. The evaluation of capacity needs two tasks to complete the estimation which are:

- Throughput estimation corresponding to the configuration analysis;
- Estimating the supported subscriber per cell or sites depending on the traffic model.

Given that the required total subscriber capacity is known, which can be a forecasted subscriber, capacity-based sites counts will be determined to know the total traffic demand in the network.

A.Trunking and Grade of Service

Cellular systems rely on trunking to accommodate a large number of users in a limited radio spectrum. The concept of trunking allows a large number of users to share the relatively small number of channels in a cell by providing access to each user, from a pool of available channels. In a trunked radio system, each user is allocated a channel on a per call basis, and upon termination of the call, the previously occupied channel is immediately returned to the pool of available channels. In a trunked mobile radio system, when a particular user requests service and all of the radio channels are already in use, the user is blocked, or denied access to the system.

Grade of service: Measure of congestion (or ability of a user to access a trunked system) during the busiest hour. Given as likelihood that a call is blocked, called Erlang B or the likelihood of a call experiencing a delay greater than a certain amount of time, called Erlang C. When a call is offered (requested) but all channels are full then Blocked calls will be cleared (Offers no queuing for call requests) Erlang B or the Blocked calls will be delayed Erlang c.

Blocked calls cleared: There is Memoryless arrivals of requests I.e., all users, including blocked users, may request a channel at any time. The probability of a call durations (or a user occupying a channel) is exponentially distributed I.e., longer calls are less likely to occur. This occurs when there are “infinite number of users” and “finite channels”.

$$A = UA_u \qquad (7.11)$$

Where U is number of users, A is total offered traffic intensity for U user, Au an average traffic intensity offered (generated) by each user.Rather than a finite number U of users each requesting Au traffic, set the total offered traffic as a constant A, and then let $U \rightarrow \infty$ and $A_u \rightarrow 0$ in a way that preserves $A = UA_u$.

These assumptions lead to the Erlang B formula also known as the “blocked calls cleared form”.The probability of an arriving call being blocked is:

Erlang B: is used to calculate how many lines are required from a knowledge of the traffic figure during the busiest hour. The Erlang B figure assumes that any blocked calls are cleared immediately. This is the most commonly used figure to be used in any telecommunications capacity calculations.

B. Frequency Reuse: Is the scheme in which allocation and reuse of channels throughout a coverage region is done. Each cellular base station is allocated a group of radio channels or Frequency sub-bands to be used within a small geographic area known as a cell. The shape of the cell is Hexagonal. The process of selecting and allocating the frequency sub-bands for all of the cellular base station within a system is called Frequency reuse or Frequency Planning.Silent Features of using Frequency Reuse:

- Frequency reuse improve the spectral efficiency and signal Quality (QoS).
- Frequency reuse classical scheme offers a protection against interference.
- In Frequency Reuse scheme, total bandwidth is divided into different sub-bands that are used by cells.

A.Traffic Modeling

In Ethiopiaethio telecom uses 0.02 erlang individual traffic intensity for medium cities like

Bahir Dar, so we used it as an input and design our average individual traffic intensity. Average traffic intensity offered (generated) by each individual user (in erlang) is:

$Av=H*\lambda$ ……………………………………………………… (7.12)

Where: λ is average arrival rate: average number of UEs requesting service (call request/time), and H is average holding time (average duration of a call or time for which UE requires service).

In this work design we used erlang B Channel allocations for cells and 1% grade of service for voice traffic modeling. Grad of service is a measure of the ability of a user to access the trunked.

system at the busiest hour. So, we can use it as an input and calculate individual voice traffic intensity in erlang. Our assumption here is that based on Ethio telecom existing 0.02 erlang traffic intensity for Gondar as standard, so that in our design a user makes on average one call per hour, and that a call lasts an average of 90 seconds based on Ethio Telecom existing network voice traffic model. Individual voice traffic intensity:

Av=1call/3600second*90second/call

Av =0.025 erlang.

B. Average Sector/Cell Throughput calculation

The average sector/cell throughput is an important factor in the LTE capacity dimensioning. There are three approaches which can be used to get the average sector throughputs in LTE which are Vendor's Approach, Simulation-based Approach, and Based on the available Traffic Channel RB. From this we used vendor's approach. Once the eNodeB throughput is known, the maximum subscriber supported per eNodeB can be estimated by assuming the data volume of each subscriber per month and their throughput during busy hour. A simplified calculation of this approach is shown in the Table.

Table 3 Capacity based sites count based on vendor's approach

Parameter	Variable	Remark
Data volume/ month/subscriber	a	Given by the operator
Days /month	b	30 days
Busy hour to whole day traffic (%)	c	Given by the operator
Busy hour throughput /subscriber(Kbps)	d	d=(((a*8*10^6)/b)*c)/3600
Average enodeB throughput(Mbps)	e	Given by the vendor
Maximum subscriber supported per enodeB	f	f=(e*1000)/d
Total subscriber	g	Given by the operator
EnodeB required	h	h=g/f

- Determine the available RB for PDSCH:

Available RBPDSCH=TotalRB- Fixedoverhead- control_CHoverhaead- Pagging_CHoverhead.. (7.13)

- Calculate the available symbols for PDSCH

Available symbol=Available RBPDSCH*NSCRB-NSYSC …………………………… (7.14)

Total PDSCH throughput capacity per sector carrier

Total through put=AvailableSymbol*Spectral efficiency ………………………. …………(7.15)

Where: Available RBPDSCH is the available RB for PDSCH by subtracting the overhead from the total RB. Availablesymbol is the available symbol, NSCRB is the number of subcarriers per RB=12,

NSYSC is the number of symbols per subcarrier (6 or 7) thus the average through put, in Mbps at a certain DL loading can be calculated as:

Average_Sthroughput=[Available RBPDSCH*DLloading* Totalthroughput]/1000 … (7.16)

After the cell throughput is calculated by the above formula, the capacity-based sites count can be calculated by using Table 3.

C. Capacity Based Sites Count

The capacity-based sites count can be calculated using:

$$\text{Capacity based sites count} = \frac{\text{Total subscriber supported in the network}}{\text{subscriber supported per site}}$$

Chapter Eight

Simulation Result Analysis and Discussion

8.1 Overview

By using chapter 7 as guidance in this chapter the actual planning and dimensioning will be performed. The chapter starts by defining the target network requirements and continue to show all the required input and output for both coverage and capacity planning. The coverage-based sites count will be calculated using RLB and considering capacity requirement of the target network, the site count based on the capacity will be calculated, finally the maximum of the two will be taken as the final sites count for the target area and parameters will be simulated by using atoll software[11].

8.2 Coverage Analysis

Table 4 LTE Link Budget DL Parameters

parameters	Formulas	
Transmitter (eNodeB/UE) side link budget parameters		
Max total Tx power(dBm)	A	46
RB to distribute power	B	100
Subcarrier to distribute power	C=12*B	1200
Subcarriers power(dBm)	D=A-10log(c)	15.21
Tx Antenna gain(dBi)	E	17
Tx cable loss(dB)	F	0.5
Tx body loss(dB)	S	0
EIRP per subcarrier (dBm)	G=D+E-F-S	31.71
Receiver (UE/eNodeB) side link budget parameter		
SINR (dB)	H	-3.06
Rx noise figure(dB)	I	8
Receiver sensitivity(dBm)	J=H+I-174+10log10$^{(15KHZ)}$	-127.30
Rx antenna gain(dBi)	K	0
Rx cable loss(dB)	L	0
Rx body loss(dB)	M	3
Interference margin	N	3
Min signal Reception strength(dBm)	O=J-K+L+M+N	-121.30
Path loss and shadow fading margin		
Penetration loss (dB)	P	20
Shadow fading margin	Q	9.34
Max allowable path loss(MABL)		
MABL (dB)	R=G-O-P-Q	123.66

Table 5 LTE Link Budget UL Parameters

Parameters	formulas	
Transmirret(eNodeB) side link budget paramiters	A	23
Max total Tx power(dBm)	B	3
RB to distribute power	C=12*B	36
Subcarriers to distribute power	D=A-10log(c)	7.44
Subcarriers power(dBm)	E	0
Tx Antenna(dBi)	F	0
Tx cable loss(dB)	S	3
Tx body loss(dB)	G=D+E-F-S	4.44
EIRP per subcarriers(dBm)		
Reciever (UE/eNodeB) side link budget parameters		
SINR(dB)	H	-1.83
Rx noise figure(dB)	I	2.3
Receiver sensitivity(dBm)	$J=H+I-174+log10^{(15KHZ)}$	-131.77
Rx Antenna Gain(dBi)	K	17
Rx cable loss(dB)	L	0.5
Rx Body loss(dB)	M	0
Interference margin	N	3
Min signal Reception strength(dBm)	O=J-K+L+M+N	-145.27
Path loss and shadow fading margin		
Pentration loss(dB)	P	19
Shadow fading margin	Q	9.34
Maximum allowable path loss(MABL)		
MABL(dB)	R=G-O-P-Q	121.37

8.2.1 Coverage Based Sites Count

Using the selected propagation model and the UL and DL MAPL, we can calculate the cell radius governed by both the UL and DL path. Let us consider the eNodeB and UE antenna height to be 30m and 1.5m respectively. The cell radius in the UL path, and the cell radius in DL path, dDL can be calculated by using Okumura Hata model.

Let hbs=30m, fc=1000Mhz, hm=2m

LP (urban)for downlink=46.3.55+33.9log(f)-13.82log(hbs) - α(hm) +(44.9-6.55log(hbs)) log(d)

Where a(hm) for medium size city= (1.1log(fc)-0.7) hm-(1.56log(fc)-0.8)

= (1.1log (1000)-0.7)2-(1.56log (1000)-0.8)

=1.32

123.66-69.55-26.16log (1000) +13.82log (30) +a(hm)= (44.9-6.55log(hbs)) log(d)

-5.31=35.22(log(d))

d=$10^{-0.1507}$ =0.706km

LP (urban)for uplink=46.3+33.9log(f)-13.82log(hbs) - α(hm) +(44.9-6.55log(hbs)) log(d)

Where a(hm) for medium size city= (1.1log(fc)-0.7) hm-1.56log(fc)-0.8

= (1.1log (1000)-0.7)30-(1.56log (1000)-0.8)

=1.32

121.37-69.55-26.16log (1000) +13.82log (2) +a(hm)= (44.9-6.55log(hbs)) log(d)

-7.6=35.22(log(d))

d=$10^{-0.2157}$=0.608km

Determine the appropriate cell radius by balancing the DL and UL radiuses. Normally the minimum of the maximum path losses in UL and DL directions is converted into cell radius i.e.minimum of the radii is used as cell radius Since the cell with minimum radius is chosen, the cell radius will be 0.608km then Calculate the site coverage area and the required sites number.

Site coverage Area for three sector Site = $9/8[3]^{1/2} R^2$

$= 1.948[0.608]^2$

$=0.721km^2$

Considering coverage of densely populated area around center of Gonder city $192.3km^2$

The Total number of sites to cover this area is:

Number of site=Area to be covered/site area

$=192.3km^2/0.721km^2$

$=267$

8.3 Capacity analysis

The capacity planning can be started by estimating the daily traffic as a percentage of the busy hour traffic. The busy hour assumed to be in different three-time segment within the 24 hours of a day. The first segment is from 10:00 AM to 11:00 AM in the morning, the second segment is from 3:00 PM to 4:00 PM in the afternoon, and the third segment is assumed to be from 8:00PM to 09:00PM in the evening. Thus, a total of 3 hours is considered to be the busy hours within 24 hours of a day, which makes the busy hour traffic to be 12.5% of the daily traffic.

A.Data volume/Month/Subscriber

From the given target network requirement, the three service categories, are used in the data volume per month per subscriber. a category couldn’t utilize all the 100% service throughout all the time, thus service usage distribution is required and assumed to be 10%, 40%, 50% for Gold, Silver, and Bronze users respectively as shown the Table 5.

Table 6 Users service usage category

Parameters description	User service category		
	gold	Silver	bronze
Data volume per month per subscriber(GB)	20	15	10
Service usage(%)	10	40	50

B. Average eNodeB throughput (Mbps)

Let us a channel bandwidth of 20 MHZ and, and by assuming the available RB for PDSCH as 85% with 80% downlink loading and an average spectral efficiency of 2.8, Number of subscribers per RB=12, Number of symbol =6, the average sector throughput according to equation 6.15 can be calculated as follows:

Average sector throughput (Mbps)= available PDSCH RB%*DL loading% *average spectral efficiency *number of subscriber per RB* twice the number of symbols*number of total RB/1000

=0.80*1*2.8*12*12*100/1000

=32.25 Mbps

Therefore, for a three sector with 20 MHz channel bandwidth, the average eNodeB throughput can be found by multiplying the above average sector throughput by three. Thus, the average eNodeB throughput for this particular case will be 3×32.25 Mbps = 96.76Mbps≅97 Mbps.

A.Capacity Based Site Count

By taking the values of the user’s service category from Table 6 and the average eNodeB throughput of 97Mbps, the maximum subscriber supported per eNodeB can be calculated by using the formula given in Table 3 of chapter 7.

Table 7 Maximum subscribers supported per eNodeB

parameter	User services category			Remarks
	Gold	Silver	Bronze	
Data volume per month per subscribers(GB)	20	15	10	A
Days per months	30			B
Traffic Ratio of busy Hour to whole day(%)	12.5			C
Busy hour throughput per subscriber (kbps)	185.19	139.89	92.59	D=(((A*8*10^6)/B)*C)/3600
Service usage (%)	10	40	50	P
Total average busy hour throughput per subscriber(kbps)	120.37			T=sum of {package percentage(P)*busy hour throughput per subscriber
Average eNodeB throughput for 20MHz(Mbps)	97			E
Max. subscriber supported per eNodeB	806			F=(e*1000)/T

From the above Table, a total of 806 subscribers can be supported per eNodeB. Thus the number ofeNodeBs required to accommodate the given total number of subscriber cab be calculated by using Equation be calculated by using Equation 7.16.

$$\text{Capacity based sites count} = \frac{\text{Total subscriber supported in the network}}{\text{subscriber supported per site}}$$

=155,428/806=193eNodeBs

Thus, a total of 193eNodeB's are required to meet the capacity demand. In this planning stage, it is shown that a total 267eNodeBs are required to meet the coverage requirement and on the other hand a total of 193 eNodeBs are required to meet the capacity requirement .since the target network should satisfy both the requirements of coverage and capacity, the total number of eNodeB's that will be used in order to analyze the target network further in the planning stage become 193 eNodeB's.

8.4 Simulation output

8.4.1 Digital map

The first input is digital map, which is used to setup working environments on the Atoll software. In this study digital map assumption Gondar is used. A digital map is an electronic database containing geographical information such as land usage (clutter information), height data, and vector data (streets, main roads, secondary roads, highways, and railways). In addition, it is important to include vectored data for building locations in digital maps. If available, road information (raster or vector) can also be used in certain operations, such as traffic modeling and coverage predictions. A raster unit (map resolution) is usually in the range of 1 up to 200 m.

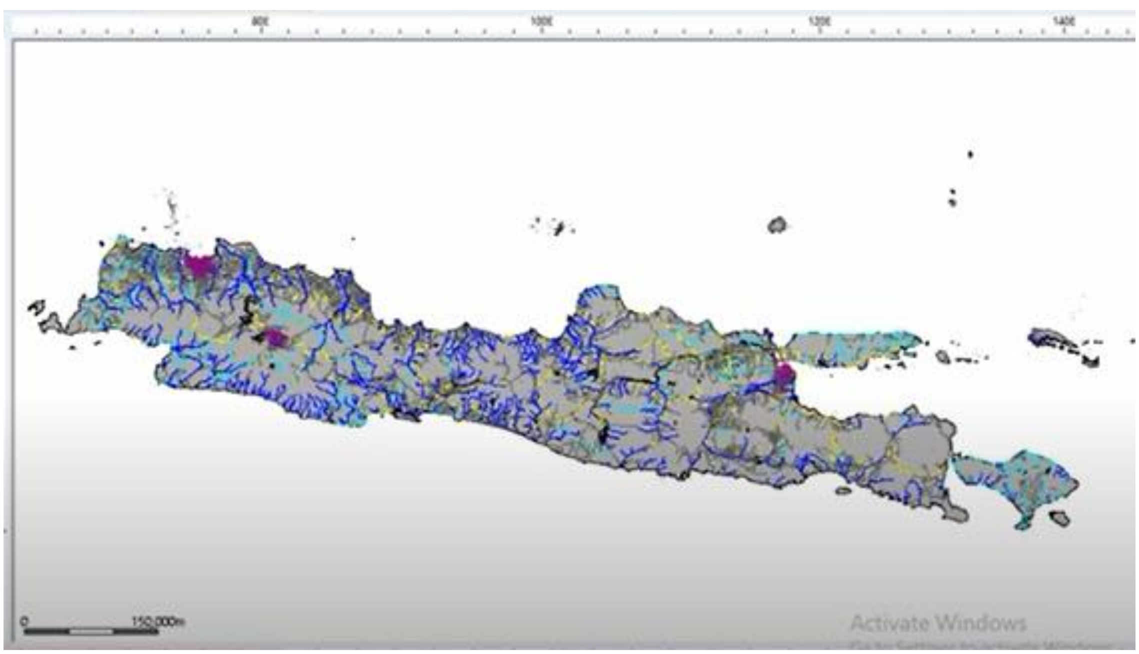

Figure 8. 1 Sample of digital map

8.4.2 Area and population of Gondar

The city of Gondar is situated in North-western parts of Ethiopia, Amhara Regional State. It is at 120 3’ N latitude and 370 28’E. Gondar is located at 727 km from Addis Ababa, the capital city of federal government of Ethiopia, and 120 km from Bahir Dar, the capital city of Amhara National Regional State. Gondar has a total area of 192.3 km2 with undulating mountainous topography. According to the 2007 National Population and Housing Census, Gondar consists of a total of 50, 817 housing units. Gondar is the center of political and economic activities of the North Amhara region and it is main city of the North Gondar Zone. The city is classified into 12 administrative sub-cites, which have their own legislative, executive and judiciary organs.

Gondar is a major tourist and business hub in North-West Ethiopia. Among many tourist attraction sites of Gondar, Fasiledes Castles within the city and the Semen National Park, located 120 Km to the north west of Gondar can be found. The city earns a significant amount of money from hotel and tourism. Trade is also a key economic activity in Gondar. The city’s success in trade is attributable to the surrounding areas, for instance, Metema, and Humera that produce cotton and sesame.

8.4.3 Clutter classes

A term clutter refers to a land use/land cover classification of surface features. They are classified in to different classes: water classes, classes of built-up area, classes of land scape and vegetation.

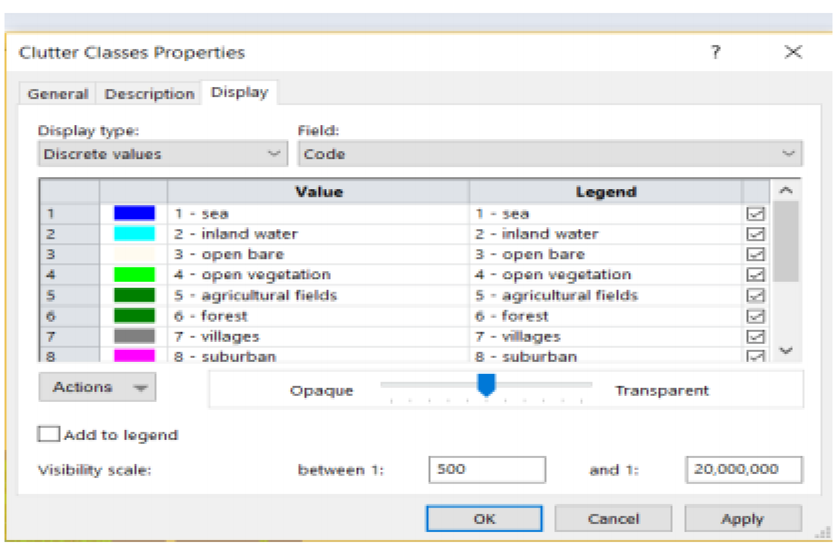

Figure 8. 2 Clutter class

8.4.4 Site Placement

Based on the planning phase a total of 193eNodeB’s are created in the atoll. These sites are initially configured by the parameters. Depending on the coverage prediction results ahead, we may affect the initial assumptions of these parameters shows the sites placement of these 193 eNodeB’s on the target list of the sites with their initial geographical coordinate information (Longitude, Latitude, and Altitude).

Figure 8. 3 Site placement

8.4.5 Coverage by Transmitter

A coverage prediction by transmitter allows the user to predict coverage zones by transmitter at each pixel antenna. You can base the coverage on the signal level, path loss, or total losses within a defined range. For a transmitter with more than one cell, the coverage is calculated for the cell with the highest reference signal power and Display the best server coverage. Figure 31 shows the coverage prediction is done for the all sites.

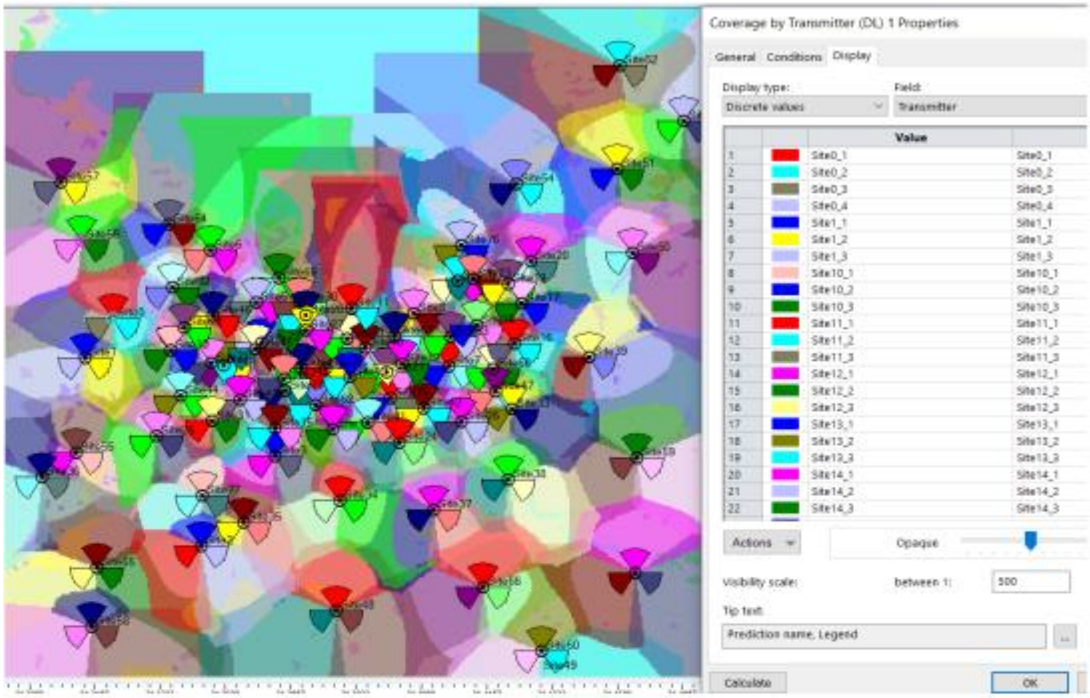

Figure 8. 4 Coverage by Transmitter

8.4.6 Coverage by Signal Level

Coverage is defined as the possibility to get a service with a defined network requirement in terms of signal quality. A coverage prediction by signal level allows us to predict coverage zones by the transmitter signal strength within the digital map. Signal level in a cell addresses the highest signal strength of the best server of the studied area. A signal level coverage prediction displays the signal of the best server for each pixel of the area studied. For a transmitter with more than one cell, the signal level is calculated for the cell with the highest power. In this figure, the red color represents the signal level ≥ -70 dBm that accounts for the best signal level where as the blue color plots represent the signal level>-105 dBm that shows the poor coverage signal on the target area.

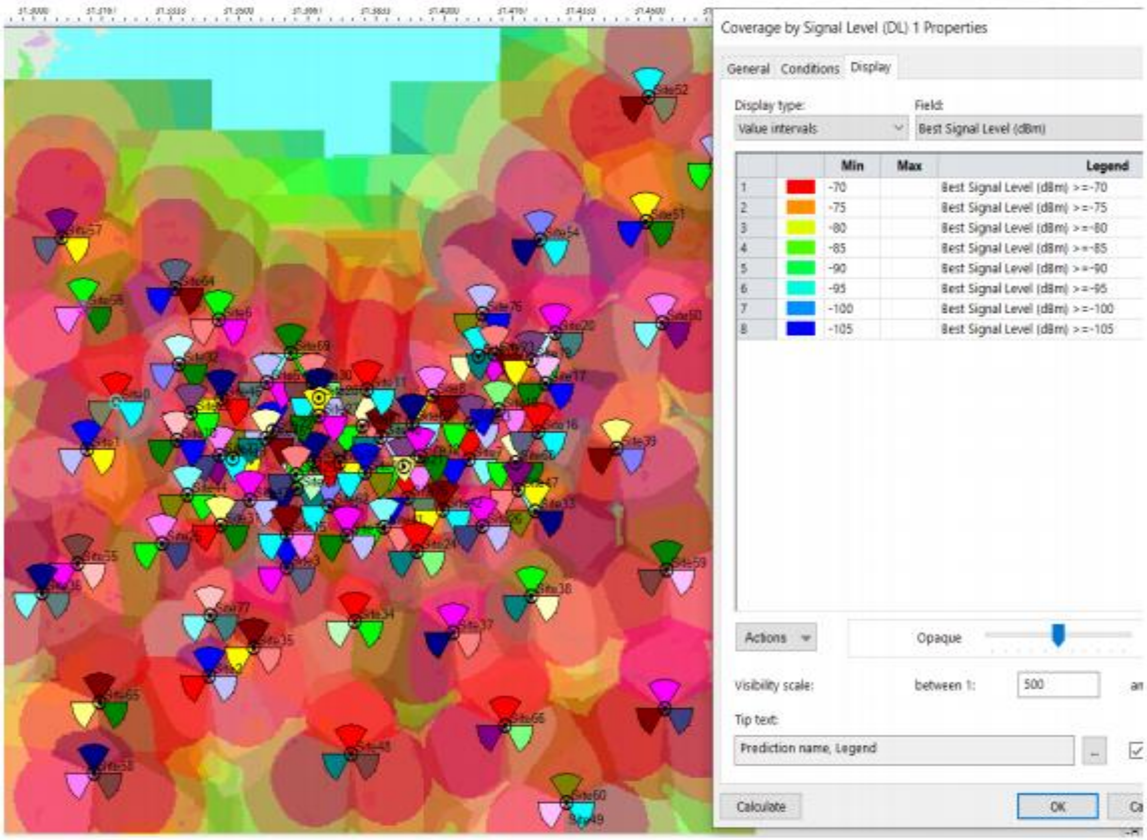

Figure 8. 5 Coverage by Signal Level

8.4.7 Coverage prediction by Overlapping Zone

In LTE system the main source of interference by coverage is overlapping between cells but there is also high coverage.Display the signal level across the studied area.

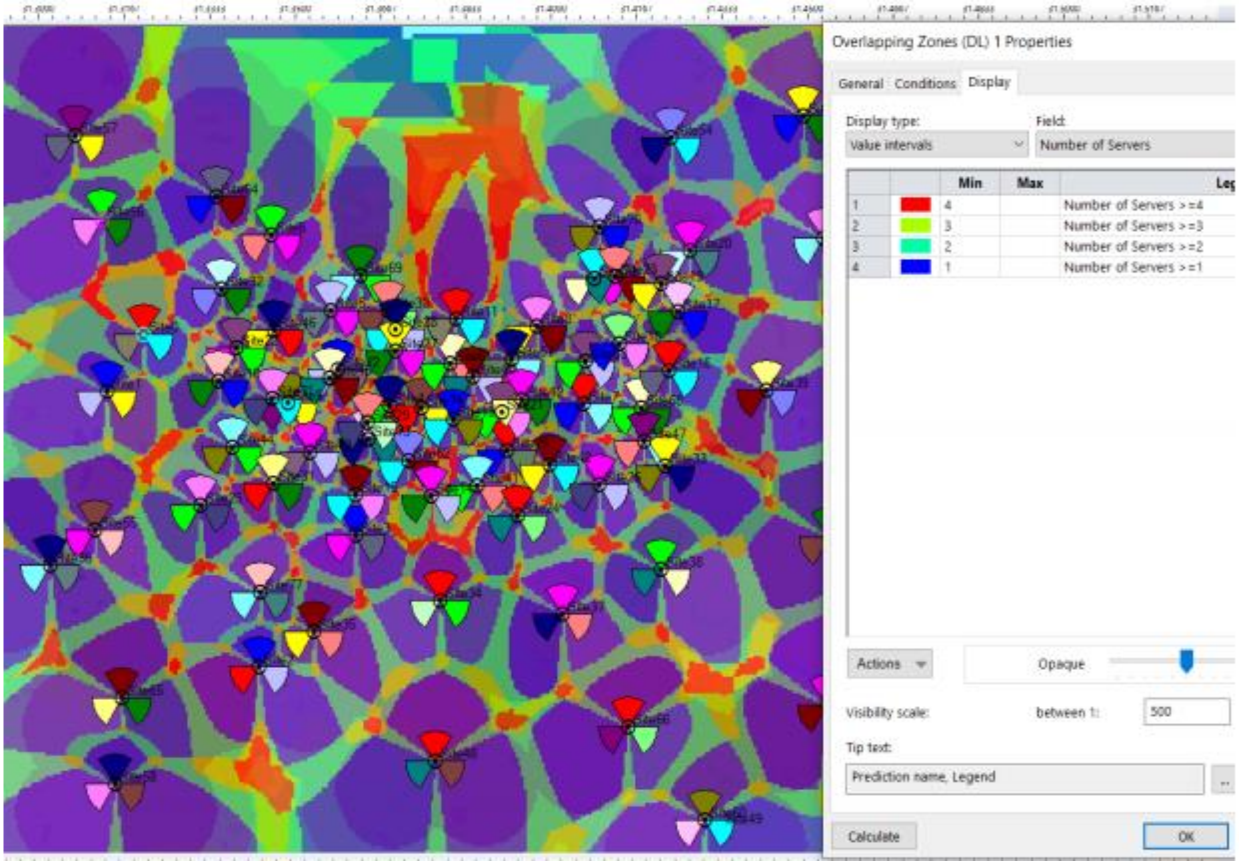

Figure 8. 6 Overlapping Zone

Chapter Nine

Conclusion and Recommendation

9.1 Conclusion

LTE brings new features, and services, which carry also new challenges, which needs to be solved. The main goals of planning and design is to minimize the financial cost by minimizing the number of eNode B's with guaranteed quality of service. This project focuses mainly on LTE coverage and capacity planning which is intended to identify and describe the necessary steps which lead us in to finding our objective of planning LTE RF network. The coverage area planning is essential importance in the whole radio network planning. The objective of coverage planning is to determine the service range. The output of this planning process by using Radio Network prediction and simulation can verify and adjust the coverage and planning results. The LTE parameters that include cell Range of sites and required sites number and the DL and UL throughput are some of the main important factors for our final simulation results. The simulation is by Using ATOLL and taking assumption of Gonder city digital map as input we modeled the network and simulate it. The results consider coverage and capacity as well as point analysis based on different service measurements and its results are done based on the calculated value. Hence the overall output fulfills the design requirement and it enhances the accuracy of LTE nominal radio network planning to perform optimum quality of services for Gondar subscribers.

8.2 Recommendation

A great effort has been made in order to achieve the objectives of this study. the following issues are recommended as future works:

- There are three approaches which can be used to get the average sector throughputs in LTE; vendor's approaches, simulation -based approach, and based on the available traffic channel RB. In this study the vendor's approaches have been used and further study can be done by using the other approaches as well.

- Subscriber forecasting is one of the inputs to estimate the number of eNodeB's in terms of capacity. The subscriber forecasting used in this study is based on the population projection from census data. However, it can be further studied considering data users penetration for both 2G and 3G data service usage from the live network.

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