INTERFERENCE ANALYSIS AND OPTIMIZATION ON 3G WCDMA NETWORK CASE OF HAWASSA CITY

MASTER OF SCIENCE IN COMMUNICATION ENGINEERING AND NETWORKING

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Declaration

I hereby declare that this MSc thesis is my original work and has not been presented for a degree in any other university, and all sources of material used for this thesis have been duly acknowledged.

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This thesis has been submitted for examination with my approval as an advisor.

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Abstract

Hawassa is a city of tourism and education therefore city should have reliable and fast network access. Currently Ethiotelecom's serves as a service provider in the city with CDMA2000, 2G GSM and 3G WCDMA wireless mobile network. 2G GSM and CDMA 2000 were the existing wireless service networks, in the last five years, 3G WCDMA wireless service is added. As an issue, there is still a lot of complain considering 3G WCDMA performance of network. We consider the high interference value taken from the ethiotelecom network management system and analyze problems, and solution for the problems is found by tuning Two main parameter of the network CPICH power and Antenna electrical tilt using a heuristic algorithm to define the optimum value for this specific case, The task is performed by measuring received total wideband power (RTWP), Radio access bearer (RAB) and radio resource controller (RRC) key performance indicator (KPI) values from the operation and maintenance center client system, then analysis is done using WINPROP simulating tool, to compare the real network current configuration parameter value with the parameter configuration that we suggested, using Ethiotelecom's suggested KPI value as a base line. From the analysis we concluded that using the two parameters in combination enabled more improvements in both reductions of interference and network capacity gain comparing with the tuning parameter individually. Accordingly, interference could be minimized from $-94.9dBm$ to $-101.7dBm$ with network capacity gain of 4.04% fulfilling the required Eb/No and received power threshold and using common pilot indicator channel(CPICH) signal power of 7.5% of the total base transceiver station(BTS) power and electrical antenna down tilt by 2 degrees. Using common pilot indicator channel (CPICH) power and antenna tilt setups, the heuristic algorithm we use optimizes RTWP (uplink interference). The parameters chosen have a considerable impact on network capacity. We use WINPROP, a static universal mobile telecommunication system (UMTS) frequency division duplex (FDD) network simulator, to evaluate the network settings.

Key Words – 2G, GSM, 3G, WCDMA, CDMA2000, KPI, WINPROP, RTWP.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ARPU	Average revenue per user
BCR	Block coding rate
BO	Business object
BTS	Base transceiver station
CCSR	Call completion success rate
CE	Channel Element
CPICH	Common pilot indicator channel
CS	Circuit switched
CSSR	Call setup success rate
DCR	Drop call rate
DL	Down link
DPM	Dominant Path Model
FDD	Frequency division duplex
FDMA	Frequency division duplex
FLC	Fuzzy logic controller
GSM	Global system for mobile
KPIs	Key performance indicator
MAC	Media access control
MTC	Mobile terminating call
NCC	National communication committee
OMC	Operation and maintenance center
PHS	Personal handy system
QoS	Quality of service
RBS	Radio base station
RF	Radio Frequency
RLC	Radio link controller
RNC	Radio network controller
RoT	Rise over Thermal
RRU	Remote Radio Unit
RSCP	Received code power
RTWP	Received total wideband power
SHO	Soft Hand Over
SHOSR	Soft handover success rate
TCP	Transmit code power
TDMA	Time division duplex
TFS	Transport format set
TMA	Tower Mounted Amplifier
TRA	Telecommunication Regulator Authority
UE	User equipment

UMTS	Universal mobile telecommunication system
WCDMA	Wideband code division multiple access

CHAPTER 1

1. INTRODUCTION

1.1. BACKGROUND

Telecommunications has been around for a long time and has undergone many changes in recent years, particularly with the emergence of mobile communication technologies. From the first generation of mobile networks, which used analogue communication, to the most advanced today, such as 4G and 5G, technology has improved in terms of quality and availability [1]. With the increasing number of subscribers and the emergence of bandwidth-intensive applications such as gaming, animations, and video streaming in recent years, the demand for additional bandwidth resources has become a major concern. The solution to the capacity problem is the provision of new spectrum and the advancement of a new technology—Wideband CDMA, generally known as WCDMA. WCDMA is an international standard for real-time multimedia services with guaranteed internal roaming that operates on a specific frequency of 2GHz with a bandwidth of 5MHz. WCDMA provides various advantages over GSM, including higher system capacity, higher data transfer rates, different traffic classes, better voice service quality, and low transmission power. Despite the fact that the WCDMA system appears to perform better than the previous GSM network, it may continue to perform poorly due to design flaws or man-made issues. Network operators will not only set out and plan new networks to provide better service, but will also optimize existing networks, which can help the network operator save money [2].

WCDMA is a member of the newer 3G group of technologies [3]. Being latest and more advanced, WCDMA is presently the technology that people need and it is gradually being implement in a lot of areas that are preoccupied by GSM. eventually, the WCDMA network would be equivalent to the coverage of GSM, making the GSM network redundant. With this said, it is obvious that the GSM network is gradually being phased out and substituted with the latest and better WCDMA [4]. An operator's infrastructure is an advancing sophisticated spot. raising ARPU (average revenue per user), lowering of operational expenses and a higher level of quality of service for end user are all objectives that operators are chase after. Quality, traffic/revenues, and financial considerations all play a role in network optimization. Customer objections rise without fine-tuning the system, and marketing appears ineffectual [5]. To accomplish these objectives operator's, required to make certain they are making effective use of the network resources which is available. Operators who carry out a strategy of Network Optimization can expect to see a decrease or holdup in the need for another network capital investment and it can also enable them to react better to unexpected network events. There is also the added advantage of excelling the user experience for their customers by guaranteeing better network coverage and an enhanced quality of experience [6]. The goal of radio network optimization is to provide operators with a thorough grasp of the underlying issues they must address, such as network layout, user equipment, and system. Poor 3G radio optimization leads to poor 3G radio performance, such as call setup failure, call drop, and other issues [7]. The responsibilities of network design and resource optimization are becoming more difficult as modern wireless communication technologies and the scale of radio networks rise. This is primarily due to the fact that radio resources are now insufficient due to the increasing number of users and the variety of networks operating within the limited frequency range. Furthermore, utilizing and managing a large network is costly, necessitating careful network dimensioning to ensure maximum resource usage [8, 9]. The term "radio network optimization" refers to improving network performance by leveraging existing network resources [5].

Optimizing the network from control plane point of view is learning the performance by evaluating traffic data, acquiring real-time data, analyzing parameters, and inspecting hardware. adjusting parameters in the WCDMA network is also named as parameter optimization, which plans to search for a set of finest parameter values that identifies the point of balance for network performance, i.e., a compromise between capacity, coverage and quality [10].

Network optimization aims to improve the efficiency of existing network resources in order to make a more cost-effective investment with maximum returns. The measurement reports are collected by report-based network optimization, which the UE sends to RNC during the call connection. These real-time and massive data sets are a precise depiction of the environment in which the UE is situated. As a result, we can fully utilize these facts to achieve our goals [2]. The goal is to expand and utilize network resources while also identifying present and potential network difficulties and creating solutions for future network planning. The RLC grants the Radio Bearer service for the transport of user data via the UE and UTRAN. RLC parameters, MAC parameters, Transport Format Set(s) (TFS), physical channel parameters, and the information bit rate make up the Radio Bearer. When a service request is accepted, the RNC performs Radio Bearer Translation, which is a mapping of UMTS service parameters to Radio Bearer parameters.

A UMTS service may be projected to a signaling Radio Bearer or a combination of a (service-specific) Radio Bearer and a signaling Radio Bearer, according to the specifications [11].

At Hawassa UMTS network is introduced at 2015, since then there are 53 three sectored WCDMA sites distributed all over the city all of them are managed by one RNC as per the fetched data from the network on January 2021

1.2. STATEMENT OF THE PROBLEM

The growing number in the network subscribers allows the communication channels so jammed. This establishes interference in the entire communication network consequently decreasing the Quality of Service (QoS) [1]. As a result, there is the need to study the possibilities for increasing the capacity of the available radio resources by lessening interferences that occurred in the system. This directed to the emerging of properly optimizing key radio network setups and system parameters. These techniques are aimed at increasing network capacity while reducing system interference. The network performance data concerning interference for 30 days from January 1 to 30, 2021, is taken out from network management system of the operator(ethiotelecom), namely the business object (BO) for 7 UMTS sites. The average received total wideband power (RTWP) value is between -93dBm and -94dBm which is beyond the recommended value which is between -104.5dBm and -105.5dBm and also RAB and RRC failure is above ethiotelecom target. figure 1.1 shows cumulative distribution function of the RTWP (received total wideband power) for the selected 7 sites. the RTWP can cause performance deterioration, mostly CS Call Drops. In fact, it's not RTWP that causes performance deterioration. What is going on that when its value is 'bad', is it's actually justifying the existence of interference.

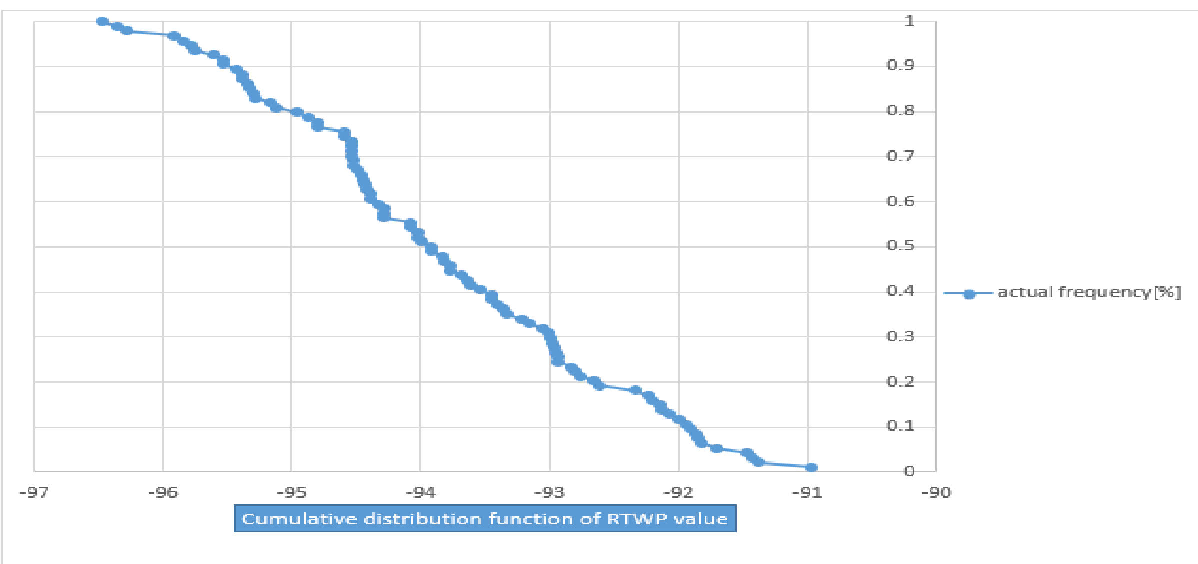

Figure 1. 1 CDF of RTWP for the current network of Hawassa city

1.3. OBJECTIVE

The objectives of research in this thesis can be divided as follows:

1.3.1. GENERAL OBJECTIVE:

The main objective of this thesis is to exhibit effective method of optimizing interference within a WCDMA network of Hawassa.

1.3.2. SPECIFIC OBJECT

- Investigating area of congestion of Ethio Telecom's WCDMA network.
- Investigating influence of Antenna tilt and CPICH power configuration on network capacity.
- Identifying the areas where enhancement should be attained.
- Conducting simulated trials for lowering the interference in the system.
- Reduce the network uplink interference and attain an enhancement in capacity by using different configuration for CPICH power and antenna tilt.

1.4. SCOPE OF THESIS

WCDMA Network Optimization is a massive and complicated task that involves balancing a number of criteria, including service coverage, network capacity, quality of service (QoS), equipment prices, and predicted network revenue. For the purpose of bounding the scope of this thesis, the main emphasis has been on the actual network capacity evaluation, service capacity degrading problems, particularly uplink interference and actual remedies for RTWP alarms notification as a result of uplink interference, common to sub-optimality of WCDMA networks at Hawassa.

1.5. THESIS LAYOUT

The remaining chapters of the thesis are divided into six sections. Literature review is presented on chapter 2 CDMA and WDMA technology, which includes background on UMTS is presented in Chapter 3. the interference which is explained by RTWP (received total wideband power), optimization parameters, and optimizing ways are explained. In Chapter 4, you'll learn about system modeling, suppositions, strategies for selected region details, tool explanations, and simulation parameters. In Chapter 5, the specific outcome of the simulation is discussed and compared, the near optimal solutions for interference and capacity gains for different scenarios are described and compared between each other. Finally, Chapter 6 concludes and suggestions.

CHAPTER 2

2. LITRARTURE REVIEW

The results of performance benchmarking of cellular network operators in Turkey are presented in this article. Benchmarking refers to the comparison of standard key performance indicators (KPIs) among Turkey's major cities, such as Ankara. Customer insight and surveys on how valuable KPIs are from the user's perspective are used to construct performance benchmarking. KPIs are measured using standard test equipment and a drive test technique on paths that have been pre-determined in Ankara, the GSM and UMTS network operators with the best performance were selected based on the performance benchmarking results. Different statistical techniques, including statistical analysis, were used to evaluate the speech quality of network operators, the most well-known service. With the methodologies used, the network operator providing the best speech quality in Ankara was identified. The author in [12] summarizes the findings and methods for benchmarking cellular networks in Turkey. The authors intend to investigate the voice transmission QoS of existing UMTS network in the city of Addis Ababa. The evaluation is made by studying fetched real data from both control plane and user plane systems, by employing industry-standard investigation tools such as Element Management System (M2000), Performance Surveillance (PRS), Nastar, Nemo handy, Nemo outdoor and Actix Analyzer. The analysis output reflects that, in general, there are some variations between the ethio telecom baseline and investigation results, which displays the need to further enhance the voice QoS. To enhance the quality of voice transmission the advisable interventions incorporate: implementation of QoS manager in various stages of network, suitable resource assignment in the network, check if the inter node B distance or inter system distance (ISD) matches the needed separation and lastly, arranging the city’s UMTS coverage in a hierarchical manner [1].

The Author examines the results of a drive test in Yogyakarta's rural, suburban, and urban areas, as well as KPIs for 3G services in Yogyakarta, Indonesia. The RSCP and Ec/No performance parameters are included, and the average RSCP value for all three sectors is excellent. They outperform the benchmark (-117dBm). Despite the fact that the value of Ec / No must be a subject of interest, the value of Ec / No in some regions, particularly in suburban areas, is low. CSSR, CCSR, BCR, DCR, and SHOSR are all KPI parameters. The data call event parameters are gathered from the computed results and used to construct the KPI. In metropolitan areas, the CSSR and CCSR percentages are the lowest, with 90.41 percent and 91.78 percent, respectively. The

SHOSR percentages across the board are likewise excellent. SHOSR is about 100 percent valuable. Because the CCSR and CSSR values are the lowest in the city, it is necessary to bring attention to it. The combination of tall structures and a large number of users causes this. The research concludes that, while 3G services in general perform well, the metropolitan region deserves special attention. In comparison to sub-urban and rural locations, the CSSR and CCSR values of urban areas are the lowest. Because of the number of subscribers and the shapes of the buildings, this is the case in [13]. Mobile network planning and optimization are critical for guaranteeing high service quality and a positive user experience. This study has provided demos that may be used for in-depth investigation of the optimization standard as well as network planning. CDMA network operators have a number of options for increasing system capacity, both short and long term. Nonconformities such as a forward/reverse link imbalance, too many soft handoff locations, and incorrect RF parameter settings could result in the system's capacity being underutilized. Operators can swiftly and efficiently use their network resources to reach optimum system capacity with adequate network planning and network optimization of the deployed CDMA network, according to [14]. This thesis aims to describe the various concepts and solutions that can be utilized to improve the quality of service of Ethio Telecom's CDMA networks. This thesis studies the effects of antenna height, tilt, and power on network coverage and capacity. The objective of the study is to find out which areas have the best signal strength so that the cell can effectively serve the traffic in the area, to improve the coverage and capacity the network, the recommendations are either add new BTS or relocate existing ones. Tradeoff between various system parameters is used to ensure the optimal utilization of the network. The author focuses also on the concept of system interference management by precise power control. [2].

The authors of [3] set out to examine network performance in Owerri, the capital of Imo State, Nigeria, in order to determine the degree of deterioration on WCDMA networks in specific geographic locations. Structured questionnaires and empirical analyses were used in the study. The two networks were subjected to empirical analysis to determine their network efficiency using the selected Key Performance Indicators (KPIs). Because of the large number of subscribers, Aba road, FUTO road, Onitsha road, Orlu road, and Wetheral road were chosen for the evaluation. The chosen KPIs, which included Call Setup Success Rate (CSSR), network accessibility, Call Completion Success Rate (CCSR), network retainability, Call Drop Rate (CDR), and Receive Signal Level (RXLEV), were used to evaluate a variety of network performance behaviors based on QoS. According to the findings of the assessments, no networks meet the Nigerian Communication Commission's (NCC) baselines, with the exception of the MTN network on the FUTO, Wetheral, and Onitsha roads. In addition, MTN's network on the route to Onitsha Road comes close to meeting the NCC's CSSR and network accessibility benchmarks. The authors conducted a thorough analysis of WCDMA network challenges that affect the sites in advance, and the problems were identified, as well as optimization steps needed to resolve the issues [4].

The researchers described a rule-based approach for optimizing the two most important characteristics of a UMTS base station, CPICH power and antenna tilt, in [5.] The program looks for the optimal antenna tilt and common pilot channel power configuration for the base stations. Their job and the provided algorithm is a continuation of the rule-based approach which is studied before, the major dissimilarity to the algorithm provided before this work is that with the current algorithm, CPICH power and antenna tilt are modified simultaneously. Their algorithm yields a higher capacity gain of around 62.6% with an iteration of 50. and therefore, it rescues computation time as compared to the older work. SYMENA's static UMTS FDD network simulator was used to test their rule-based approach on a virtual network scenario with 25 three sectored base stations. The provided algorithm is a parametric approach, on the basis of rule set.

In [6], their investigation majorly emphasizes on decreasing uplink interference levels by evaluating network performance information from network management systems to detect the area in problem. The outcomes of their investigation shows that the RTWP way of troubleshooting is supportive in determining whether Node-B is impacted by interference. The analysis of RTWP was founded on the operator(indosat) active network in Indonesia. The interference is being alleviated by relocating the WCDMA antenna as far as possible. WCDMA antennas are supposed to be higher or lower than PHS (personal handy system), and evaluating the NodeB device for loose or disconnected connections and feeders. The activities they used to solve the problem included routinely assessing the above set of tasks to ensure that cell performance in each BTS remained steady and that data exchange was smooth. A Taiwan operator was challenged by high RTWP issues (high noise level in the uplink band) from numerous regions in city of Taipei. The Viavi team joined with the operator to solve the issue by indicating the interference source by applying Interference Advisor, Viavi’s automated interference searching method. The operator informed the list of problems below:

• the sites which have very high RTWP record.

• the problem was challenging to figure out as it was intermittent

• the interference variation level was as big as -88 dBm to -78 dBm

A mobile network operator in Taiwan who is facing interference in a particular region, A high RTWP being detected in one site, thus interference impacts the area served by the site. It indicates that two UL bands were impacted. Once this problem is triggered, the mobile telecom operator engages a drive test crew to the focal site and carries many checkups to specify the root cause of interference, by applying a spectrum analyzer or interference advisor [7].

The crew carried out a brief manual interference inspection by driving over the region; they effectively identified the root cause of the interference it was an RF repeater suspended on a building.

The issue of capacity optimization in 3G cellular networks is addressed in [8] by using Rule-Based Fuzzy Logic to manage CPICH power and, as a result, increase cell capacity. The main reason they chose Fuzzy Logic Controllers (FLC) was because of its logical resemblance to a human operator. They used a network of six cells for their experiment. The main operation is aimed at reducing the amount of thought and effort required by a radio optimization engineer to do capacity optimization tasks, which are now done manually. The FLC will help identify high-load 3G cells with insufficient cell resources that could benefit from CPICH power change, which a radio optimization engineer would conduct manually. In comparison to a fixed CPICH power system configuration, their simulation results showed that the CPICH power management system based on fuzzy ensures a significant increase in Downlink cell utilization, which in turn improves cell efficiency.

CHAPTER 3

3. THEORETICAL BACKGROUND

3.1. CDMA AND WCDMA OVERVIEW

In the early 1990s, Qualcomm launched Code Division Multiple Access (CDMA), a relatively new wireless communication technology. CDMA differentiates distinct calls using unique codes that are assigned to each call independently, unlike prior technologies like as FDMA and TDMA, which employ several frequency sub-bands and time slots to carry out numerous calls. CDMA has considerable benefits over TDMA and FDMA technology in cellular networks. Increased capacity, multi-path fading resistance, voice activity, and a soft handoff mechanism are among the enhancements. The battery life of CDMA handsets has been extended as a result of these benefits and features, and the quality of voice transmissions has improved. [In accordance with [9]]. The key parameters defined for WCDMA are listed in Table 3.1.

Table 3. 1 Main WCDMA parameters [10]

Multiple access method	**DS-CDMA**
Duplexing method	**Frequency division duplex/time division duplex**
Base station synchronization	**Asynchronous operation**
Chip rate	**3.84 Mcps**
Frame length	**10 ms**
Service multiplexing	**Multiple services with varying service quality criteria are multiplexed on a single connection.**
Multi-rate concept	**Variable spreading factor and multi-code**
Detection	**Coherent with the use of pilot symbols or a common pilot**
Multiuser detection, smart antennas	**Supported by the standard, optional in the implementation**

WCDMA is a wideband Direct-Sequence Code Division Multiple Access (DS-CDMA) system in which user data bits are multiplied by quasi-random bits (known as chips) derived from CDMA spreading codes and distributed over a large bandwidth. For directing very high bit rates, it is recommended to utilize a variable spreading factor and multi-code connections (up to 2 Mbps). Narrowband CDMA, also known as IS-95, is a DS-CDMA system with a bandwidth of less than 1 MHz. WCDMA's 5 MHz wide carrier bandwidth allows for high user data rates while simultaneously improving multipath diversity. Network operators can construct a few of 5 MHz carriers to magnify capacity, possibly in the framework of hierarchical cell layers, according to their operating license. On a 200 kHz grid, the exact carrier spacing can be selected between 4.4

and 5 MHz by relying on carrier interference. WCDMA allows for a wide range of user data rates, allowing for the concept of acquiring bandwidth on demand (BoD). During each 10 ms frame, the user data rate is kept constant. However, the data capacity of users can change from frame to frame. To provide the best throughput for packet data services, this quick radio capacity allocation will often be handled through the network. WCDMA has two basic operating modes: frequency division duplex (FDD) and time division duplex (TDD). In FDD mode, separate 5 MHz carrier frequencies are used for the uplink and downlink, but in TDD, just one 5 MHz carrier frequency is time shared between the uplink and downlink. In our analysis, we consider FDD mode of operation. Uplink refers to the connection between the mobile and the base station, whereas downlink refers to the connection between the base station and the mobile. WCDMA uses pilot symbols or a shared pilot to detect coherent signals on the uplink and downlink. While coherence detection is already employed at the downlink in IS-95, it is novel for public CDMA systems and will result in a general increase in coverage and capacity at the uplink. WCDMA is intended to be used in conjunction with GSM. As a result, handovers between GSM and WCDMA are encouraged in order to take use of GSM coverage while introducing WCDMA.

3.2. UMTS ARCHITECURE

The GPRS core network is reused by UMTS; nothing has changed on the core side, but the radio interface has been substantially redesigned. The UTRAN radio network in UMTS is connected to the GPRS core network via the Iu interface, which is the UTRAN interface between the radio network controller RNC and the radio core network CN.

Fig3.1 outlines the UMTS architecture.

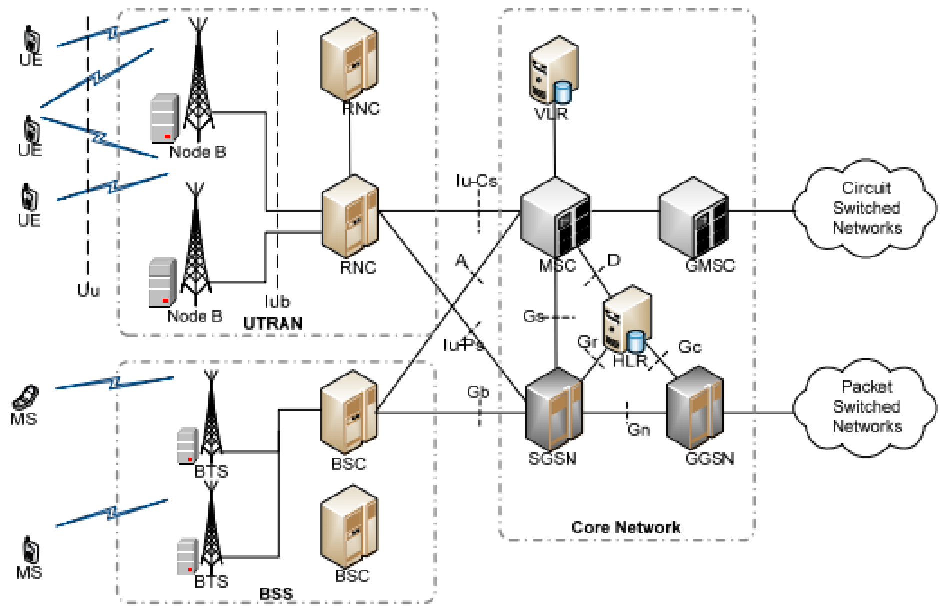

Fig 3. 1 UTRAN architecture hybrid configuration [11]

In UMTS, a user phone is referred to as a user equipment (UE). The UE is connected to node B via a high-speed Uu (2Mbps) interface. The GSM equivalent of BTS is the Node-B. RNC uses the Iub interface to manage many Node-Bs. The Iu-CS interface is used to send circuit switched data, while the Iu-PS interface is used to send packet switched data. The Iur interface, which promotes communication between RNCs, is a new interface that is advertised during UMTS. The Iur interface is the one that handles all RRM concerns and has taken over the responsibility from the CN. USIM is in charge of subscriber identification, implementing authentication algorithms, and storing authentication and encryption keys, as well as a few subscription records that are required on the terminal. UMTS also aids GSM mode connections in which the MS connects to the CN via the Um interface to the BSS and the BSS connects to the CN via the A (Gb interface in GPRS) interface. Node B transforms information flow between the Iub and Uu interfaces and helps manage radio resources. RNC owns and controls the radio resources of Node Bs connected to it, as well as providing an access point for all UTRAN services available to the CN. Cu, Uu, Iu, Iur, and Iub are the basic open interfaces in UMTS. Cu is the electrical interface between the USIM smartcard and the ME, while Uu is the interface via which the UE communicates with the machine's fixed part. Iur is the interface that allows soft handover between RNCs and Iu connects UTRAN to the CN. Iub establishes a connection between Node B and an RNC.

3.3. RANDOM ACCESS PROCEDURE

During UMTS network access many circumstances should be considered. Random-Access Channel (RACH), is a shared channel. Due to this, the probability of colliding with many user access attempts is imaginable. And also, all uplink transmissions produce in co-channel interference and thus it needs strict power control to reduce this interference. since the RACH does not apply closed loop power control, the UE required to guess the power needed to transmit the RACH information. The objective of the Random-Access Procedure is to reduce the probability of collisions, and to guess the UE transmit power in order to reduce interference to other UEs. despite, these goals must be accomplished while reducing system access time [12].

3.4. OVER ALL POWER CONTROL PROCEDURE

power control plays the main role in operating WCDMA system. In order to overcome “near-far effect’ it is mandatory to balance the transmitting power of the mobile phones as well as the power, received at the base station [13]. On this subject, three power control algorithms were invented in order to achieve the reliability and integrity of radio link which are:

- Closed loop power control
- Inner loop power control
- Open loop power control

3.5. POWER CONTROL OF UP LINK CHANNELS

The Need for open loop power control: open loop power control is used to manage the power of uplink control channels, which is controlled by the terminals. In a UMTS network, the UE is responsible to begin the RRC connection setup procedure. This is used for mobile terminating calls (MTC) if not the network pages the UE, informing it to create an RRC connection. The UE is able to do this by utilizing the random-access procedure. the UE has to know how much power is needed in the uplink, before it initiates the random-access procedure. If a UE utilizes a constant power level for random access, and if it is approaching to the BTS, this would block UE`s from far. Therefore, the UE must always apply the minimum attainable transmission power. The objective of power control is for the UE to transmit the lowest amount of power needed during call set up to access the network. initially the UE have no any idea about the power needed to access the system, so it guesses the initial preamble power based on broadcast information and downlink measurements. If there is no acknowledgement from the RBS to this initial request (via acquisition indication sent by the RBS), the UE will increase its power based on predefined increments and retransmissions until it is heard. This procedure is known as 'Power Ramping' and because of the limited feedback provided by the network is termed open loop power control [14]. The UE utilizes an equation to guess the initial preamble transmit power on the physical random-access channel (PRACH), based on CPICH received power and System Information (broadcast in the cell).

$$P_{PRACH} = (PCPICH\ Dl\ Tx\ Pwr - CPICH_{RSCP}) + Ul\ interference + constant\ value \quad \textbf{(3.1)}$$

Where: -

- P_PRACH Power of the first preamble on the PRACH
- PCPICH DL Tx Power Primary CPICH transmit power (sent in SIB5)
- CPICH_RSCP Received CPICH RSCP measured by UE

UL Interference measured by RBS and broadcast by BCH (broadcast channel), Constant Value CPRACH is a configurable parameter which is utilized by the UE to estimate the initial power on the PRACH [14].

3.6. RTWP (received total wideband power) optimization parameter

For the evaluation of the performance of the network, a fitness function is needed. The fitness function indicates the goal of optimization. In this paper, we want to reduce the uplink interference of the network so that the network capacity increases; therefore, we consider the received total wide band power amount at the base station as the objective of the optimization. As RTWP reflects the amount of uplink interference, it is used as our fitness function.

RTWP (received total wide band power) Is the number of unwanted signals inside the frequency band of a cell or you can call it the uplink interference. due to many reasons like the number of users in the cell, Connection Types, the Service, and Conditions of Radio environment, uplink interference might happen. But the most usual cause is the number of terminals in that cell [1]. Monitoring the value of RTWP supports to manage the call drops - mainly CS. This in turn helps to manage the capacity as it offers information for the Congestion management concerning Uplink Interference. If a network is not loaded the reasonable RTWP Average amount is usually around

-104.5 and -105.5 dBm.

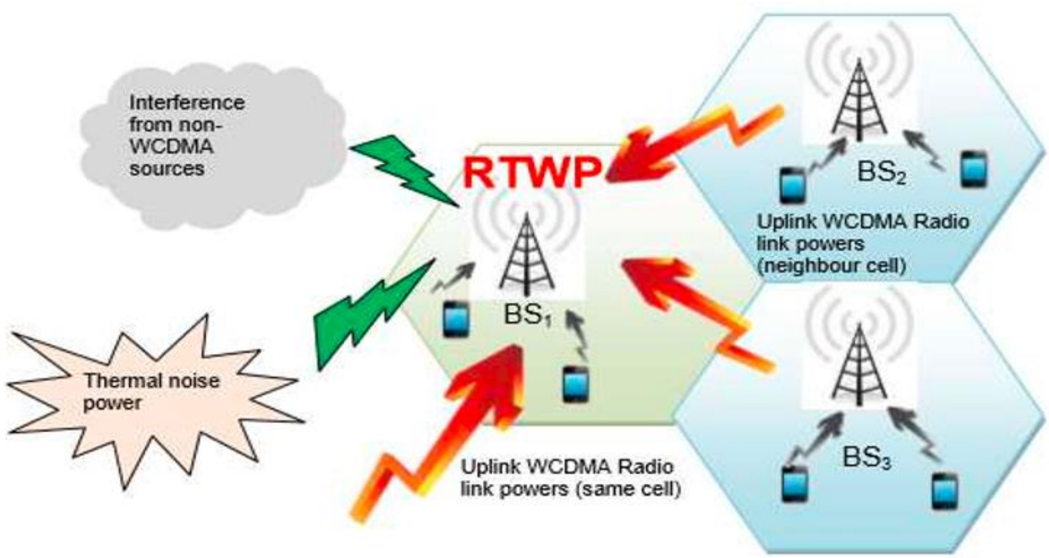

Fig 3. 2 RTWP measurement setup [10]

Most mobile telecommunication companies follow some sort of process to identify and overcome RTWP issues in a RAN. Generally, once the alarm is reported to the Operation Maintenance Centre (OMC) or once some degradation in KPI has been observed that is related to RTWP, the support team will check the configuration and perform some parameter changes or reset the board in NodeB. After confirming that the configuration is completely checked, the field maintenance team will check the hardware and make some changes in the antenna direction, such as azimuth or inclination. If no improvement is observed, the issue is escalated to the RF team, which conducts further tests and identifies the source of interference. Generally, the RF team uses a spectrum analyzer or frequency hunter to identify the sources of interference [15]. The RAN generally experiences interference from other wireless systems, which is why the Telecommunication Regulatory Authority (TRA) assigns a specific frequency and guard band so that each operator can access its allocated frequency without interfering with another operator [15].

Congestion occurs when the capacity of the system that has been allocated for a specific service is exceeded. In UMTS, power congestion can be observed in both uplink and downlink. When it is observed in downlink, it is called Transmit Code Power (TCP), and when it is observed in uplink, it is called RTWP. Theoretically, DL capacity is limited to 125 Erlang per cell since the other codes are needed for signaling purposes. UL capacity is not restricted by physical radio resources as a user specific scrambling code is assigned in addition to the Orthogonal Variable Spreading Factor (OVSF) code which every UE generates its own [16]. As a result, UL signals are uncorrelated and interfere with each other. Channel Element (CE) is defined as the logical resource used for the baseband processing unit in the NodeB; the capacity of the services that can be provided by the NodeB is determined by CE congestion, which occurs when multiple users access different services and when the required CE is greater than the capacity of the system hardware [15]. An example of this scenario is the Dedicated Channel (DCH), which is the radio channel that is responsible for carrying voice services in a 3G network. Whenever this channel is increased in size, it will increase the CE utilization in the NodeB, since many users require voice services in the NodeB; RTWP will increase accordingly. Figure 3.8 shows the relationship between RTWP and DCH.

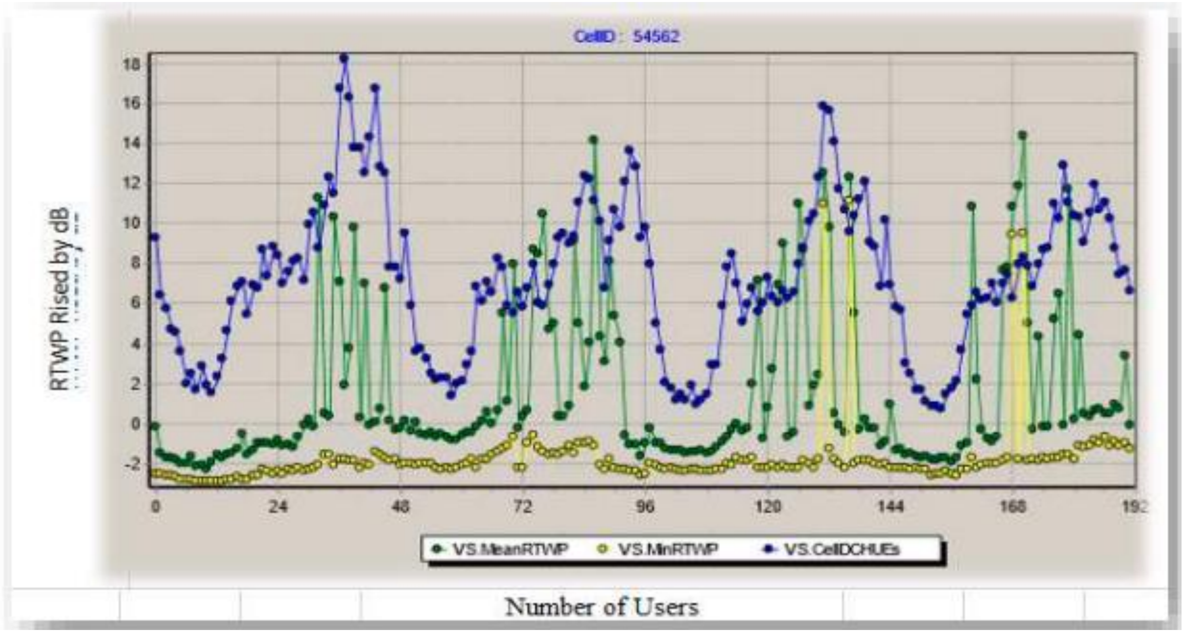

Fig 3. 3 RTWP and DCH [7]

The green line indicates the Mean RTWP, the yellow line indicates the Min RTWP, and the blue line shows the Cell DCH UEs (the number of users in a cell). The figure above shows that the RTWP rises by several dB, as more users are served. The solution is to increase the CE resources in NodeB first by changing either the software or the hardware until the RTWP value has normalized. The TMA is a low noise amplifier designed to improve the coverage of the cell and capacity in wireless communication; it is installed near the antenna and it improves the uplink signal performance. One of the main reasons for using the TMA is to increase the coverage in the area where the received signal is weak and to reduce call interface and noise. Therefore, any issue with this device could cause interference on the RAN side. There are occasions where one link is weaker than the other in two-way communications systems this situation is referred as unbalanced link, this situation can be adjusted by doing the transmitter on that link stronger or the receiver more sensitive to weaker signals [17].

The load which is in the cell is explained by noise rise and directly related with power. Rise over thermal (ROT) is the most crucial parameter of all parameters used for noise, which is referred as the division between, received total wideband power (RTWP) at the RBS and the thermal noise power floor as explained in equation 3.1. thus, it is very important to evaluate the noise floor precisely [15].

$$ROT = \frac{RTWP}{Thermal\ noise\ power\ floor} \tag{3.2}$$

thermal power floor and received power level vary with time. To guarantee the expected coverage and cell consistency uplink load supposed to be with the definite extent which is determined as the RoT limit as outlined in the figure 3.9

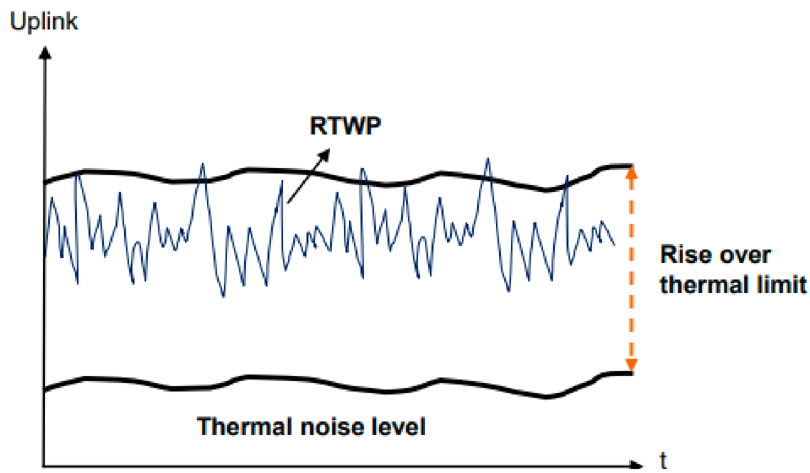

Fig 3. 4 Rise over thermal [6]

RTWP is an important parameter in the design of wireless radio access networks. Equation 3 show how RTWP is calculated:

$$RTWP(t) = \sum_{k=1}^{k} P(K(t) + I(t) + N(t)) \tag{3.3}$$

Where:

ROT(t)=rise over thermal

RTWP(t)=received total wideband power

N(t)=thermal noise value that is recorded at the antenna terminal

I(t)=the power radiated from the N neighboring cell surrounding the NodeB

Pk(t)=the external source power that can be considered as external interference.

Thermal Noise occurs in wireless communication systems when there is some minimum detection level that is determined by the noise floor, which very much relies on the surplus noise produced in the wireless communication system and the thermal noise power. the random movement of atoms on any material creates Thermal noise, which is with a spectrum of white. The Power in (P_in) signal received by the antenna is amplified by the TMA (tower mounted amplifier), and a Remote Radio Unit (RRU) in a NodeB and then converted from a digital signal to an analog one. After that, the Power out (P_out) signal is the output. Therefore, RTWP indicates the power of a signal received by the antenna receiving port [15]. The formula for calculating the Received RTWP is as follows:

$$\boldsymbol{RTWP = P_{in} = P_{out} - G} \qquad \textbf{(3.4)}$$

In the preceding formula, (G) indicates the total gain of the receiving channel, namely the sum of the TMA gains and the NodeB gain. (G) is a constant value. Therefore, RTWP is measured at the NodeB and then reported to the Radio Network Controller (RNC) for access and congestion control. The RTWP on all antennas is measured at NodeB. In addition, the RTWP on each receiving channel in all cells is measured at the NodeB. Figure 3.10, shows the calculation that occurs only inside the receiving chain of NodeB [15].

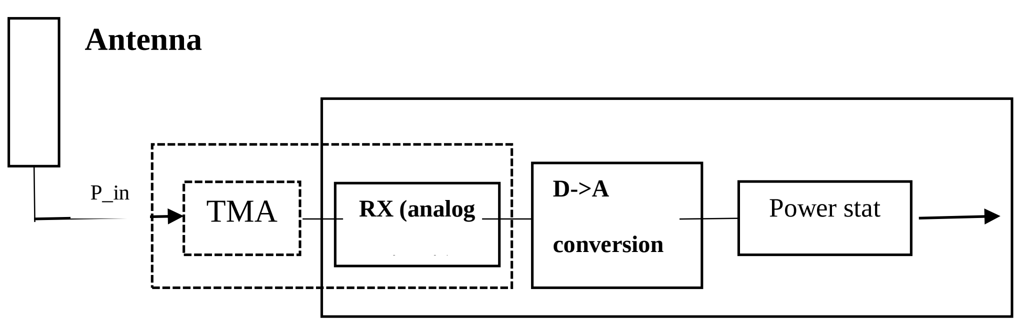

Fig 3. 5 RTWP computation [15]

When no signal is input into NodeB, the RTWP measured in the NodeB equals the NodeB PN

(Noise Power); the formula for calculating NodeB PN is as follows:

$$\boldsymbol{PN = Ktb + NF} \qquad \textbf{(3.5)}$$

Where:

K=Boltzmann constant NF=noise floor of the RF system

T=290k (room temperature) PN=noise power

B=RF carrier bandwidth (Hz)=3.84MHz

Therefore, the NodeB PN is about -106 dBm at room temperature. The PN is affected by the analog circuit of the RF system (for example, component performance is affected by external factors, such as frequency and temperature) and changes due to the factor T. Therefore, a normal PN ranges from -108 dBm to -104 dBm [15]. Due to certain networking configurations, the NodeB PN rises in the following two scenarios:

• When the TMA or the line amplifier is used without the configuration of attenuating the RX channel.

• A NodeB uses the configuration of multiple RRUs.

The network operator can change a variety of base station parameters to effect coverage and capacity, such as antenna settings like azimuth, height, and tilt, CPICH power, and handover parameters. [8], [19].

These multiple parameters have a non-linear effect on the system. As a result, determining good or even optimal network configurations is a challenging and time-consuming task [20].

All of these variables have a significant impact on system interference and, as a result, the number of mobile terminals served. We focus on optimizing CPICH power and antenna tilt to optimize uplink interference in this research.

3.7. CPICH POWER

Terminals use the CPICH to get an initial network synchronization and to help with channel estimation for the dedicated channel. A terminal chooses its serving cell by selecting the best CPICH signal after turning on the power and while traveling in the network. As a result, the cell coverage field is determined by CPICH power. The cell coverage field will grow or contract as the CPICH power is increased or decreased. Thus, by correctly managing the base station's CPICH power, the number of clients per cell will be balanced between neighboring cells, reducing inter-cell interference, stabilizing network operation, and encouraging radio resource admiration [5]. On the contrary, there are some limitations to tuning CPICH power; for example, too high values would cause interference known as "pilot pollution" in neighboring cells, reducing network capacity. Configuring very low CPICH power will induce bare regions among cells. In the regions which is laid bare, the CPICH power is too weak for the terminal to decipher the signal, so network access is unfeasible.

3.8. RTWP RELATION WITH CPICH POWER DURING RANDOM ACCESS PROCEDURE

The Random-Access Procedure is utilized by the UE to access the UTRAN network from an Idle, or Cell_FACH state. Since this is a critical step in the CS or PS call setup process, understanding this procedure is essential to successfully maintain and operate the UMTS network. In addition to being familiar with the Random-Access Procedure, it is important to understand the configurable parameters utilized by the algorithm, and the effects of modifying these parameters. It is quite possible to aggressively configure the Random-Access parameters to improve the likelihood of accessing the network, at the cost of capacity. Alternatively, it is also possible to be overly concerned about capacity at the cost of successfully accessing the network. The initial preamble power (P_PRACH) must be conservatively calculated to ensure that uplink interference to other UEs is minimized. To achieve this, the initial preamble power (P_PRACH) is calculated by the following equation:

$$P_{PRACH} = L_{PCPICH} + RTWP + constant\ value\ CPRACH \qquad \textbf{(3.6)}$$

Where:

- L_PCPICH = the estimated downlink path loss of the Pilot Channel (CPICH)
- RTWP = the Received Total Wideband Power (i.e., Uplink Interference) measured by the Node B
- constantValueCPRACH = is a configurable parameter applied to offset the equation's outcome

The downlink path loss of the Pilot Channel (L_CPICH) is estimated by subtracting the CPICH RSCP (measured by the UE) from the primary CPICH-TX-Power, which is broadcast in System Information Block including, constantValueCPRACH. The uplink interference (RTWP) evaluated by the Node B is broadcast in system block information. To consider for the processing gain of the preamble which is equivalent to 10Log (256) = 24dB constant value CPRACH is

used. Ericsson's default value for constantValueCPRACH is equal to -27 dB, which results in a

3dB offset to the initial preamble transmit power. This negative offset yields a conservative estimate for the transmit power of the initial preamble, thus reducing the potential of causing unnecessary uplink interference.

3.9. ANTENNA TILT

When an antenna said to be down tilted it should be suspended down to level of some degree mechanically or the radiation pattern should be tilted down in case of electrical tilt. Down tilting of antennas reduces distance coverage horizontally but maximizes signal coverage near to the cell site.

The usual spot to set up a down tilt antenna is on a tall tower or a hill at a cell site or at close proximity to a large body of water. Down tilt antennas are also utilized to minimize the far-field influence in wireless networks. The far-field effect happens when the radio coverage extended from site A may totally and accidentally engulf the planned coverage range of site B or other neighboring sites. Site A serves at the perimeter of site B or other nearby sites, supposedly leaving these sites unexploited. This is offensively unproductive and wastage of radio resources both at the cell site and neighboring radio base stations [21].

To make sure that the coverage limit of site A stays with in its own boundary the placement of down tilt antenna should be precisely installed the far-field effect can happen as a result of this mentioned reasons down below:

- The radio base station RF power is settled too high.
- Base station antennas have no the feature to down tilt.
- If the tower is very tall or the point where the antenna installed is high
- If the radio base station Antenna gain is too high so that it extends its coverage limit.

although RF power amount is configured at fixed point Down tilt antennas can contract the area for base station. Down tilt antennas enhance movable coverage for users. The antennas may also be utilized to drag the coverage away from a market boundary to prevent protruding coverage into neighboring sites.

Antenna tilt is described as the rise angle of the principal beam of the antenna with respect to the azimuth plane. It is common to use Antenna down tilt in mobile wireless network, specifically in the UMTS network, where traffic is supported simultaneously using the similar carrier frequency. The required outcome is to minimize the other-to-own-cell interference ratio *i*, which is determined in accordance with [19] as,

$$\boldsymbol{I} = \frac{\boldsymbol{I}_{oth}}{\boldsymbol{I}_{own}} \qquad \textbf{(3.7)}$$

In (19), I_{oth} indicates the inter-cell interference and I_{own} is the intra-cell interference. The other to-own-cell interference proportion I can be minimized using a down tilting antenna: the principal beam of the antenna distributes fewer power on the way to the adjacent base stations, and thus much of the emitted power goes to the area that is planned to be assisted by this particular base station [19]. Furthermore, an antenna tilt modification also disturbs the cell coverage area, which restricts the tilt to practical values.

3.9.1. INFLUENCE OF CPICH POWER AND ANTENNA TILT

Fine-tuning the antenna tilt and CPICH power can set the uplink interference with in the recommended range thus network capacity will raise. And this is done by;

i. minimizing the interference between cells and pilot pollution.
ii. by setting the power resources of the base station to its optimal level.
iii. appropriate load sharing and balancing in the cells is used.
iv. SHO (soft hand over) regions should stay optimal.

3.10. INTERFERENCE ANALYSIS

In the deployed WCDMA network of Hawassa there are 53 sites and every one of them are three sectored which of them are controlled by one RNC, all are three sectored sites with a maximum of three carriers and there are a total of a total of 159 cells in the network. The interference (RTWP) value is obtained from the system using the formula [22].

$$\boldsymbol{ULRSSI = -112 + \left(\frac{PmSumULRSSI}{PmSamplesULRSSI}\right) \times 0.1} \quad \textbf{(3.8)}$$

Were:

ULRSSI represents the average of RTWP (received total wide band power) in the uplink,

-112= is the interference which is there because of the system thermal noise

PmSumULRSSI=the total sum of sampled ULRSSI on the system

PmSamplesULRSSI= no of samples and 0.1 is the resolution used to sample. Theoretically ideal value of RTWP is calculated as:

RTWP=ASC (access service class) noise for Unloaded network +Thermal noise from the system

RTWP/ULRSSI=-174dBm/Hz+2dB=-172+10*log (3.84*10^6) =-106.2dBm

Typical ASC (access service class) is 1.3db, when the service is guaranteed, it will be 2db, and it is different for different ASC, therefore for 50% system load

RTWP=-106.2dBm+3dB= -103.2dBm.

3.10.1. PILOT POLLUTION

In WCDMA networks, mobile stations in the peripheral regions covered by overlapping base stations have the ability to connect with several base stations. Pilot signals from a large number of base stations should not be present in an overlap area. As a result, pilot pollution would occur, and radio base stations would become overburdened. In WCDMA, there are three types of channels: logical, transport, and physical channels. Each wireless system organizes these channels differently from the downlink to the uplink path. In the WCDMA system, there are four sorts of logical channel categories: traffic, synchronization, paging, and common pilot channels. The radio base station (RBS) transmits a short code on the common pilot channel (Walsh code 0). While searching for the greatest power level, the mobile station continues to listen for pilot signals. The pilot signal from the base station is important for system functions including load balancing and handover measures. In terms of demodulation reference, it also acts as a reference for mobile stations. The WCDMA coding method is another factor that might have a significant impact on the pilot pollutant interference (PPI) problem. Reducing the height of the undesired antennas, introducing down tilting or change-outs, lowering the RBS broadcast power, and introducing sophisticated smart antenna systems have all been mentioned in the literature as ways to mitigate the impact of the pilot pollution interference problem. The drive test result suggests that there are numerous servers on the specified perimeter, as shown in the table below, which was tested on 1148 bins. According to the drive test done around the selected Area it shows that there is high pilot pollution so the area needs to be optimized, from all the sites which is there at Hawassa this perimeter is selected because of the availability of enough system information and necessary data Fig3.7 shows the drive test route used for this Analysis

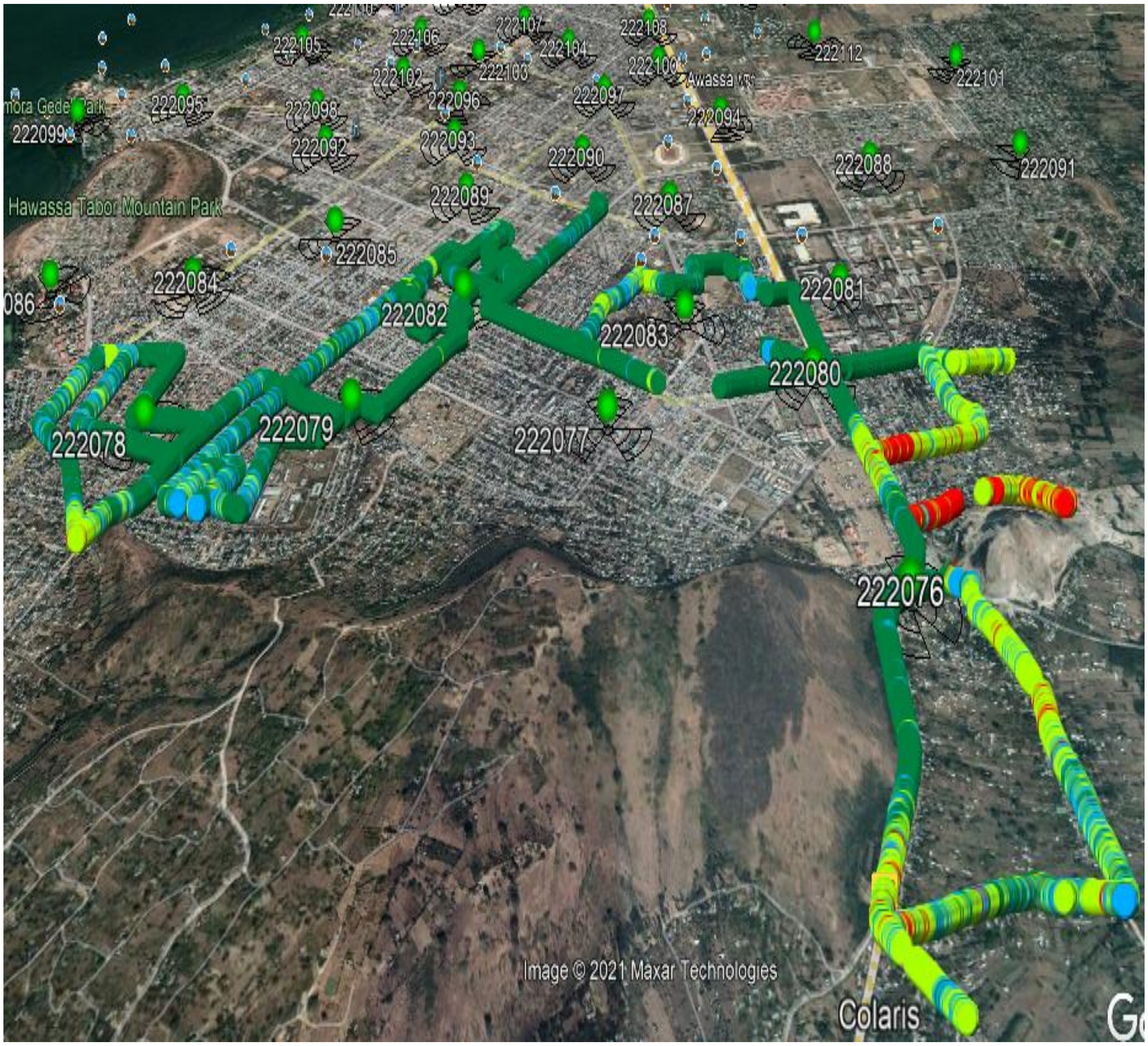

Fig 3. 6 Drive test route for interference analysis

Table 3. 3 Ethiotelecom Thresholds

Thresholds	Values indB
Pilot Pollution Threshold	-15
EcNoInterferenceThreshold	-15
Too many Server Threshold	5
RSCP_InterferenceThreshold	-80
HighUE_TxPower	15
LowUE_TxPower	-15
Poor EcIo Threshold	-15
Exececssive Time Threshold	6000

Table 3. 2 drive test results

Events	Occurences
MeasurementBins	11864
Pilotpollution	17
TooManyServers	168
Coverage issues	65
SystemInterference	27
Call Attempts	170
Call Failures	38
Excessive Setup Time	7
Dropped Calls	15
Softer Handoff	1311
Soft Handoff	3900
Soft-softer Handoff	152
3-way Softer Handoff	35
3-way Soft Handoff	446
Handoff_Attempts	841
Handoff_Fail	0

managing the execution of Radio Access Bearer (RAB), which is intended for information transfer and Radio Resource Control (RRC) for signaling is vital to a telecom operator. The RAB and RRC's failure rate are the two KPIs that are evaluated weekly by ethio telecom. From the evaluation we do on two RNC`s The RAB's failure rate for Hawassa network is above 2%, which is above the base line for ethio telecom network. The evaluation of RAB failure rate for the two of Radio Network Controllers (RNCs) serving Hawassa and around are shown in Figure 3.8 (below).

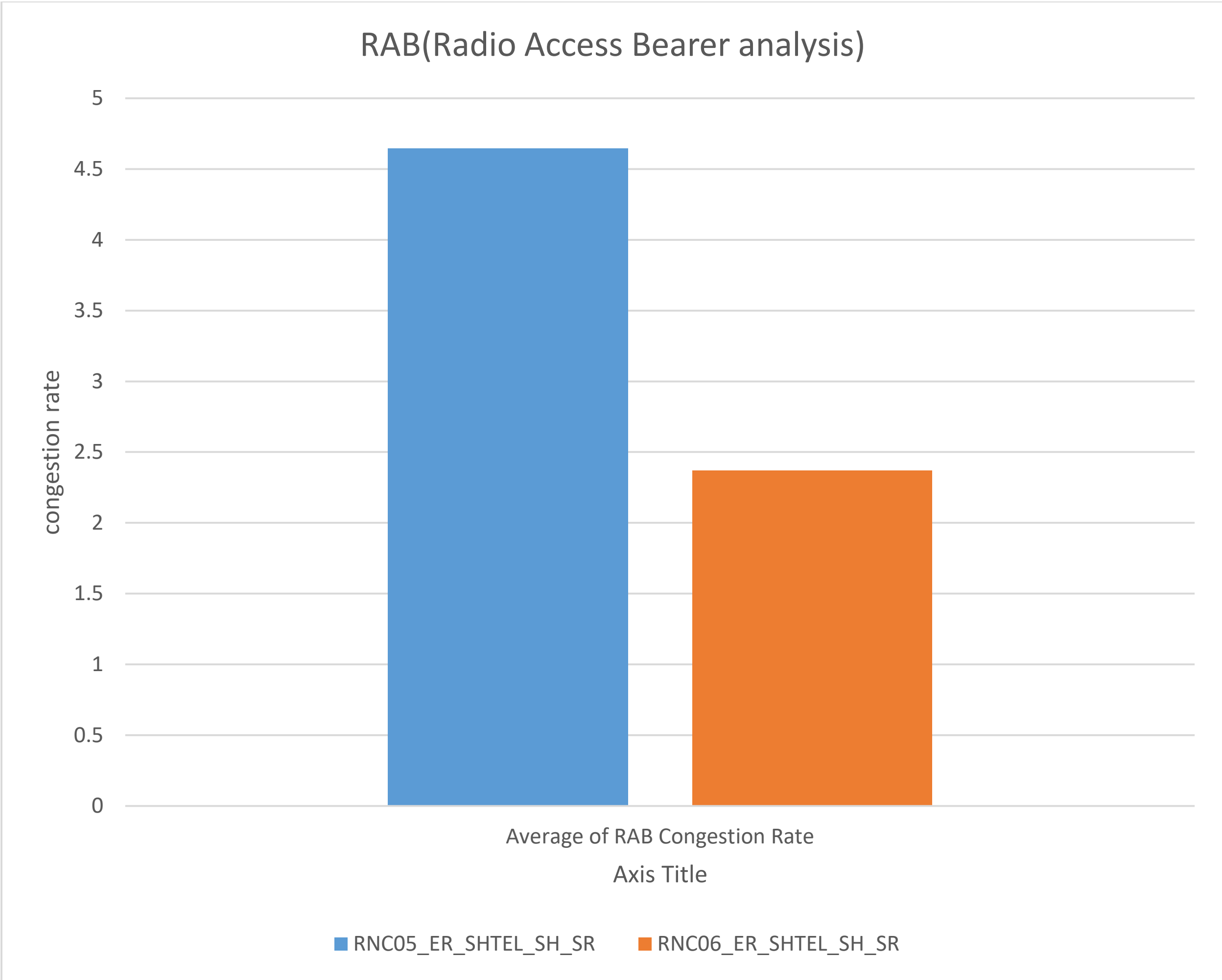

Fig 3. 7 RAB (radio access bearer) analysis for the current(January 1 to 30 2021) network of Hawassa

CHAPTER 4

4. METHODOLOGY

The technique of optimization is an ongoing operation. It is conducted repeatedly until the required network performance baseline is acquired. KPI (key performance indicator) conveys the performance of a network. therefore, this research paper is completely founded on books which is about WCDMA Network Optimization, 3GPP standardization credentials, diverse IEEE journals and articles, former researches on this subject.

The research has started by exploiting performance data from the network element for Hawassa WCDMA services. The research work is followed by surveying the system parameters and configuration on simulating software WINPROP.

The methodology will have the following steps

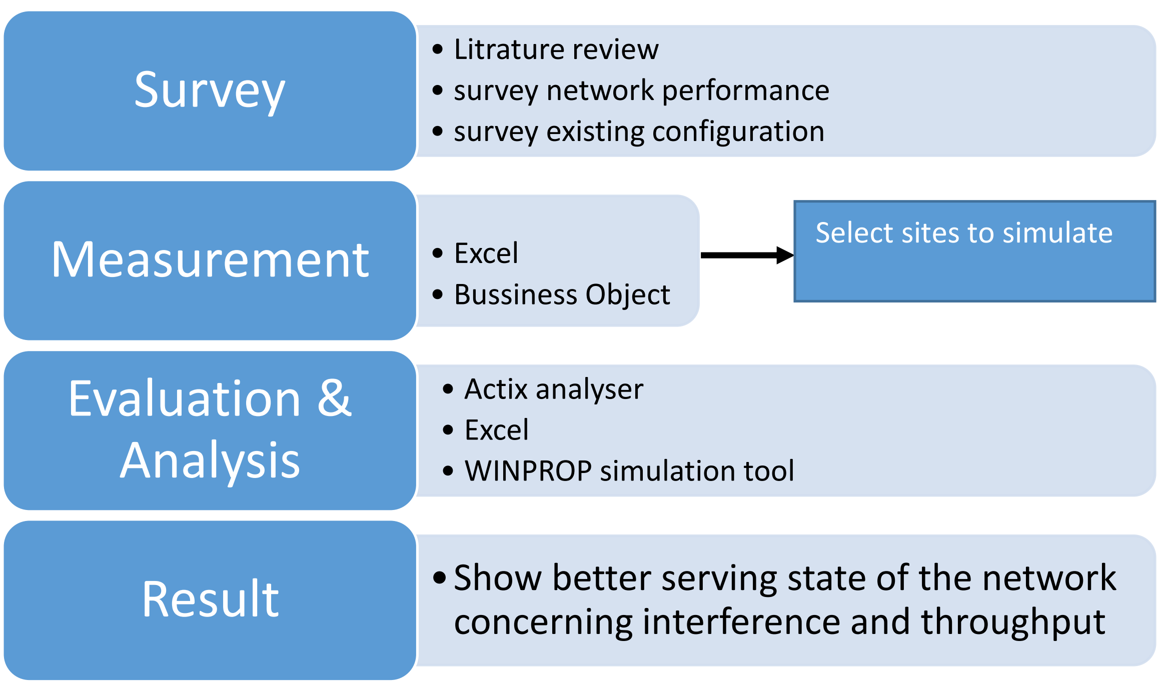

Fig 4. 1 Research Methodology

4.1. OPTIMIZATION APPROACH

In a WCDMA network a cell theoretical spectral efficiency is evaluated using the load equation whose derivation outlined below, initially we determine $^{Eb}/_{N0}$, the quotient of energy per user b it and the noise spectral density[31]:

$$\left(\frac{\boldsymbol{Eb}}{\boldsymbol{No}}\right)_{\boldsymbol{j}} = \boldsymbol{processing\ gain\ of\ user\ j} \times \frac{\boldsymbol{signal\ of\ user\ j}}{\boldsymbol{total\ recived\ power(except\ own\ signal)}} \quad 4.1$$

This can be written:

$$\left(^{\mathrm{Eb}}/_{\mathrm{N0}}\right)_j = \frac{W}{V_j R_j} \times \left(\frac{P_j}{RTWP \times PL_j - P_j}\right)$$

Where:

W =is the chip rate, PL_{j} = path loss

Pj =is the received signal power from user j, Rj =is the bit rate of user j, and

v_j =is the activity factor of user j

Itotal= RTWP (Total received wideband power) together with thermal noise power at the radio base station. resolving for Pj provides: -

$$\boldsymbol{P_j = \frac{1}{1 + \frac{W}{(^{Eb}/_{No})_j + R_j + V_j}} \times RTWP \times PL_j} \quad \textbf{(4.2)}$$

We define P_j as:

$$\boldsymbol{P_j = L_j \times PL_j \times RTWP} \quad \textbf{(4.3)}$$

and acquire the load factor L_j of one connection

$$\boldsymbol{L_j = \frac{1}{1 + \frac{W}{(^{Eb}/_{No})_j + R_j + V_j}}} \quad \textbf{(4.4)}$$

excluding the thermal noise P_N, the total received interference (RTWP), can be scripted as the aggregate of the received powers from all N subscribers in the same cell.

$$\boldsymbol{RTWP - P_N = \sum_{j=1}^{N} P_j = \sum_{j=1}^{N} L_j \times RTWP} \quad \textbf{(4.5)}$$

the fraction of the total received wideband power to the noise power is defined as noise rise [31]

$$\boldsymbol{Noise\ rise = \frac{RTWP}{P_N}} \quad \textbf{(4.6)}$$

And utilizing equations 4.2 we can achieve:

$Noise\ rise = \frac{RTWP}{P_N} = \frac{1}{1-\sum_{j=1}^{N} L_j} = \frac{1}{1-n_{ul}}$ where we have determined the load factor n_{ul} as

$$\boldsymbol{n_{ul} = \sum_{j=1}^{N} L_j} \quad \textbf{(4.7)}$$

noise rise approaches to infinity when n_{ul} close to 1. and the system will arrive its pole capacity. Furthermore, the interference from the other cells also needs to be considered by the ratio of another cell to own cell interference (i), in the load factor equation.

$$\boldsymbol{i = \frac{other\ cell\ interference}{own\ cell\ interference}} \quad \textbf{(4.8)}$$

The uplink load factor subsequently scripted as:

$$\boldsymbol{n_{ul} = (1+i) \times \sum_{j=1}^{N} L_j = (1+i) \times \sum_{j=1}^{N} \frac{1}{1 + \frac{W}{(Eb/No)_j \times R_j \times V_j}}} \quad \textbf{(4.9)}$$

The load equation guesses the value of noise rise above thermal noise because of interference. Noise rise is equivalent to $-10 \times \log_{10}(1 - n_{ul})$. From link level simulation measurements, the needed Eb/No can be dragged. It incorporates the impact of soft handover and closed loop power control. The fraction of other cell to own cell interference $i,$ is a function antenna setup and cell isolation or environment.

The value of total interference in a cell (RTWP) can be low, medium, and high. Despite those the highest and lowest values, are utilized only as a base line since these values may be produced by high utilization of resources.

From the perspective of giving information about mobile coverage, National Regulatory Authorities (NRAs) are recommended to choose the criteria based on the strength of the signal received [19]. A given area is declared in coverage if the average received signal power in that area is greater than a pre-specified minimum. In this research, -100 dBm is taken as a threshold because 83% of the NRAs in Europe using 100dBm and less.

The problem which is selected here in this thesis needs optimization and it is A multi objective when coverage constraint is considered, which is described in terms of the received power within the receiver sensitivity threshold and the $Eb/_{No}$ requirement for the services used by a UE. For M number of base station in the network ,Thus, the function f in Equation (4.10) denotes the objective function:

$$-100 \leq f(\frac{1+i}{n_{ul}} \sum_{m=1, m \neq j}^{M} (\sum_{j=1}^{N} \frac{P_j}{CPICH_{pwr} + RSCP_j})) \leq -106 \qquad \textbf{(4.10)}$$

When RTWP rises the interference level from the other cell rises because I is a ratio of other cell to own cell, services for own cell deteriorates because the allowed load is fixed. Path loss also has negative effect for service deterioration for own cell much of the resources get wasted for soft handover where path loss, $PL = CPICH_{pwr} - RSCP$ pilot signal power plays roles for path loss so that the pilot signal power should be tuned.

Path loss is a constraint which should be considered, most of national regulatory agencies in Europe applies the received power by the UE which is less than -100dBm should not be more than 5% as the threshold, to determine the coverage of a cell [8]. While adjusting the two parameters CPICH power and antenna tilt for mitigating interference the coverage of the cell should be kept within the threshold, for the purpose of showing that the base line is kept this paper uses CDF (cumulative distribution function) to examine all received powers by the UE whether it lies within the base line:

$$f(RSCP) = P(RSCP \leq -100dBm)$$

$$P(RSCP \leq -100dBm) \leq 5\%$$

Where;

RSCP= received code power

4.2. SYSTEM MODELLING, SCENARIOS AND ASSUMPTIONS

4.2.1. TOOLS

WinProp and Excel are utilized for the network simulation and analysis respectively. WinProp is a software which have highly precise and very quick empirical and deterministic propagation models that are accessible for a wide range of conditions like rural, urban, indoor, tunnel and vehicular. It works with a wide range of transmitters, including cellular and broadcast sites, satellites, repeaters, and leaky feeder cables. WinProp is a well-known software in the field of wireless propagation and radio network planning, and it is detailed in depth in [19]. WinProp calculates the capacity of different radio links of cells, such as throughput, maximum data rates, packet delays, and QoS in the network. Coverage analysis and traffic assumptions are used in the calculation.

Capacity constraints and overloaded cells can be identified immediately, and systems can be tuned for high capacity and throughput. ProMan, Aman, WallMan, CoMan, TuMan, and CompoMan are the six WinProp software suites. Three of them (ProMan, Aman, and Wallman) were employed in the network simulation. ProMan is a software package that is meant to precisely anticipate path loss between transmitter and receiver, taking into account all of the crucial parameters of the mobile radio channel. Network planning components are available for 2G/2.5G, 3G, WLAN, and WiMAX networks. To anticipate the path loss between two random places, radio network planning technologies rely on precise wave propagation models. Aside from object shielding and multipath propagation, the antenna pattern of the communication link's antennas has an impact on the actual path loss. AMan was created for this purpose, and it uses a user-friendly Windows interface to handle antenna designs. WallMan is a powerful graphical user interface that makes it easy to alter various sorts of building databases. Databases are used in all of Win Prop's calculations including wave propagation modeling in urban and interior environments.

Finding the best answer to the challenge, which necessitates a practical arrangement of the sites using simulation, is not easy. An educated guess, which is included in the metaheuristic algorithms, is used to select near ideal solutions. The tuning parameters are variables of the function which is used to find the optimal solutions. The approach is to simulate by varying tuning parameters individually and in combination. Fig 4.2 describes what is we are doing specifically in this research.

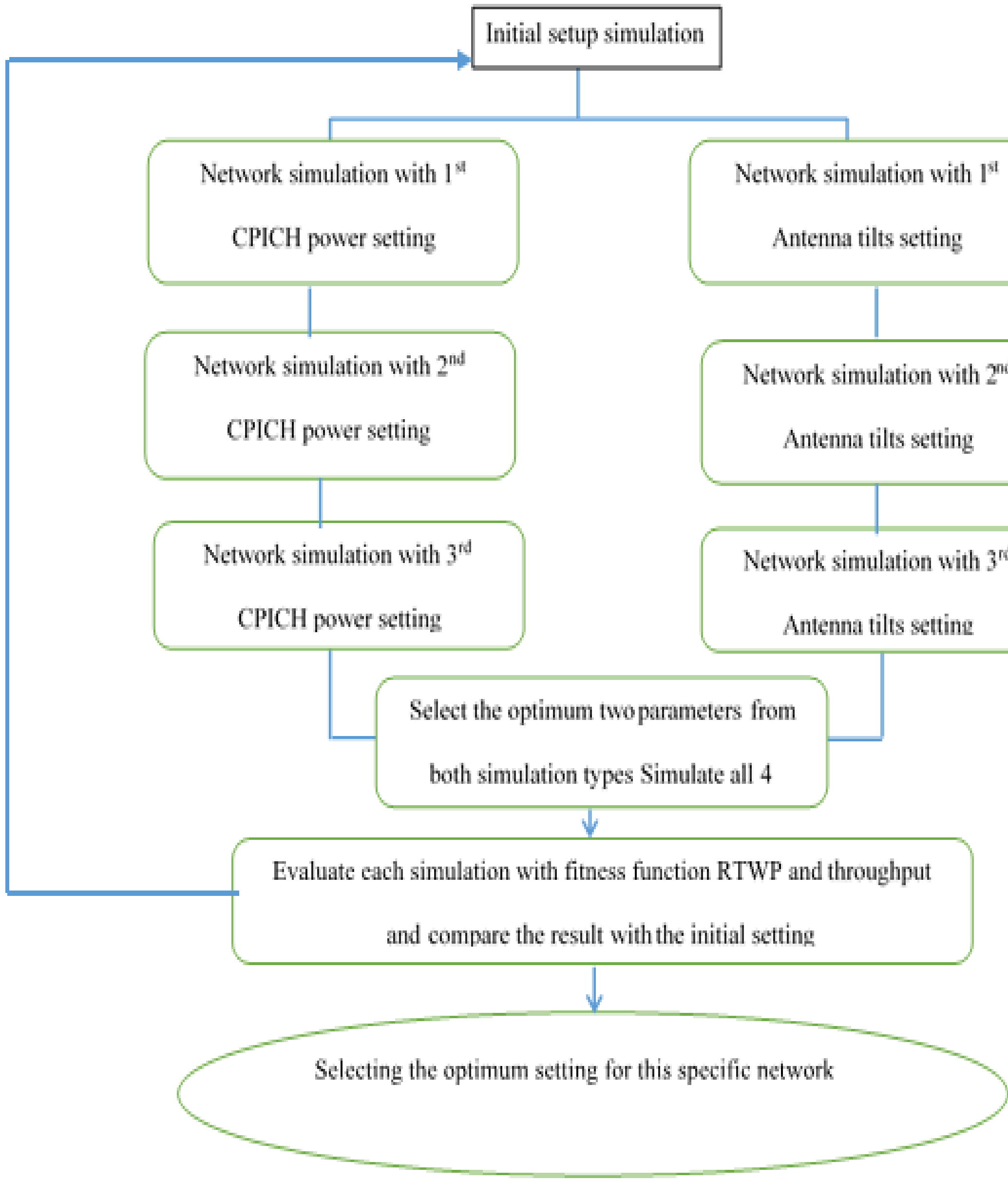

Fig 4. 2 way of searching solution for the problem on this research

4.2.2. PROPAGATION MODEL

Win Prop offers various wave propagation models, and the dominant path model is among these models. The Dominant Path Model (DPM) is not based on all power rays between the transmitter and receiver, which contribute to the total power received with similar energy. In terms of energy input, only a few propagation pathways are prominent [19]. The DPM can be used indoors, in cities, and in rural areas. It just calculates the dominant paths and ignores the routes with a low energy contribution.

4.2.3. SELECTED SITES/AREA

Sample UMTS sites are chosen for the network simulation and to work on the optimization of RTWP (uplink interference) and network capacity. For this study, a 7.5 square kilometer, which consists of new bus station hot spots. Currently, 7 WCDMA sites with three sectored cells are deployed in the specified location. Fi4.3 shows the snap shot of the area from simulating tool WINprop, the color variation is shows that the coverage of each sites located in the middle of each colored area.

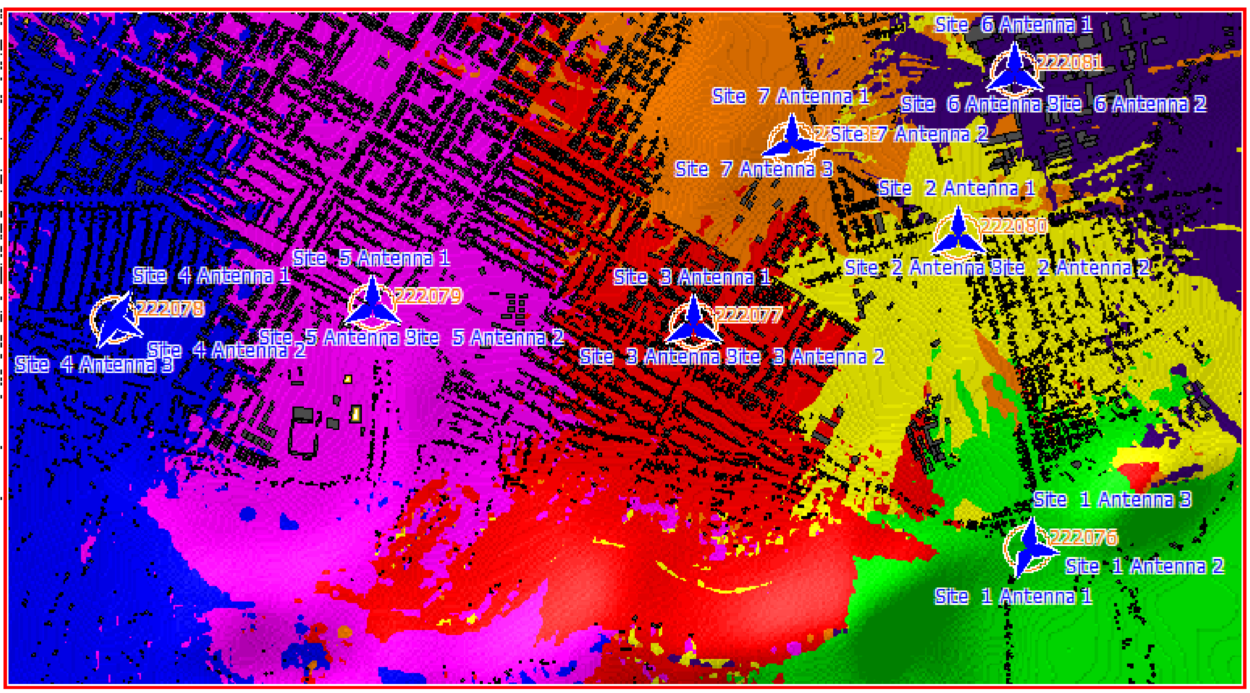

Fig 4. 3 selected Area for evaluation

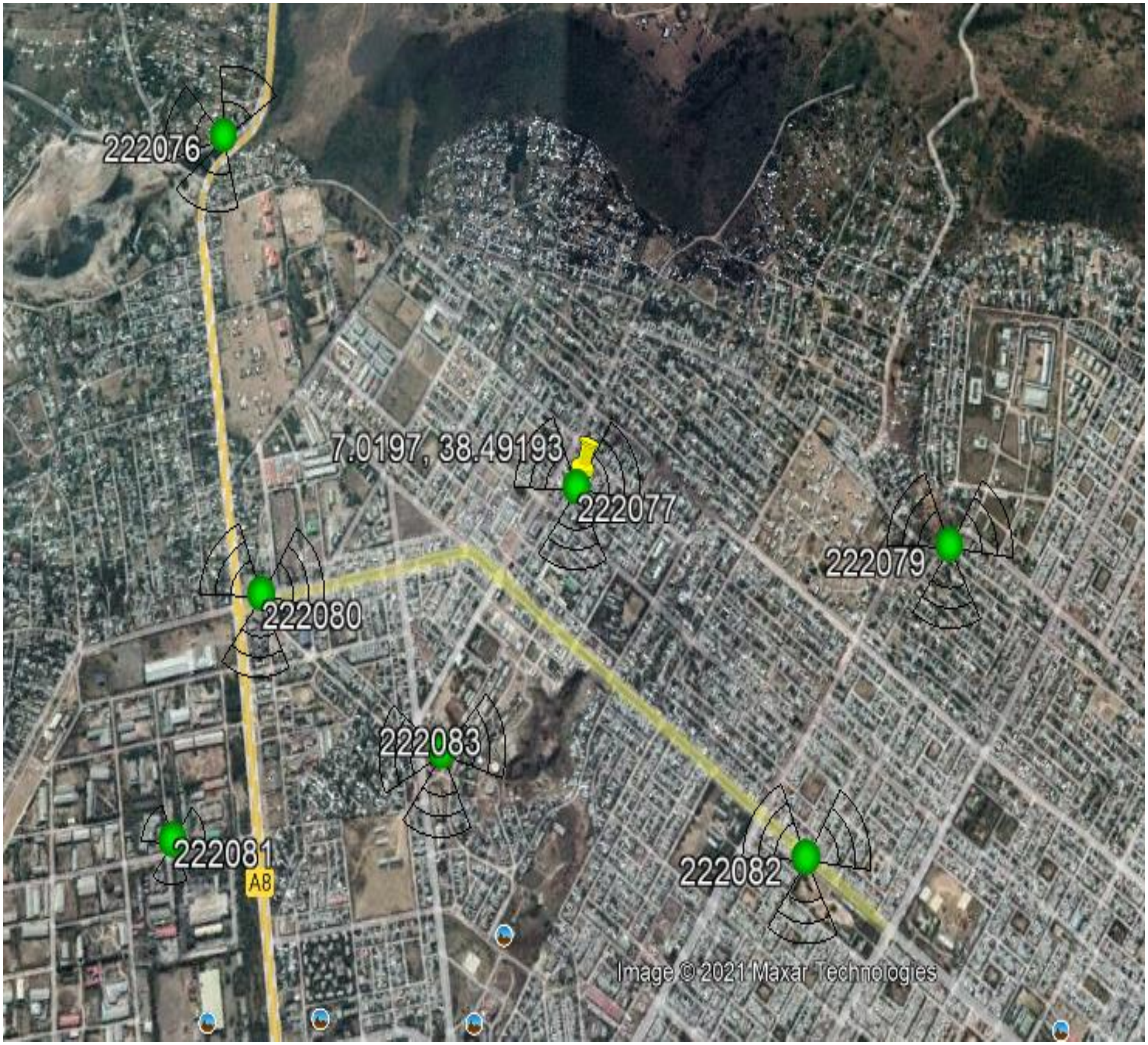

Fig 4. 4 selected Area for evaluation the view on Google Earth

4.3. ASSUMTIONS AND PARAMETERS

Simulation assumptions and parameters used for the specified area are as per the existing configuration and shown in Table 4.1

Table 4. 1 Simulation assumptions and parameters

parameters	Assumptions
Air interface	**One 5 MHz carrier (DL/UL frequency 2112.4/2127.4 MHz), 3.84 Mchips/s, Duplexing scheme FDD**
MS height	**1.5m**
Propagation modeling	**Dominant path model**
Antenna	**Kathrein_742212**
Voice activity	**Uplink: 0.67**
Resolution of prediction results	**15mx15m**
UE	**Omnidirectional 1 dB body losses, 6 dB noise figure, Antenna Gain 1dBi, Transmit Power 23dBm**
Simulation	**Static simulation which is homogeneous traffic per cell**
i	**0.65**

4.4. SCENARIO DESCRIPTION

Description of the scenarios used to perform performance evaluations is presented in this section and shows the network capacity and noise rise for all the parameters considered for optimization. In all scenarios, the assumptions and parameters in network simulation are the same except the changes of Pilot power, and electrical antenna down tilt.

In the first scenario, Pilot power with values of 12.5%, 5%, and 7.5% are used. In this scenario, electrical antenna down tilt of the cells are kept as they are configured in the existing network.

In the second scenario, electrical antenna down tilt by 2, 4 and 6 degrees are used. In this scenario, Pilot power of the cells are kept as they are configured in the existing network. In the third scenario, the combinations of the two parameters are selected by choosing the two near optimal solutions from each of them. Thus, pilot power (7.5 and 5%), and electrical antenna down tilt (4 and 6 degrees) results in four combinations as shown in Table 4.2.

Table 4. 2 combination of selected parameters

configuration	CPICH power	Antenna electrical tilt
Config1	**5**	**2**
Config2	**5**	**4**
Config3	**7.5**	**2**
Config4	**7.5**	**4**

CHAPTER 5

5. RESULTS AND DISCUSSION

The current existing configuration parameters of 3G sites in Hawassa are used to simulate the four scenarios mentioned in the previous chapter. In the first simulation, the default configuration parameters of the Pilot power (10%), and electrical antenna down tilt were used. The results from this simulation were used as a reference for the optimization of the two network performance indicators that are capacity and interference of the network. One of the constraints is the received power by UE should be within the acceptable range as per the target defined. The received power also indicates an acceptable range of the coverage hole which is allowed in the network. In this simulation, the mean network capacity of the selected sites is 6.57 Mb/s, with -94db of the mean interference. The downlink received power below the threshold is 1.8% as shown in Figure 5.1.

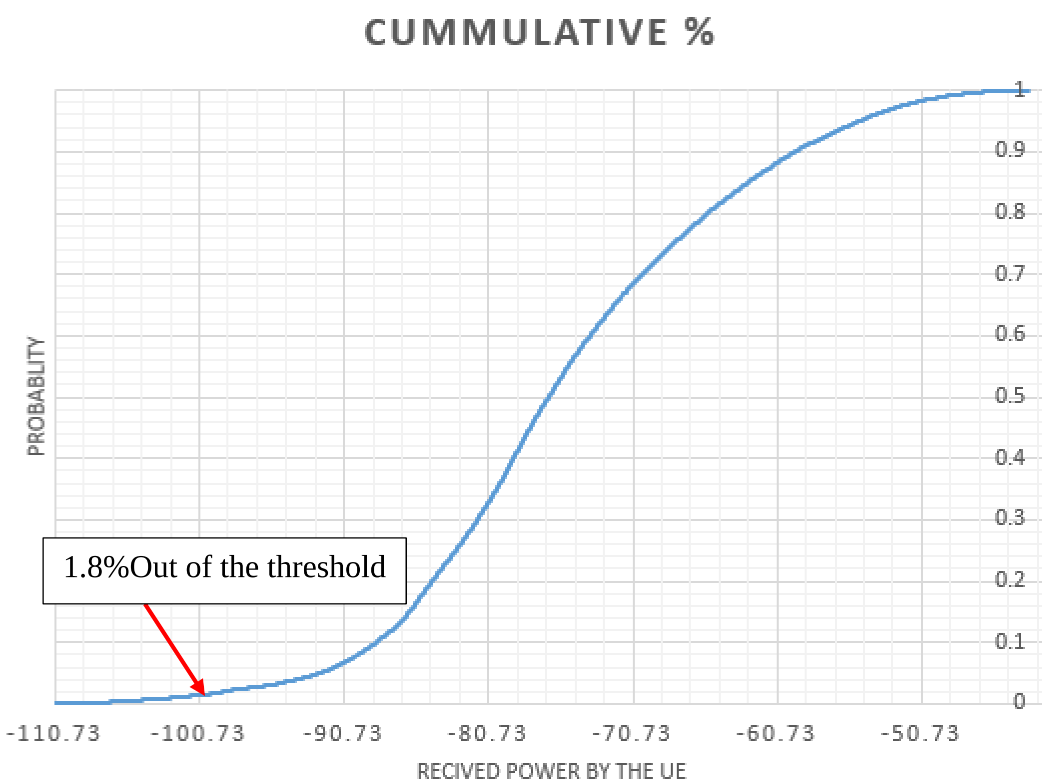

Fig 5. 1 Received power level of the original setting

In the first scenario, the CPICH power was used as a tuning parameter, and the results for the capacity and interference are shown in Figure 5.2 and fig 5.3. The interference is decreasing as CPICH power is decreasing until the same point were capacity drops using pilot power 12.5% of the total BTS is used, while throughput is increasing with decreasing the pilot signal power, using the lowest percentage of pilot signal power in our case 5% of the total assigned power for the BTS decreases the coverage as shown in fig 5.4.

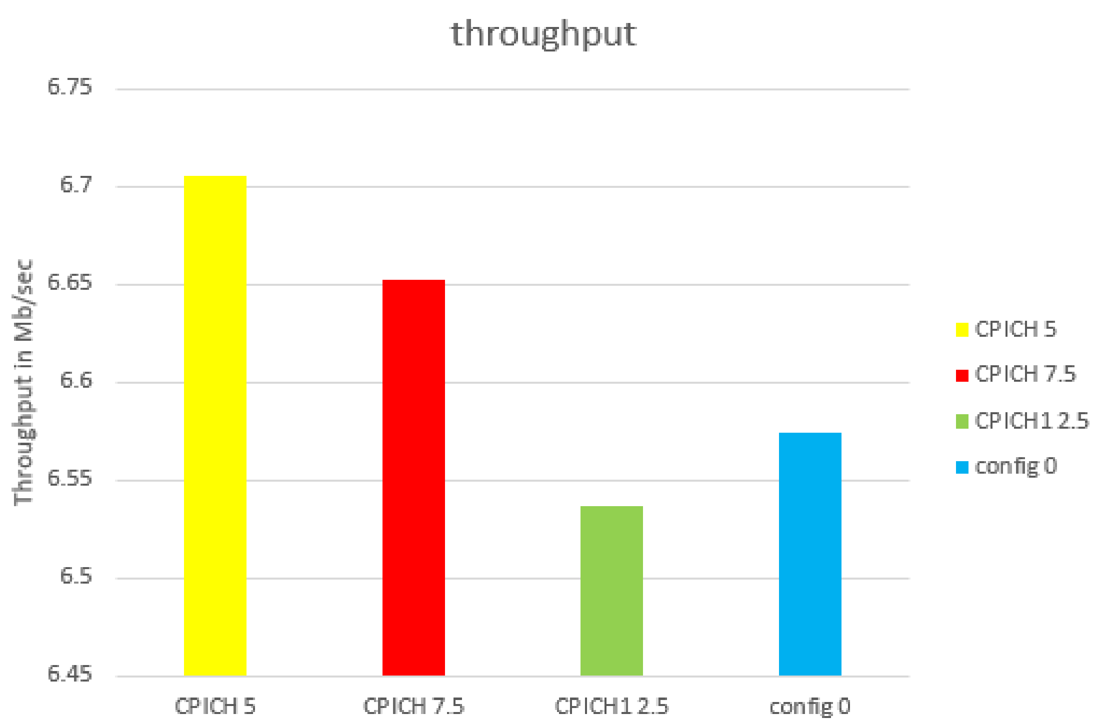

Fig 5. 2 CPICH power tuning with throughput

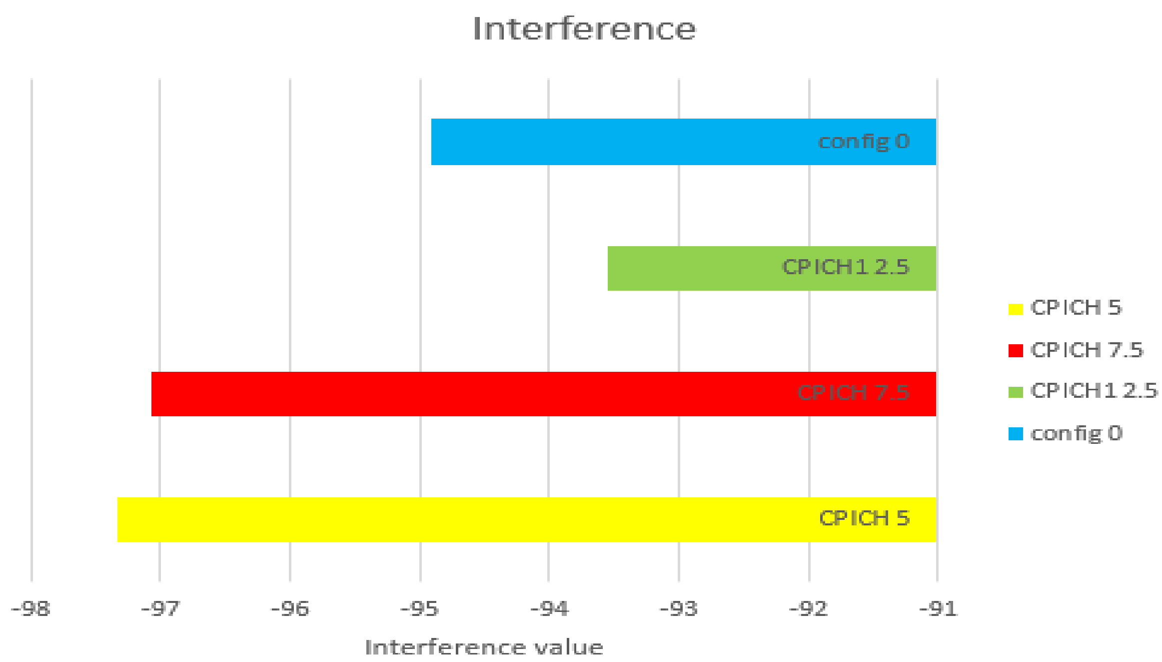

Fig 5. 3 CPICH power tuning with interference

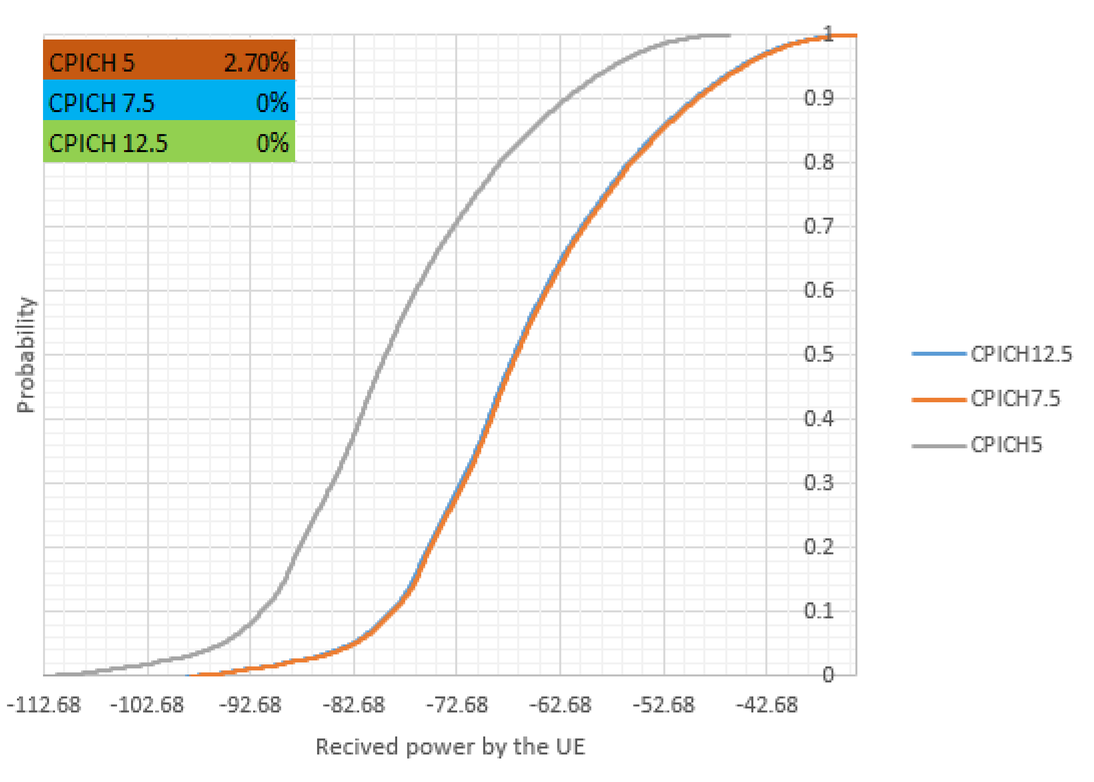

Fig 5. 4 received power for different CPICH power

In the second scenario, Antenna electrical tilt was used as a tuning parameter, and the results for the capacity and uplink interference is shown in Figure 5.5 and 5.6. network capacity is increasing as antenna tilt is decreasing and, in the uplink, interference is increasing, with all selected tilts the received signal power level is not violated, keeping the coverage as it is.

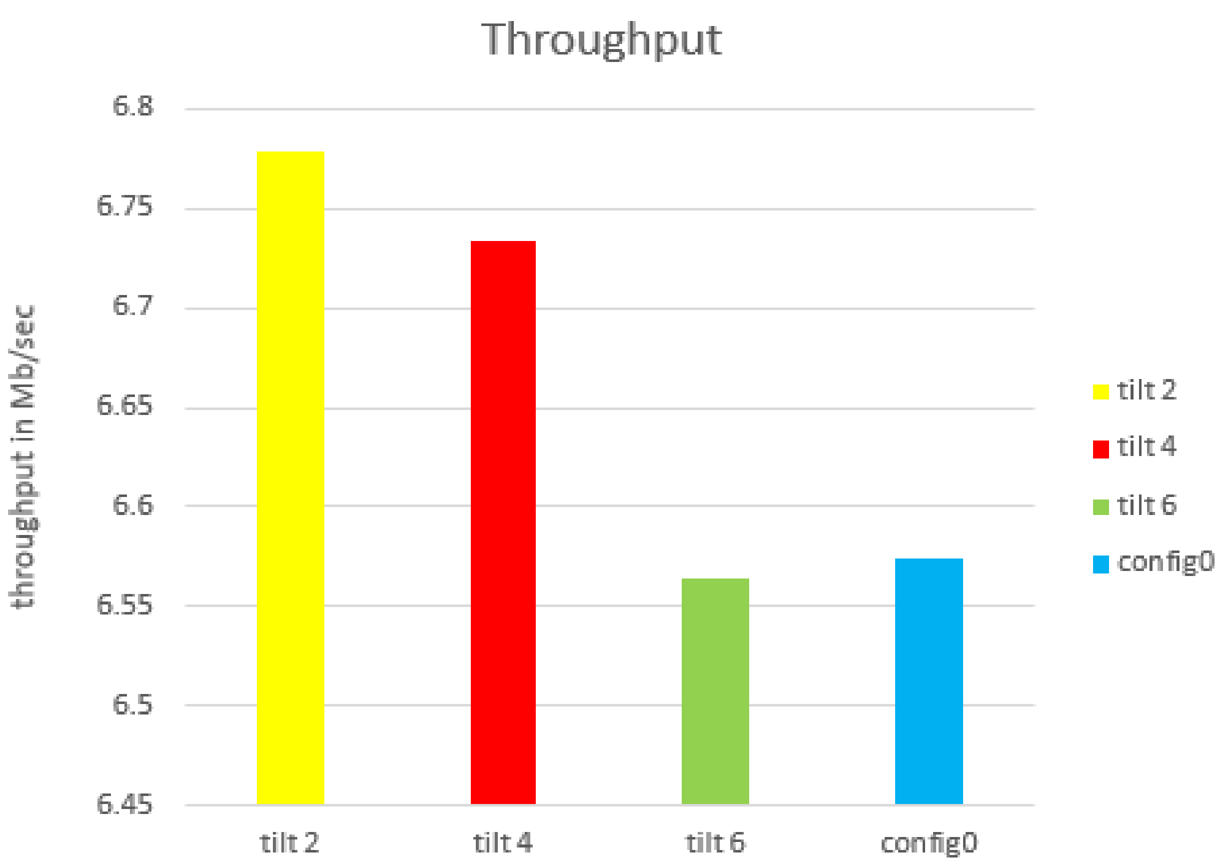

Fig 5. 5 Antenna electrical tilt tuning with throughput

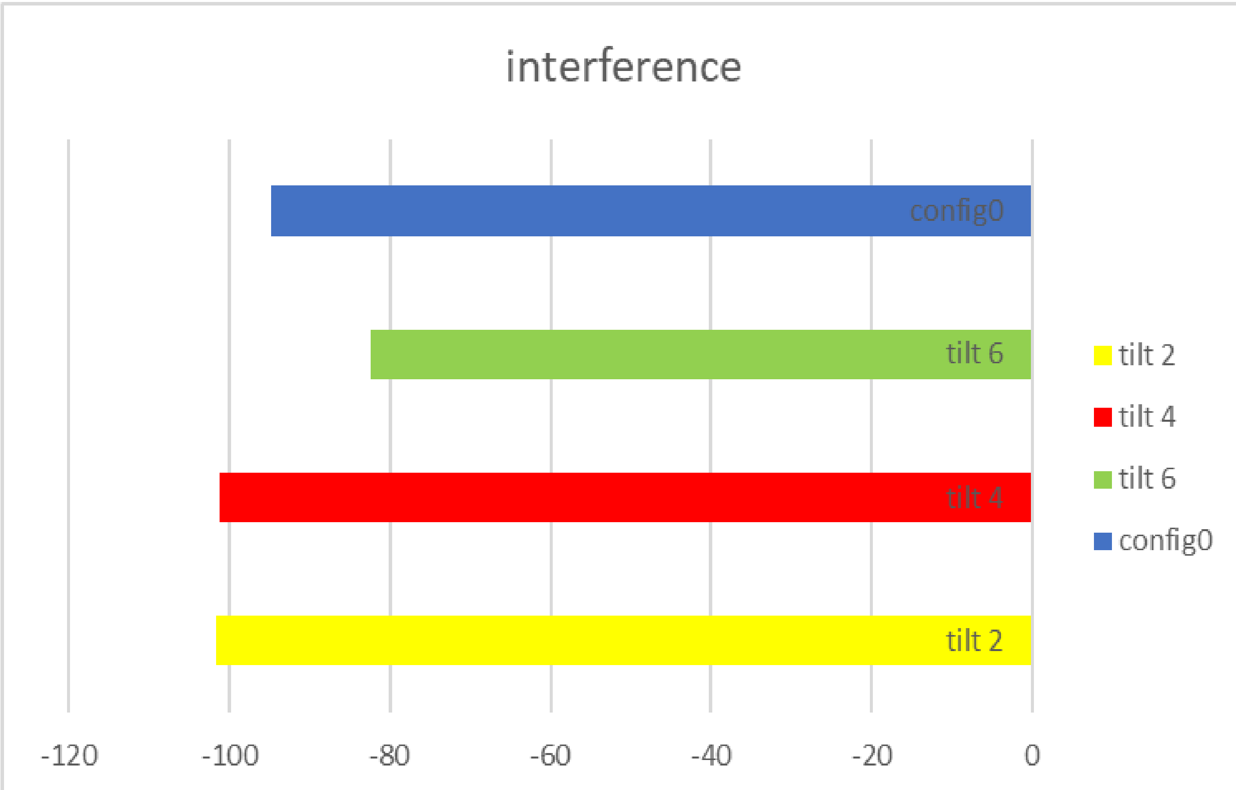

Fig 5. 6 Antenna electrical tilt tuning with interference

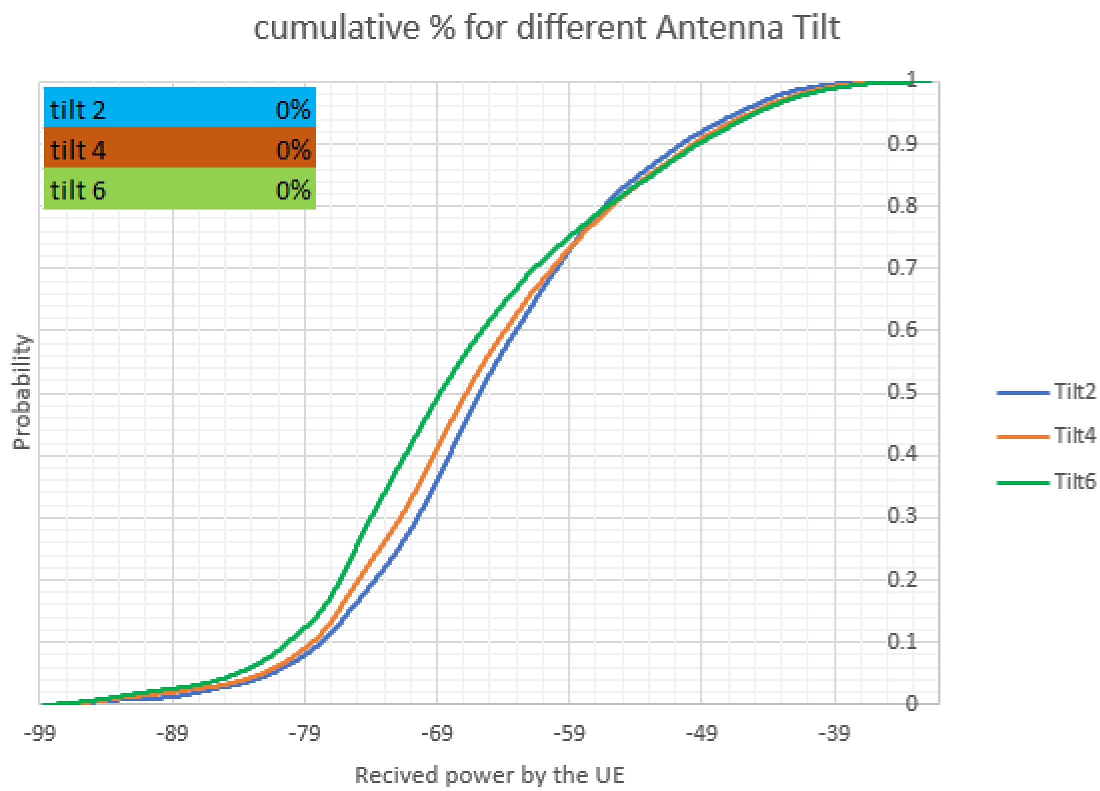

Fig 5. 7 received power for different Antenna tilt power

In the third scenario, the combinations of the two tuning parameters were used, and the results for the capacity and interference is shown in Figure 5.8 and Figure 5.9. Comparing with the two scenarios, here improvements are observed in both the reduction of interference and increment of network capacity. Their respective received power using CDF is shown in Figure 5.10. The downlink received power below the threshold is between 1.4 and 2.6% which is still within the acceptable range

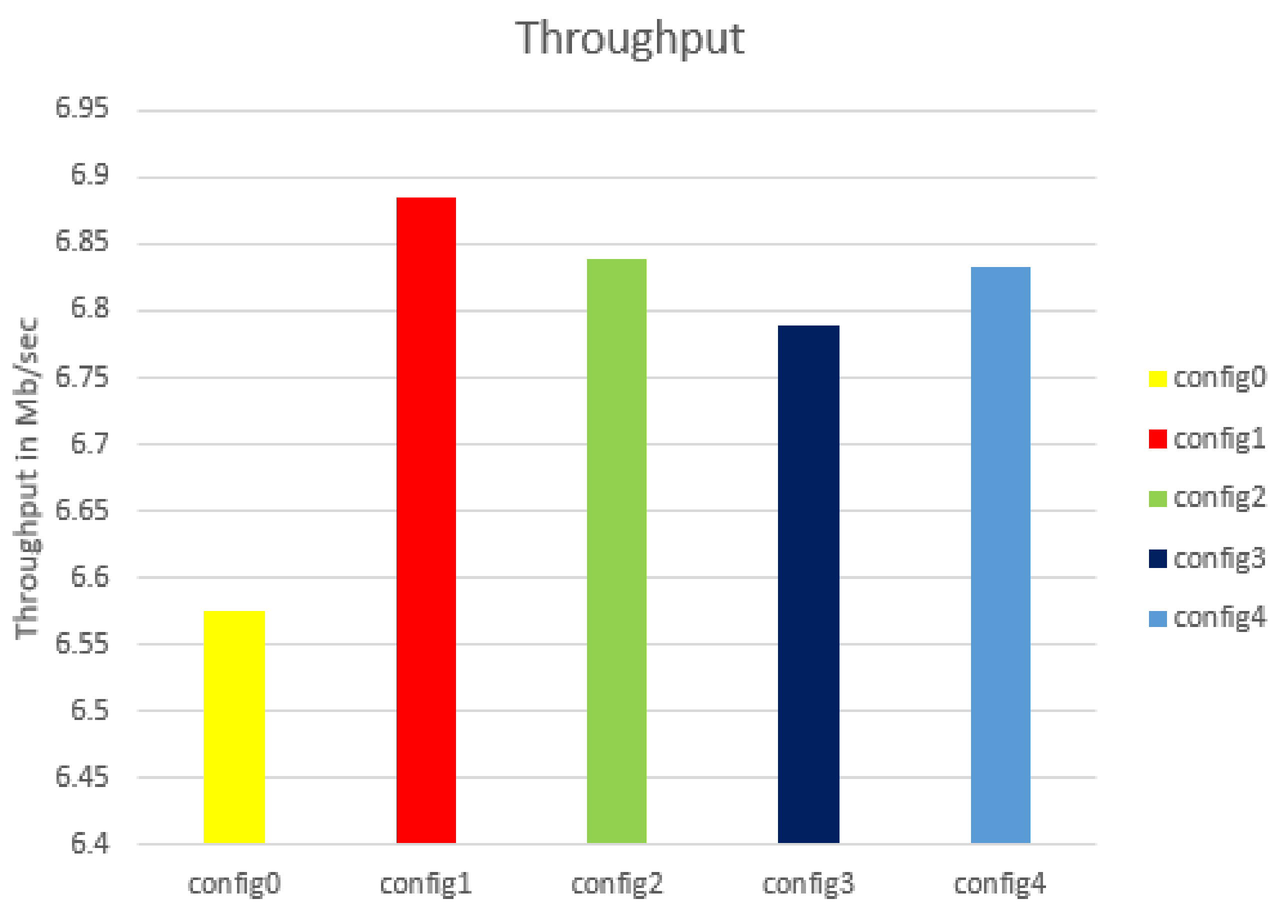

Fig 5. 8 throughput for combination parameters

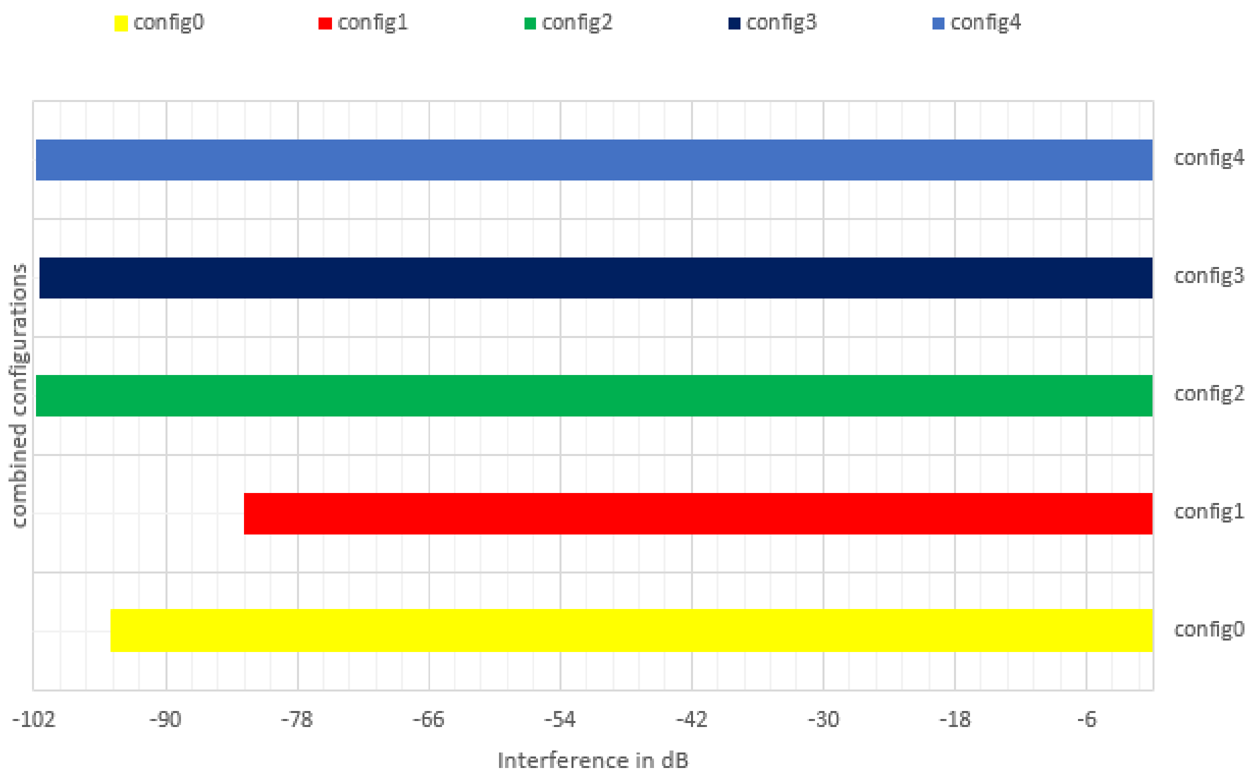

Fig 5. 9 Interference for combination parameters

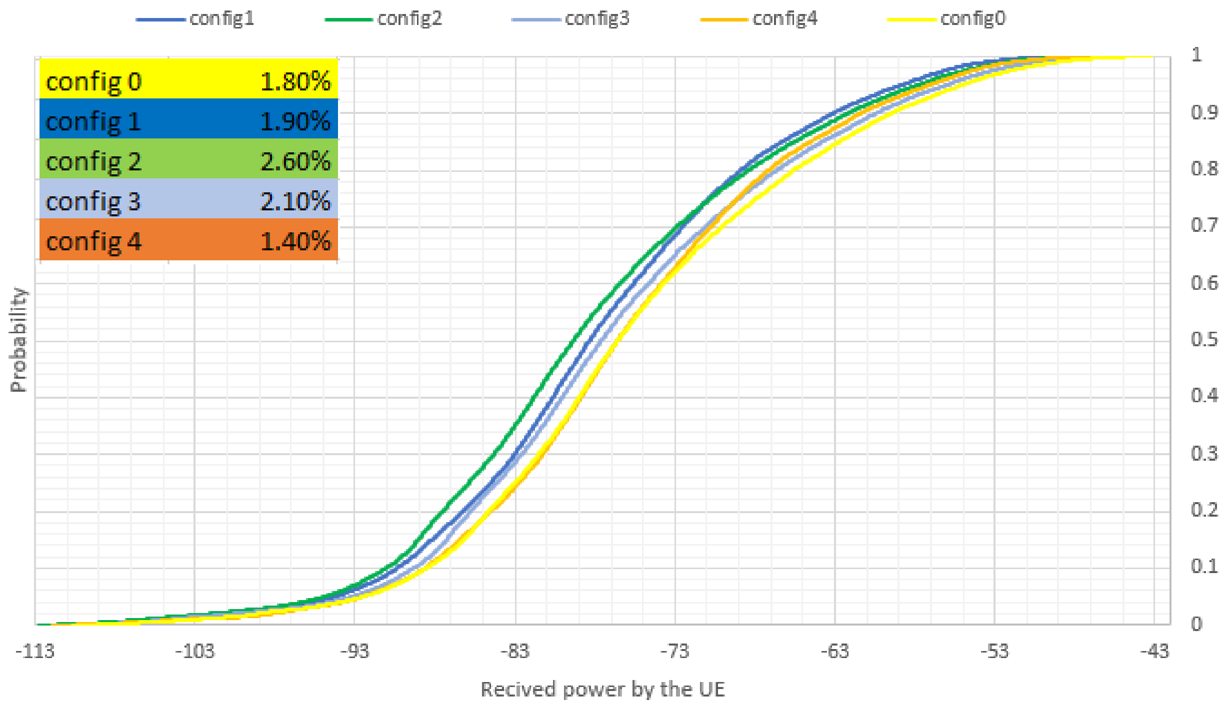

Fig 5. 10 received power for combination parameter

DISCUSSIONS

The results show that the interference could be reduced, and the capacity could be increased by tuning the two parameters fulfilling the constraints defined. In the first scenario, two near optimal solutions were chosen using an educated guess, which is one of the heuristic algorithms. A plot of Network capacity and total interference is used to select near optimal

solutions. Antenna tilt configuration of CPICH5 and CPICH7.5 is taken as near optimal solutions as interference is minimized and the capacity of the network is increased as you can see in Figure 5.11. The interference could be reduced by 2.43db and 2.2db and the capacity increased by 0.13Mb/sec and 0.08Mb/sec from the default configuration in case of using CPICH power 5% of the total BTS power and 7.5 % respectively. These two CPICH power values that were used for the better optimization of the network capacity and interference.

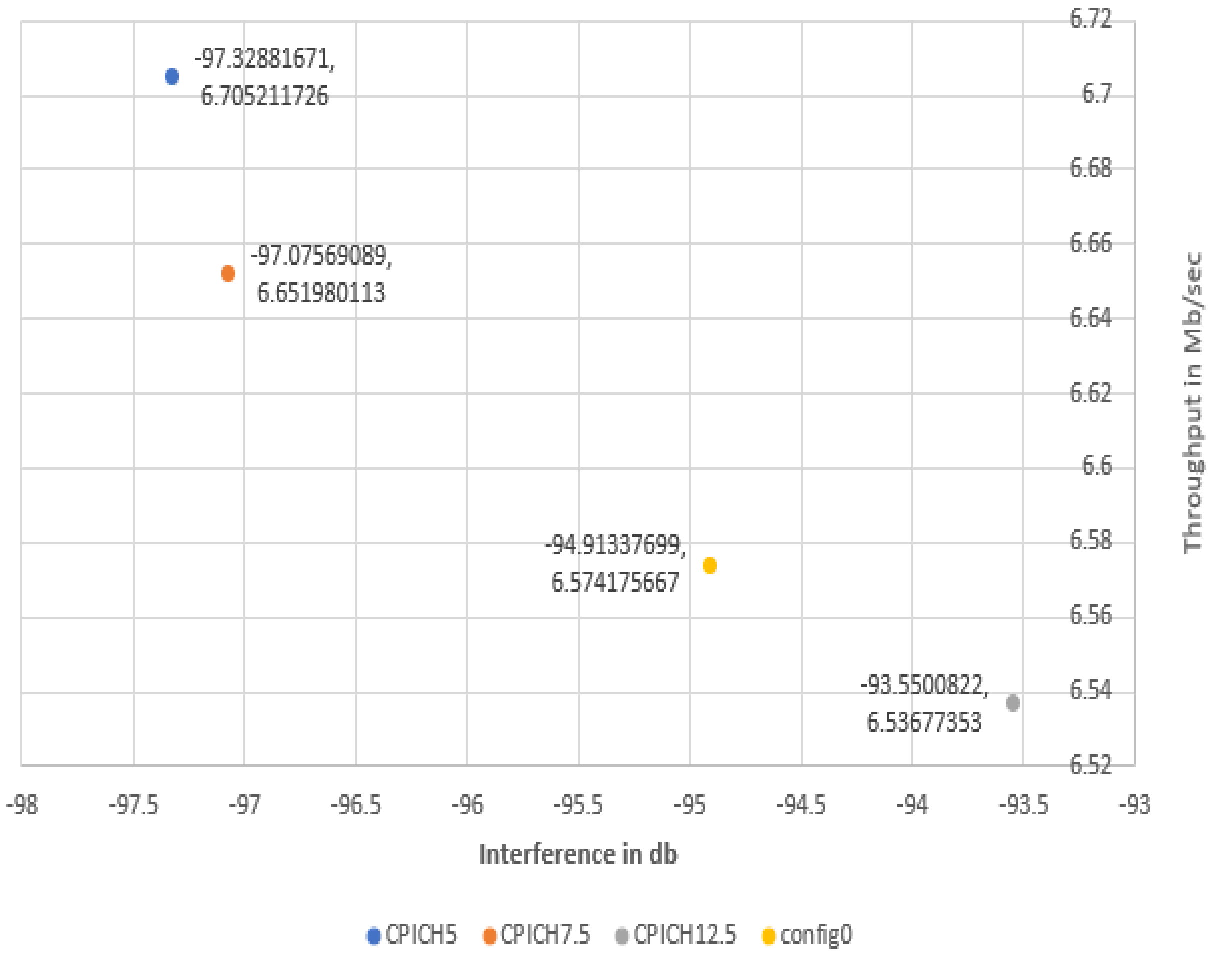

Fig 5. 11 capacity Vs interference for different CPICH signal power

In the second scenario, Antenna electrical tilt of 2 (tilt2) and Antenna electrical tilt of 4 (Tilt4) were taken as near optimal solutions as capacity is maximized with a decreasing interference

Compared with the default configuration as you can see in Figure 5.12. The capacity could be increased by 0.21Mb/sec and 0.16Mb/sec and the interference decreased by 6.7db and 6.32db from the default configuration in case of using antenna electrical tilt values of 2 and 4 respectively. These two electrical antenna tilt values were used in combination with the CPICH power parameters for the better optimization of the capacity and interference.

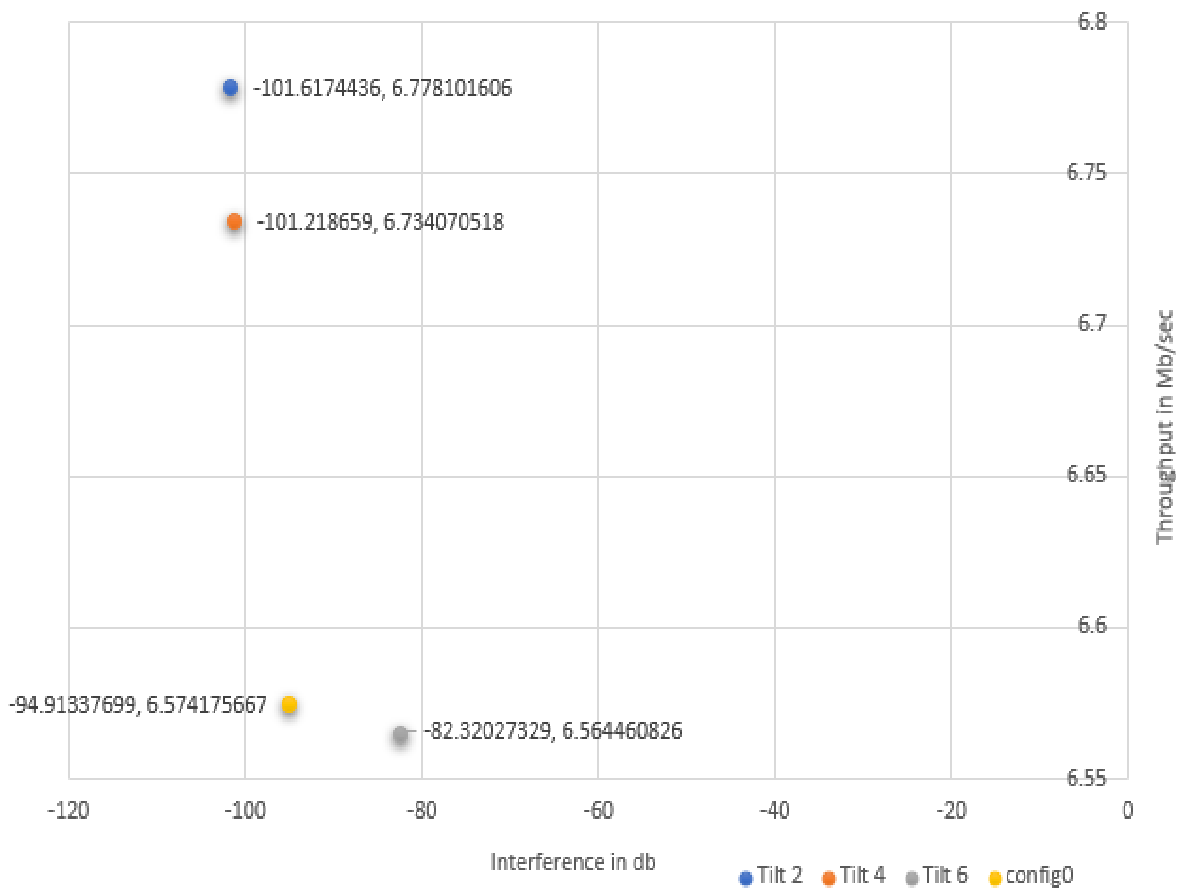

Fig 5. 12 capacity Vs interference for different Antenna tilt.

In the Third scenario, there was a reduction of interference and increment of network capacity for all combined cases except for Config 1(CPICH5 and Antenna tilt2) comparing with the default configuration as shown in Figure 5.13. The network capacity could be increased within the range of 0.22Mb/sec to 0.31Mb/sec and the interference could be reduced within the range of 6.58db and 6.98db except for config1 which increases the interference by 12.13 from the default configuration and this configuration is rejected because of the high interference it caused on the system high interference means the cell is over loaded. in Table 5.1 all configuration outputs are listed. The configurations named config1, CPICH12.5, Antenna tilt6 increases the interference by 12.8%,1.44% and13.67% respectively and configuration named byCPICH12.5 and Tilt6 decreases the capacity by 0.57% and 0.15% respectively. In this scenario, the capacity gain was increased by 2.04% and 0.94% compared with the Second and first scenarios respectively. Besides, the interference was reduced by 4.653% and 0.135%, contrasting with the first and second scenarios respectively. Thus, using combined Parameters brought improvement rather than using a single setting in optimizing interference and network capacity.

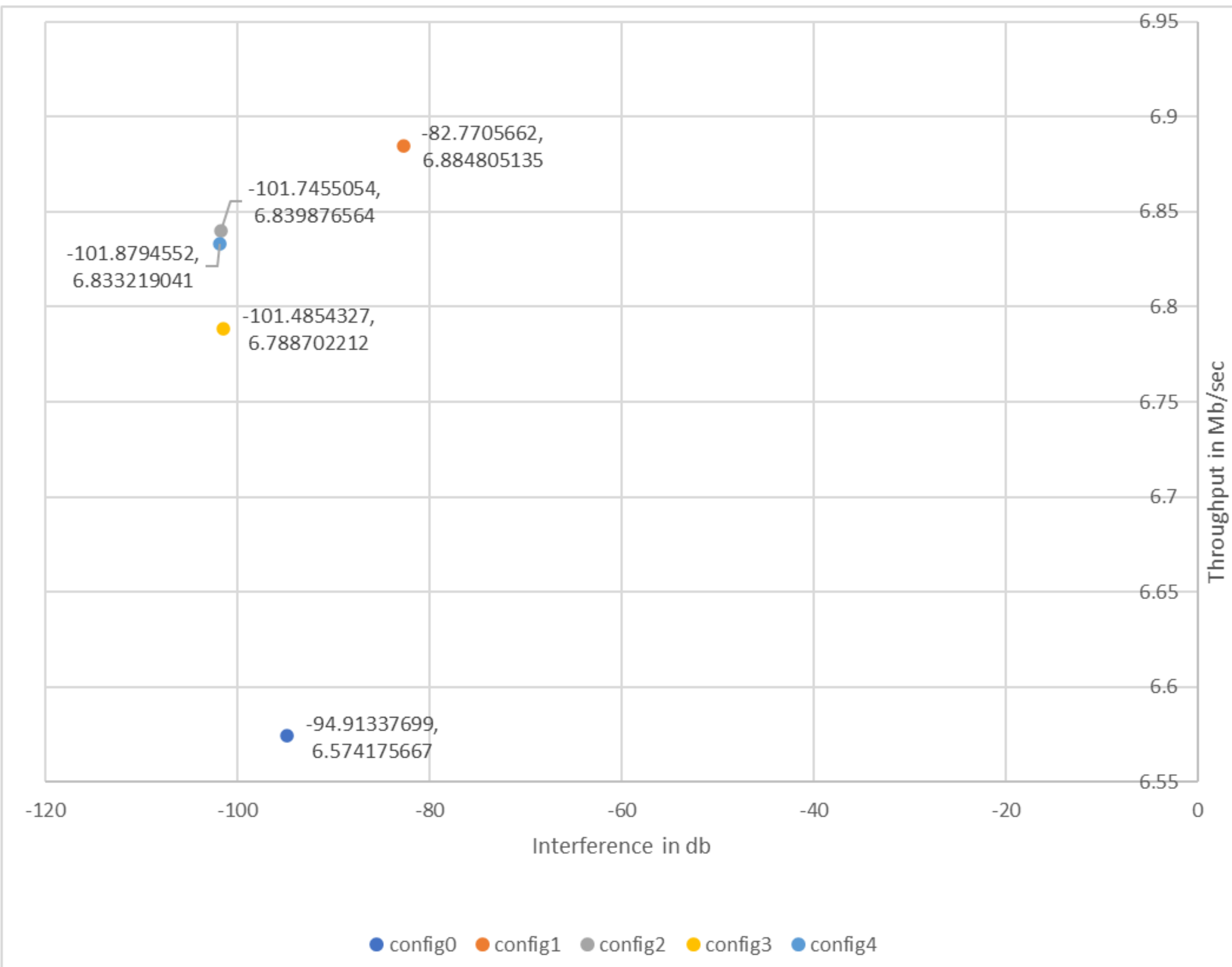

Fig 5. 13 capacity Vs interference for different combination of antenna tilt and CPICH signal power

Table 5. 1 capacity gain and interference reduction

Configuration	Interference in db	Capacity inMb/sec	Interference gain in%	Capacity gain in%
config0	-94.91337699	6.574175667		
config1	-82.7705662	6.884805135	12.79357155	4.72499495
config2	-101.7455054	6.839876564	-7.19827763	4.041584993
config3	-101.4854327	6.788702212	-6.924267098	3.263170247
config4	-101.8794552	6.833219041	-7.33940617	3.94031719
CPICH 5	-97.32881671	6.705211726	-2.5448886	1.993193761
CPICH 7.5	-97.07569089	6.651980113	-2.278197197	1.183485959
CPICH1 2.5	-93.5500822	6.53677353	1.436356854	-0.568925127
tilt 2	-101.6174436	6.778101606	-7.063352697	3.101924088
tilt 4	-101.218659	6.734070518	-6.643196321	2.432165784
tilt 6	-82.32027329	6.564460826	13.26799668	-0.14777276

Previous researches focused on optimizing either of the network capacity or interference related parameters. In [31], soft handover overhead could be reduced from 85.4% to 38.8% using Parameter setting, However, interference improvement is not considered. Optimization of the pilot power and Antenna tilt based on a rule-based algorithm was presented by [16] and concluded that their algorithm brings efficiency on the network operation considering capacity only. My thesis relied on configuration parameters of the real network and optimized both the interference and network capacity, considering the constraints defined. Thus, the network capacity could be increased by 4.04%, and interference could be reduced by 7.2% when using CPICHpower 7.5% of the total BTS power and electrical antenna down tilt by 2 degrees.

CHAPTER 6

6. CONCLUSION

In this paper interference in 3G system particularly uplink interference in UMTS network has been studied. The primary focus of the paper has been on the factors that influence RTWP value, thus, the uplink interference, in the UMTS system used by EthioTelecom. It has been proven that high RTWP value results higher call drop rate, therefore, reducing number of the serving users within a particular cell. The presented results have shown that RTWP level is proportional to the number of connected users to a dedicated cell. High RTWP level has been recorded as the number of user increase. This problem, however, can be addressed by adding lowering CPICH channel power and antenna down tilting. Tuning main parameter in UMTS sites for receiving desired signals has been shown as a solution for such problem.

This thesis aimed to analyze the interference and optimization of interference for the 3G network. Based on the measurement counters from the network management system of the operator namely business object (BO), the interference presents at 2021 September on the performance data of Hawassa 3G network shows -94.1db average, which is considerably beyond the maximum recommended value. Thus, the network is congested because of interference and there is 2.5% service rejection where the base line is2%. CPICH signal power and electrical down tilt were used to optimize both the interference and capacity of the 3G network. Decreasing CPICH signal power and antenna tilt value contributed to the reduction of the interference and increment of network capacity respectively. Using the two parameters in combination enabled more improvements in both reductions of interference and network capacity gain comparing with the tuning parameter individually. Accordingly, interference could be minimized to -101.7 with network capacity gain of 4.04% fulfilling the required Eb/No and received power threshold when using CPICH signal power of 7.5% and electrical antenna down tilt by 2 degrees.

6.1 RECOMMENDATION

In this research, a total of 22 simulations have been computed and near optimal results were established. So additional researches are required to further optimize the interference and capacity of 3G networks. These expected deeds incorporate: A new investigation on the optimization of the interference and network capacity by applying a combination of the two parameters from scratch. In such a case, a dynamic simulator is needed as the total amount of simulations going to be 126 and tedious to manipulate them laboriously one by one.

✓ Investigate the optimization considering algorithms which operate automatically on the system for tuning the parameters with a small resolution to get a better result.

✓Investigate the optimization of interference and network capacity gain by varying parameters related with soft handover.

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