Performance study of Uplink and Downlink of Macro cells

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APPROVAL

This research titled "**Performance study of Uplink and Downlink of Macro cells,** Department of Electronic and Telecommunication Engineering (ETE), Daffodil International University , has been aceepted as satisfactory in Partial Fulfilment of Requirement for the Degree of Masters of Science in Electronic and Telecommunication Engineering and approved as to its style and contents. The presentation was hled on 18 December, 2022.

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I hereby declare that this research is my own work and effort under the supervision of **Md. TaslimArefin,Associate Professor& Head, Department of Electronic and Telecommounication Engineering, Daffodil International University,** Dhaka. It has not been submitted anywhere for any award. Where other sources of information have been used, they have been acknowledged.

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It is a great opportunity for me to write on the subject “**Performance study of Uplink and Downlink of Macro cells**”. At the time of preparing this thesis paper, I go through different books, websites and pubilations which help me to get acquainted with topics and ideas. I actually focuse on topics and works which are important for me to understand the work easily.

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Apart from me, this thesis paper will certainly be immense importance for those who are interested to know about this subject work. I hope they will find it comprehensible.

I try hard and soul to gather all relevant documents regarding this work. I do not know how far I am able to do that. Furthermore, I donot claim all the informaiton in this paper is included perfectly. There may have shortcoming, factual error and conflicting opinion which are all mine and I alone am responsible for those but I will try to give a better volume in future.

ABSTRACT

A Radio Access Network (RAN) is the major part of a mobile telecommunication system. In a RAN, radio sites provide radio access and coordinate management of resources across the radio sites. This Radio Access Network distributed over land areas called cells, each served by at least one fixed-location transceiver, known base station. In a cellular network, each cell uses a different set of frequencies which are known as uplink and downlink. The performance of Uplink and Downlink parameters of RAN in macro cell nodes and the number of users with traffic activity are analyzed and presented in this project. It especially focused on the study of the performance and analysis of path loss and noise ratio of the RANs. Traditional networks (2G, 3G, and 4G technology) are considered for data collection and simulation. The TEMS and QualiPoc software are used for Uplink and Downlink utilizations data collection and Microsoft Excel is used to present the graph and trending. Finally, this project is established about cell performance parameter of BTS and UL/DL performance of macro cell based on radio access network. The comparison of systems with cell range expansion (CRE) in the classic downlink is based on SNR. CRE not only helps to offload users from macro but also improves UL service. Instead of an aggregated throughput analysis, a detailed classification of users is performed to figure out the causes of users' gain or loss after applying each strategy at the system level. UL adjustable cell offset appears to be an interesting strategy to allow for finer control of UL interference. In this project, the design-based study of the performance of the upper and lower links from Macro cell and Uplink-Downlink parameters.

CONTENTS

LIST OF FIGURES

LIST OF TABLE

CHAPTER | 1

INTRODUCTION

1.1. Introduction

Radio Access Network (RAN) is the main component for connecting the mobile phone users to the core network via radio waves technology. It also serves as a bridge to access all the important sections on the web.

Ongoing RAN technology is available as a real -time hardware and software. The goal of Open RAN is to create a multi-vendor RAN solution that allows for separation between devices and systems through an open and virtual interface, with the system to manage and update networks. The promised benefits include supply chain diversity, solution flexibility and new capabilities controlling increased competitiveness and innovation [1].

The O-RAN Alliance (O-RAN) is a group that defines the requirements for radio connections. Founded as a global alliance in 2018, the global network has 30 operators and more than 200 suppliers. The O-RAN Alliance is a new organization based on the 3GPP standard and will start building extensions for the RAN. The goal is to provide a detailed plan to build RAN solutions using components from different vendors, as well as methods to enable understanding and machine learning for network management to be more efficiently managed. A radio access network consists of e-NB for Long Term Evaluation (LTE) radio access. RAN is linked to a 5G core and 5G terminology such as g-NB will be used and also 4G will be used e-NB [1].

1.2. Aims and objective

- To determine the review and update integrated radio access network, UP/DL splitting in Macro cell of 2G, 3G, and 4G GSM.
- To determine the CDS and UDS of Uplink and Downlink interface performance.
- To determine the uplink and downlink utilization of measurement parameters and GSM RAN components.
- To determine the cumulative probability of UL / DL single to noise ratio, loss.

1.3. Motivation

The conventional cell selection is based on downlink Reference Signal Received Power (RSRP) where small cells are deployed into the same channel and in the same manner. But the conventional uplink (UL) and downlink (DL) based cells have some problems like signal to noise ratio, traffic congestion and PRB node utilization performance. The service area of RAN is greatly reduced by the presence of macro cells. Power of the macro cells is higher than small cells. In order to keep up with increasing network traffic, small cells in cellular networks are evolving from a single-tier homogeneous network to multi-tier heterogeneous in which low-power nodes offload, macro cells increase system capacity and aggressive frequency reuse distances. These things motivate me to analyze the real performance of Uplink and Downlink parameters in Macro Cells on this project.

1.4. Project formations

- ✓ **Chapter 1**

  This chapter contains an overview of measuring various BTS parameters, aims and objective, purpose and project formation.

- ✓ **Chapter 2**

  This chapter contains the latest background history, history of RAN architecture, Review of RAN research activity, Problem statement and older publication.

- ✓ **Chapter 3**

  This chapter contains an introduction of Background study, History of cellular technology, Background study and publication of RAN Architecture evaluation, RAN functions and network applications.

- ✓ **Chapter 4**

  This chapter contains how to design a radio access network, Cellular data collection tools, data collection methods and methods.

- ✓ **Chapter 5**

  This chapter involves establishing a comparison of local conditions, the part of acquisition and analysis of data, Different type UL and DL throughput and UL and DL throughput data based on performance.

- **Chapter 6**

  This chapter contains a performance based on different type UL/DL parameter, Utilization FTP time, response time and performance comparison based on throughput parameter.

- **Chapter 7**

  This chapter provides information on the evolution and innovation of UL/DL performance for cellular network.

- **Chapter 8**

  Finally, this chapter provides the future scope of work, and definitions of terms and some references for cellular networks.

CHAPTER | 2

BACKGROUND STUDY

2.1. RAN background studies

Communication is the foundation of the development of any society. The message must be sent from one person or from one carrier to another. The world is rapidly becoming a global village; wireless communication is a necessary tool for this process. Ad hoc wireless networks are formed by groups of mobile users or devices in a particular geographic area that form the "nodes" of the network [2]. Mobile networks are used in military applications such as sensor networks, tactical networks, and positioning systems. Mobile networks are increasingly used by law enforcement agencies.

2.2. History of cellular technology

Development of the European standard (DES) began 19 centuries earlier for digital cellular communications in 1982 when the European Conference Posts and Telecommunications (CEPT) was established on the Grouped Special Mobile Committee and later provided a permanent technical support team at Paris [2].

GSM technology

- Europe released the first agreed GSM technical specifications on February1987,
- The Special Mobile Committee was transferred from CEPT to the European Telecommunications Standards Institute (ETSI) in 1989.
- In 1990, the European Commission proposed to reserve a 900MHz spectral band for GSM.
- Extended the GSM standard to the 1800MHz band in 1991 and the first 1800MHz network became operational by the United Kingdom in 1993.
- The fax communication, data transmission and short message services were introduced in commercial operation in 1995. GSM 1900MHz network was first launched earlier.
- The first commercial GPRS service was launched in 2000.First GPRS compatible phone was launched.

- The first Multimedia Messaging Service (MMS) was introduced in 2002. In the same year GSM network first in the 800MHz band operational.
- In 2014, the technology defined as GSM standard served 85% of the global market of mobile communications.

2.3 Radio access network (RAN)

Radio access network (RAN) is an important element in wireless communication systems that can establish a connection between individual devices to other parts of the network through radio links. Individual devices or user equipment are mobile phones, computers, and any remotely controlled machine which are connected via a fiber or wireless backhaul connection. This link mainly leads to a core network that can manage subscriber information, locations and other networking information [2].

The RAN part is also known as the globally access network is the wireless component of a cellular network. This Radio Access Network is distributed over land areas called cells, each served by at least one fixed-location transceiver, known base station. In a cellular network, each cell uses a different set of frequencies which are known as uplink and downlink.

RAN was introduced in the 1st generation (1G) to the 5th generation (5G) cellular communication network. The 4th generation (4G) technology was developed in 2000 where 3rd generation (3G) technology is a partnership project to introduce Long Term Evolution (LTE) RAN called 4G technology. The radio access network (RAN), Transmission and core network are changed significantly. In 4G technology, system connectivity for the first time was based on the Internet Protocol (IP) and also replaced the old circuit-based networks.

Recently the Telecommunication authority introduced LTE which is called 5G technology. LTE is mainly improving the part of RAN which is centralized. 5G also known as cloud RAN (C-RAN) where multiple antenna arrays are used such as multiple inputs, multiple outputs (MIMO) [3]. The main function of RAN has been extended into including voice calling, messaging, audio and video streaming. The user equipment that utilizes these networks has increased significantly, including all kinds of vehicles, drones, and the internet of things devices.

2.4 Background study and publication of RAN Architecture evaluation

- ✓ F. Bacardi, H. Elshaer. "How and why to Separate Top and Bottom Links in Cellular Networks," IEEE Communications Magazine, Volume 1. 54, No. 3, see 110-117 days in 2016. Reference: Publisher website
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- ✓ Q. Li, L. Zhang, and W. Li, "Analysis of Optimization and Heterogeneous Network Capacity Adaptive Cell Area Control", Journal of Antennas and Propagation, Volume 2. 6. Project ID 2158033, section. October 10, 2015.

2.5 Problem statement

As the network demand is increasing day by day and the total bandwidth usedfor it is lacking. The bandwidth of uplink and downlink based cells greatly impact system performance and overhead channel performance. The presence of Macro cells reduces these impacts but it is very expensive. In this project, the PRB utilization, the interference, SINR, cell throughput, and the FTP time are considered for studying the uplink-downlink performance of macro cells.

2.6 Proposal solution

The solution of installation methods has been developed to improve the performance of cellular networks. The Macro Base station can take a long time to run the network and it is expensive. As consideration, the first benefits that UDS can bring in terms of SINR and throughput to the flow over downlink based cell connections compared with the expanded cell (CRE) systems. CRE helps users to download Pico e-NB to Macros, but also completely segregates users in contrast to the overall network performance analysis, using every strategy at the system level and then user profits and losses.

CHAPTER | 3

INTRODUCTION AND ARCHITECTURE OF RADIO ACCESS NETWORK

3.1. Introduction and Architecture of Radio Access Network

Recently mobile operator's have access to multiple options of ability to cover more area. In terms of capacity and services they are providing best service to customers. Additionally, RAN advances in wireless communication provide higher spectral efficiency. Telecom Vendors launched new various wireless access nodes for network components. Due to the use of 3G, especially LTE, the old macro BS has been replaced by a distributed BS structure [4]. Macro-cells are still used in multiple places in small cell BTS distributed (DAS) antenna systems. Macro-cell using more mobile virtual network operators (MVNOs) is growing over the world. The cloud radio access networks (cloud RAN) expected to be deployed in the near future and RAN-as-a-Service (RANaaS) [5].

3.2. Functionality of RAN architecture

RAN main functions are flowing below [7].

- All hardware equipment and potential central sites are located at wireless sites
- Baseband based hardware
- Wireless hardware equipment
- Hardware in control processing
- Transport layer equipment is such as routers, switches and routers.
- WDM and DWDM.
- All antenna hardware RET motors or tower amplifiers (TMA) of low noise so on.
- Power infrastructure and power backup hardware
- Environmental based equipment (fans, fire, air conditioners, shelters)
- Data-center field software
- Implements 2G, 3G and 4G wireless access technology (RAT) and 3GPP security protocol layers and vendor-specific features and algorithms
- Control and field software
- Management and monitoring software
- Device management software

- Self-organizing network device software.

Traditional BTS base station architectures are driven from 2G, in 2G architecture do not having an operation and maintenance (O & M) interface. The base station site exposed to the management system. These all features are implemented into the base station software. As an example of O & M system there is no direct connection system to wireless unit. Instead of radio unit is O&M operated through at the baseband unit. The O&M is complicated to the software and its benefits are a high automation. Co-optimization failover automation and automatic fault handling between to all domains and optimization of co-power efficiency. The operating cost of OPEX perspective it would be have AAS integrated into the common base station of framework. In terms of performance and standpoint it is the advantage of sharing the same RAT software. Bands and sectors in which is AAS are expected to the interact such as inter band carrier aggregation. Tight coordination between nods is Heterogeneous network [8].

3.3. RAN Infrastructure

The basic structure of a RAN base station consists of a BBU, a RU radio unit or a long-range radio unit (RRU), an antenna, and various software-based interfaces. In 5G RAN, including 5G cloud-based RAN, BBUs are divided into distributed units (DUs) and central units (CUs). Choosing a DU and CU architecture reduces usage costs, gives you more flexibility in RAN infrastructure design, and allows you to use it in a cloud RAN infrastructure [9].

The DU performs layers of wireless link control and medium access control (MAC) in addition to several physical layers of the base station. Then it is manipulated by the CU. The CU runs a radio source control protocol that performs many functions such as broadcasting information, establishing and releasing connections between user equipment and RANs, and controlling quality of service. The CU also works with packet data aggregation protocols that compress and parse IP data stream headers and transfer user data, among other technical features. The CU can be left at the base station or placed at a more centralized site. Instead, the DU is stored in a base station that is not in a fusion or core network location [11].

SDN principles can be applied to CU. The control plane and CU user plane functions can Be separated from each other, just as an aircraft is in an SDN. Different types of RANs reflect advances in network technology. These RAN types include GSM RAN (GRAN), GSM EDGE RAN (GRANT), UMTS RAN (UTRAN), and Evolved UTRAN (E-UTRAN).

3.4. Architecture of RAN

A wireless network base station is known as a base station BTS which is a device that proves wireless communication between consumers into devices (UEs) mobile networks. BS is widely referred to in 3G and LTE networks as eNodeB and eNodB evolving (eNB), respectively. BS architecture and features have undergone many changes in addition to the evolution of wireless technology. Consider the next evolution as it is an important component in cloud-based RAN [10].

3.5. Cloud RAN (C-RAN)

Cloud RAN (C-RAN) is another variation of RAN technology. There are three main components: centralized BBU group, RRU network, and transport network. The central BBU pool behaves like a cloud. This provides the resources needed for the RRU based on network needs; much like the cloud provides resources to computers remotely. The RRU network connects wireless devices to the Internet, similar to the traditional RAN RAN tower. Transport networks use fiber optics, cellular communications, or millimeter-wave radio frequencies (mm Wave) as the type of connection. This is the high bandwidth connectivity layer between the BBU and RRU groups [11].

3.6. Legacy BS

Traditionally BS consists of more racks and a baseband of radio Equipment, which is sitting at the foot of the tower. The signaling back forth connection to the passive antenna has to mount on top of the tower. Antenna connection Connect to the rack via a coaxial cable (feeder). The BS websites are often requiring which is difficult and expensive to large sturdy shelter and strong structural support to make up the land acquisition. In the architecture of the antenna signal power is transmitted from the BS rack. There is usually about 3 dB loss with distributed BS architecture [13].

3.7. Second generation of RAN

The 2G second generation of cellular communication is a digital signaling system. This system enables transmission of data traffic and low-rate data services like messaging.2G systems having larger capacities which are previously provided as analog systems. Second generation traffic systems can also compress and multiply over the time that's called TDM. Time Division Multiple Access (TDMA) provides more levels of freedom and increases bandwidth and big capacity. Compared to 1G and 2G systems where terminals are given a channel, transmitting of second generation technology is allowed to multiple user's same time [9].

3.8. Third generation of RAN

Third generation 3G cellular systems offers the higher throughput for video calling services. 3G technologies are most widely used in Universal Mobile Telecommunications System (UMTS). It uses wideband code division multiple access (WCDMA) for remote users. WCDMA propagates to the terminal signals over a wider bandwidth; signals look like Gaussian sounds to each other. All terminals use bandwidth and signals appear to each other and add terminals effectively. Terminals to the system as long as the noise does not exceed the critical sound level. So that WCDMA has soft terminal limits compared to the hard terminal limits in case of TDMA or FDMA [11].

3.9. Fourth generation of RAN

The 4G 4th generation cellular system is increasing with data rates of 100 Mbps downlink and 50 Mbps is uplink. 4G technologies promise to meet 4G standard is Long Term Evolution-Advanced (LTE). LTE is an evolution technology called LTE and not fully tested to the requirement is in [1]. The key of LTE technologies is to enable certification and carrier aggregation with multiple antennas. The heterogeneous propagation and coordinated transmission between different BTS.

CHAPTER | 4

METHODOLOGY

4.1. Methodology of RAN

In cellular networks users tend to gather in certain areas, such as in a shopping mall or a busy square, forming so called hot zones. To support the high traffic in a hot zone a low power base station can be deployed in it. Hot zones are often modeled in an ideal manner as a perfect circle in which a low power node is placed in the center. In reality a hot zone is denoted by the location of the UEs. The shape and location of hot zones therefore change as the UEs move and the low power nodes are in general not located in the center of the hot zones.

4.2. Consider of Innovative radio access network architecture

In this section details about the performance measurements are described. The performance measurements are calculated in the same manner in all studies in this report.

PRB utilization:

In each Transmission Time Interval (TTI) the PRB utilization is calculated by dividing the number of PRBs used for transmission by the total number of PRBs, according to the equation below. The PRB utilization is averaged over the whole simulation time.

$$PRB\ utilization = \frac{number\ of\ PRBs\ used\ for\ transmission}{total\ number\ of\ PRBs}$$

Interference:

The base stations will sum the total received power under a time t seconds. After t seconds the interference is calculated by subtracting the power of the useful signal from the total power. The interference is calculated according to the equation below and is averaged over time, PRB and cell and presented in dB m.

$$Interference = 10 \times \log_{10}(Total\ received\ power - Useful\ signal\ power) + 30$$

SINR:

The SINR is the useful signal in a transmission divided by the interference plus noise, see the below equation. The SINR is presented in dB.

$$SINR = \frac{Useful\ signal\ power}{Interference}$$

The SINR is averaged over a time t = 0:2 s

Cell throughput:

The cell throughput is calculated by starting a timer and having a counter count of the number of received bits. After a time, the simulator calculates the throughput according to the equation below after which the number of received bits is set to zero before the counter is restarted.

$$Cell\ throughput = \frac{Number\ of\ received\ bits}{t}$$

Where t = 0:2 s.

UE throughput:

The UE throughput is calculated in a similar way as the cell throughput, see equation

$$UE\ throughput = \frac{Number\ of\ received\ bits}{t}$$

Where t = 0:2 s

4.3. Architecture and Functionalities

In distributed base stations, radio frequency filters and base station power amplifiers are installed next to the tower or roof antenna. The traditional macro base stations are normally located in place of the floor of the tower. The distributed BS component is known as the Remote Radio Head (RRH). The Base station power amplifier is located closer to the antenna. That helps eliminate the 3dB signal power loss. Distributed BS has other components, including a digital asset which is also known as the baseband unit (BBU).

The digital fiber optic link such as CPRI or OBSAI, In 3G networks at separate architect adopted with the modular design access network. BS key components to be installed separately, distributed BS uses available real estate to reduce power consumption more efficiently.

Feature	Benefit
BBU and RRH can be spaced miles apart	• Higher degree of deployment flexibility
Reduced space (footprint)	• Lower rental costs
	• Easier site acquisition
Lightweight RRH	• Easier installation
	• No need for feeders
Better coverage than old-style macro sites when deployed in tower-top (no feeder loss)	• Reduced total number of sites
	• No need for TMAs
Integrated maintenance and administration when BBUs pooled	• Reduced OPEX
Reduced power consumption (RRHs work in natural heat dissipation mode)	• Environment friendly
	• Reduced OPEX

Table 4.1: Features and Benefits distributed base station

In table 4.1 are presenting of Radio network uplink and downlink based on features which are additional from existing model to newer and along with benefits.

BBU and RRH which gives you more flexibility in deployment, but distributed BS makes it easier to get your site and reduces rental costs due to its smaller footprint. In addition, it consumes up to 50% less energy and can achieve renewable energy. Keep in mind that the RRH can function in its natural heat dissipation mode. Requires a fair amount of power supply and uses much less energy. Several BBUs are collected into the central location so that intercom communication is performed while the RRH is distributed at different cells.

Architecture is highly preferred to LTE (LTE) features that require coordination between adjacent. Low cost and flexibility of RRH, which is currently not only new technologies LTE. The infrastructure and older technologies are 3G, 2.5G, or 2G. Few of the operators still use traditional architecture which is very easy to access wireless devices and technical maintenance services.

4.4 RAN architecture consisting of centralized

Update RAN architectures are considering centralized BBU and one or more distributed RRHs systems installed at cellular. This update configuration is creating a new transmission bridge between the distributed RRH and centralized BBU. The traffic is re-routing from the BBU to core IP and developed packet and switch core. That is compared with backhaul networks carrying different variants of Carrier Ethernet or MPLS. The front haul network is traditionally called the Optical Transmission Network. The digitization of radio frequency signal aggregated to the various RRHs is to generate a large amount of data which is speed up to 10G bit/s.Here needs to be optical fiber with the transmission medium.

Backhaul type	Access technology	Latency (one way)	Throughput	Priority
Non-ideal	Fiber 1	10–30 ms	10 M–10 Gbps	1
	Fiber 2	5–10 ms	100–1000 Mbps	2
	Fiber 3	2–5 ms	50 M–10 Gbps	1
	DSL	15–60 ms	10–100 Mbps	1
	Cable	25–35 ms	10–100 Mbps	2
	Wireless	5–35 ms	10–100 Mbps	1
Ideal	Fiber 4	Less than 2.5 µs	Up to 10 Gbps	1

Table 4.2: Mobile front haul and backhaul

In table 4.2 are presenting of Type of backhaul with Access technology performance based latency and using throughput. The long-distance transmission networks make connections based on the digital wireless fiber optic D-RoF. Those technologies are Common Public Radio Interface (CPRI) and Open Base Station Architecture (OBSAI). Herewith CPRI is a digital interface which is standard for the serial broadband data connections. That is taking with aggregation in several companies and they are making established connections between end to end users.

The Radio network infrastructure is mainly working Ericsson, Huawei, Alcatel-Lucent and NEC as a supplier to determine the high bandwidth up to 10 GB / s and low latency reliable transmission. The transmission networking system is transmitting analog signals to digital form the radio technology. That was not only used for WiMAX but also for 2G, 3G or 4G cellular communications. A number of the transmission path options including

Fiber optic, optical transmission network, passive optical network, microwave and wavelength-based systems are most popular in Radio Access Network.

4.5. RAN architecture BTS side

Entire end-to-end RAN architecture consists of the three major parts of network radio access network carrier, which is Core network, Transmission and Radio Access. The radio access networks are the first component of the carrier in the whole network. That is providing an access network to transferring voice and data to the user device.

The core network is acting 3rd step of internal connection switching which is internal networking and other hand radio access network to external networks. In this Table 4.3 below presenting is Generation based base station, controller along with backhaul interface and aggregation.

Generation	Base station	Controller	Backhaul interface	Backhaul aggregation
2G	BTS	BSC	Abis	TDM
3G	NodeB	RNC	lub	ATM/IP
4G	eNodeB	eNodeB, MME, and SGW	S1	IP

Table 4.3: The main location of mobile backhaul networks

Radio base station (BS) and base station controller (BSC) with backhaul network are mainly consisting of Radio access network. In the RAN part there are main components of dividing various generations of mobile networks. In 2G and 3G technology only the RAN is designed for traffic systems from all BSs into controllers. The wireless source management is divided by 2G is BSC and 3G is RNC (wireless network controller. These management main functionalities are data encryption and signaling. The 4G LTE system there does not have BSC, which is BSs (e-NodeB) connecting directly to MSC. In the radio Resource Controller (PRC) that is performed are all resource allocated active users in service. The Mobility Management Entity is directly valid acting on the device. And that makes connection between LTE and other generation technologies RAN part. The Serving Gateway cell is also known as a router which repeatedly sends data to the network. This is mainly responsible for delivery of other connected e-NodeB hubs.

CHAPTER | 5

DATA COLLECTION & ANALYSIS

5.1. Data analysis

To accommodate the network trafficking system is heterogeneous and small to multi-cell networks is single-level homogeneous. Describing low-power nodes load macro cells and increase system capacity with aggressive frequency distances analysis which is collected using TEMS and QualiPoc. This analysis is also covering the radio planning paradigm arising problem and Homogeneous Load.

5.2. System parameters

Parameter	**Value**
Deployment	
Number of Macro and Pico base stations	300
Number of cells per Macro base station	3& 2
Cell radius	150 m
Macro to Macro distance	500 m
Pico to Macro distance	200 m
Resources	
Bandwidth	10 MHz
Propagation	
Macro propagation factor	-3.76
Macro attenuation constant	-35.3
Pico propagation factor	-2.50
Pico attenuation constant	-20.6
Base stations specifics	
Noise figure	5dB
Macro base station output power	40W
Macro base station antenna elements(per cell)	2
Low power base station antenna elements	2
UL antenna ports	1
DL antenna ports	2
UE specifics	
Output power	0.2W
Noise figure	9dB

Table 5.1: System parameters

Imbalance and suboptimal uplink performance data of Uplink and downlink is collected from QualiPoc [8].Range extension has been achieved by changing the ohm which theyreceive a signal. For all low power nodes an offset is added to the received power cell association algorithm which is data collected from TEMS. The UEs then connect to the base station which has the highest value.

5.2.1 Cell throughput

The same effects are applying for downlink and uplink. The downlink cell throughput is overall higher than the uplink cell throughput. It naturally follows that the macro cell area throughput is also similar to that of uplink.

	Reference case	**Configuration 1**	**Configuration 4a**	**Configuration 4b**
Macro cell area	7.9	8.6	9.1	9.5
Macro cell	7.9	8	7.5	6.3
Low power node	-	0.27	0.79	1.6
Spectral efficiency	0.79	0.86	0.91	0.95
5 % UE	0.14	0.19	0.48	1.7
50 % UE	0.69	1.1	2.7	6.1
95 % UE	5.8	8.5	11	13

Table 5.2: Downlink cell throughput

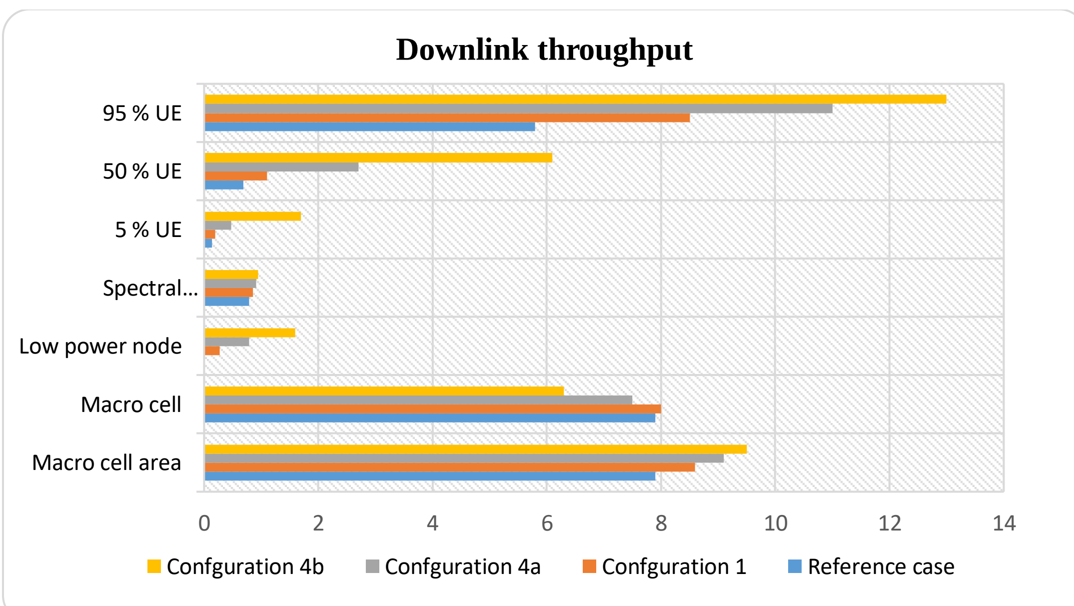

Fig 5.1: Downlink different throughput

5.3. Antenna uplink and downlink configuration with different environments

- Peak spectral efficiency of 15 bit=s=Hz and 6.75 bit=s=Hz in downlink and uplink respectively.
- Data latencies of maximum 10 ms in both uplink and downlink.
- Latencies of maximum 50 and 150 ms for intra- and inter-frequency handovers respectively.
- Scalable bandwidth up to 40 MHz

Environment 1	**Downlink (bit=s=Hz=cell)**	**Uplink (bit=s=Hz=cell)**
Indoor	3	2.55
Macro cellular	2.6	1.8
Base coverage urban	2.2	1.4
High speed	1.1	0.7

Table 5.3: Uplink and downlink antenna configuration Env1

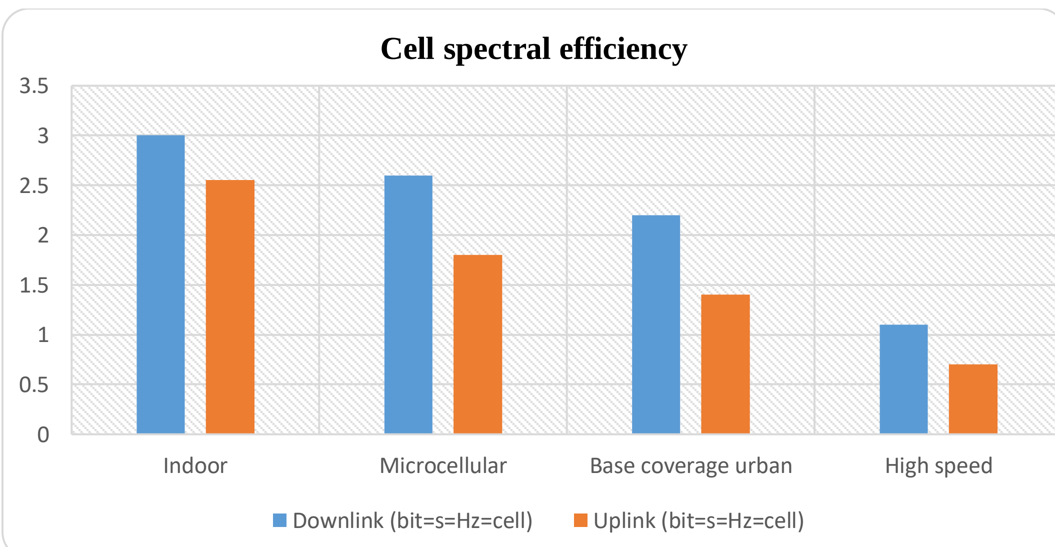

Fig 5.2: Cell spectral efficiency requirements in IMT-Advanced

- ✓ Increased cell edge user spectral efficiency according to table 5.3.
- ✓ Interworking with other radio access systems.
- ✓ Uncast and multicast broadcast services.

Environment 2	Downlink (bit=s=Hz=cell)	Uplink (bit=s=Hz=cell)
Indoor	0.1	0.07
Macro cellular	0.075	0.05
Base coverage urban	0.06	0.03
High speed	0.04	0.015

Table 5.4: Uplink and downlink antenna configuration Env2

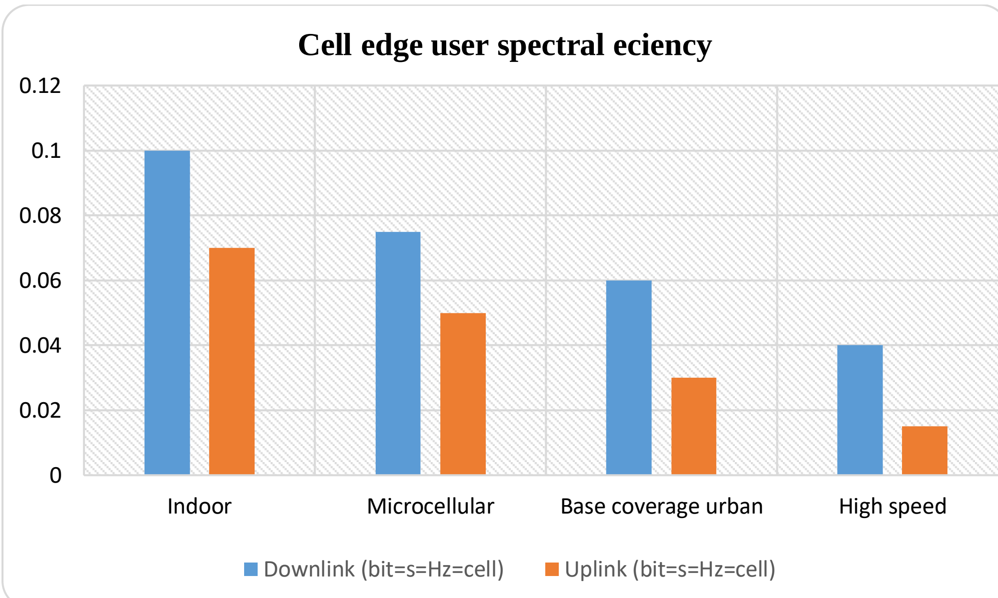

Fig 5.3: Cell edge user spectral efficiency requirements in IMT-Advanced

5.3.1 Traffic model

The traffic model is chosen to comply with the Poisson based traffic model 1 specified in. Users arrive in the system following a Poisson distribution with an arrival intensity of λ users per second. They upload or download one FTP packet of fixed size and then disappear from the system. The following results were obtained by computer simulations. Only uplink performance has been analyzed in this study.

	Reference case	0dB Bingo	0dB Random	8dB Bingo	8dB Random	16dB Bingo	16dB Random
Macro cell area throughput(Mbps)	5.5	5.8	5.8	5.8	5.8	5.8	5.8
Macro cell throughput(Mbps)	5.5	4.4	4.6	3.2	3.5	2.4	2.4
Low power node throughput(Mbps)	0.5	1.4	1.2	2.7	2.4	3.4	3.4
Spectral efficiency (bps/Hz/ Macro cell area)	0.55	0.58	0.58	0.58	0.58	0.58	0.58
UE throughput(Mbps)	0.014	0.78	0.73	1	0.98	1.1	1.1
UE throughput(Mbps)	1	1.5	1.4	1.6	1.6	1.7	1.7
UE throughput(Mbps)	1.6	1.8	1.8	1.9	1.8	1.9	1.9

Table 5.5: Uplink throughput gains compared to the reference case

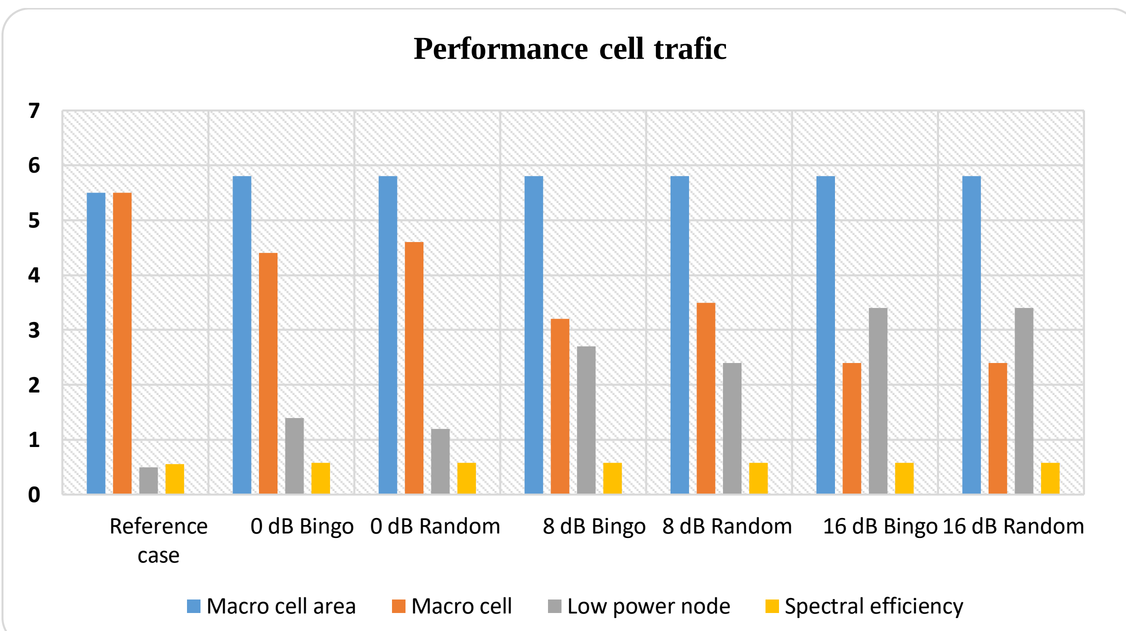

Fig 5.4: Uplink throughput performance parameter wise

5.3.2 Interference

In fig 5.6 figure the average interference received by the base stations. The difference in interference between bingo and random deployment is due to the different number ofUEs connecting to the low power nodes. The relation between the number of UEs connecting to the low power node and the interference is discussed below.

db	Bingo	Random	Increase Bingo vs. Random
0 dB	25%	20%	25%
8 dB	46%	39%	18%
16 dB	59%	56%	5%

Table 5.6: Percentage of UEs connected to the low power nodes

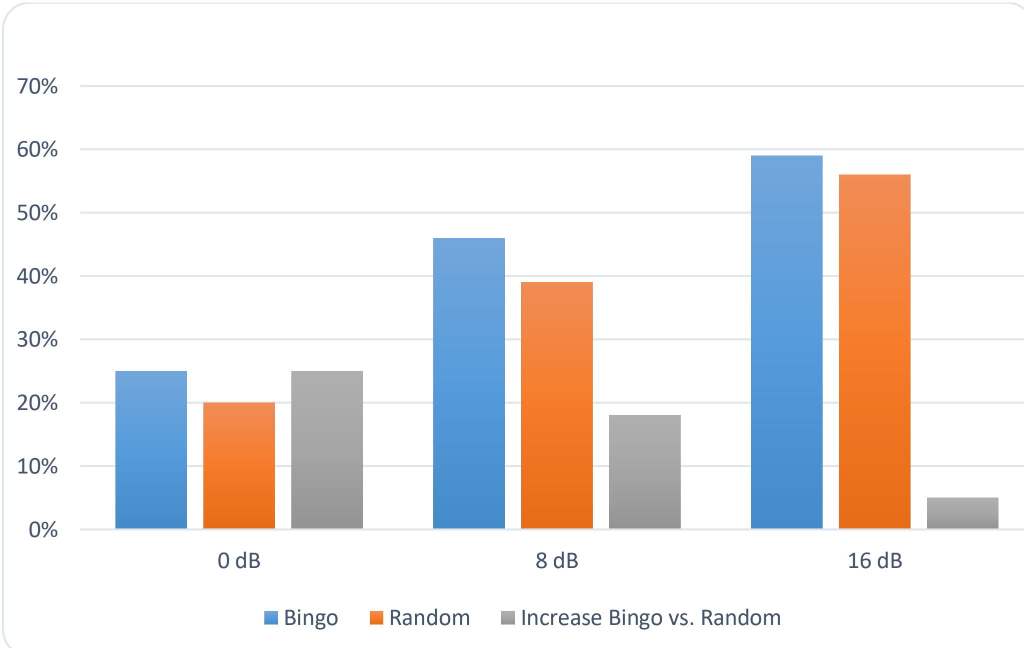

Fig: 5.5: Percentage of UEs connected to the low power nodes

	Reference case	0 dB Bingo	0 dB Random	8 dB Bingo	8 dB Random	16 dB Bingo	16 dB Random Macro uplink
Macro uplink PRB utilization	80%	65%	70%	48%	54%	39%	41%

Table 5.7: Macro PRB utilization

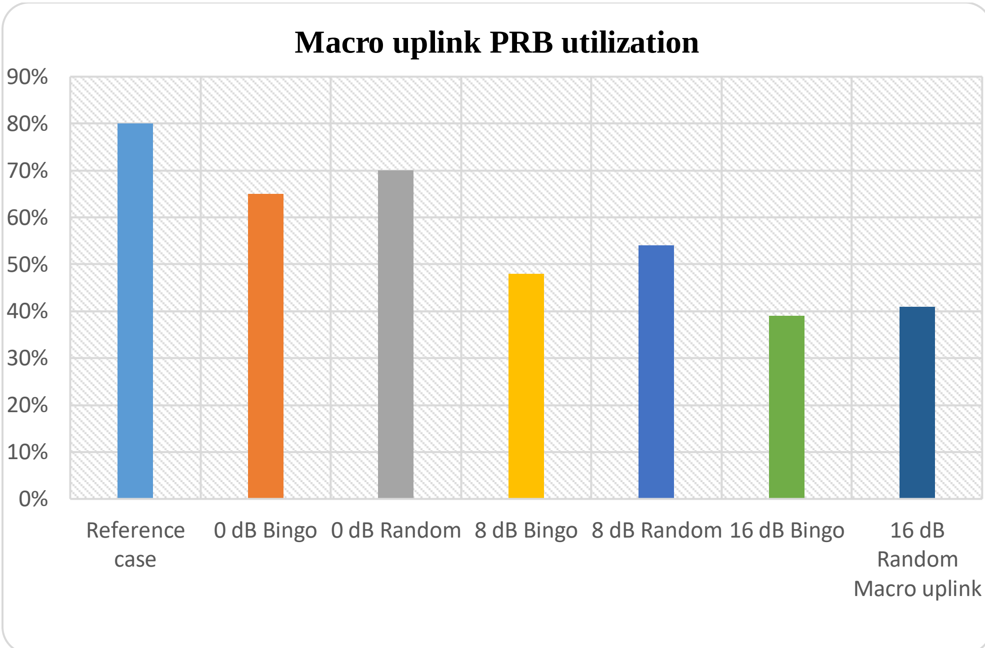

Fig 5.6: Macro PRB utilization graph.

CHAPTER | 6

SIMULATION AND RESULT

6.1. Simulation parameters

This project is to analyze the real performance of UDS parameters in Macro cells as network uplink and downlink deployments.

During the simulation of subset user equipment is reducing the quality experience. In terms of clear understanding, the issue in different types of users are identified and analyzed.

In figure 6.1 is Performance of simulation parameters comparison are respectively flowing below:

(1) Macro site users: The macro site user can connect to the macro base station DL and UL in all of the cases. Before and after changing of normal cell selection and handover Conditions are associated into CRE and UDS.

(2) Pico users: The Pico users they can connect to pico of eNBs are connected to DL and UL in all cases.

(3) Edge platform users: They are connecting into the UL from after using CRE or UDS, macro eNB to pico eNB. For each situation, there may be users in this situation Increase or decrease in throughput after changing classic correlation

There are two reasons for this: First, modify the SINR value, secondly. The difference between availability Radio and resource cell load. As an example of simulation the lower SINR can be associated with more available cell resources. Here with increasing the average throughput at all off cells. The lower SINR values are require to more conjugative modulation and coding scheme in achievable peak in low throughput.

6.2. Macro site Uplink and downlink utilization simulation

A compilation of the UE (User equipment) distributions and Physical Resource Block (PRB) utilization is shown in table 6.1. First it can be seen that less than half of the area of the hot zone is covered by the low power node. This means that there are many UEs residing just outside the low power node cell.

	Reference case	Configuration 1	Configuration 4a	Configuration 4b
Macro uplink PRB utilization	95%	94%	90%	77%
Macro downlink PRB utilization	93%	91%	80%	57%

Table 6.1: User distribution and macro PRB utilization

Fig 6.1 showing as per reference case configuration1 Macro uplink PRB utilization and Macro downlink PRB utilization is mostly utilized then other configurations

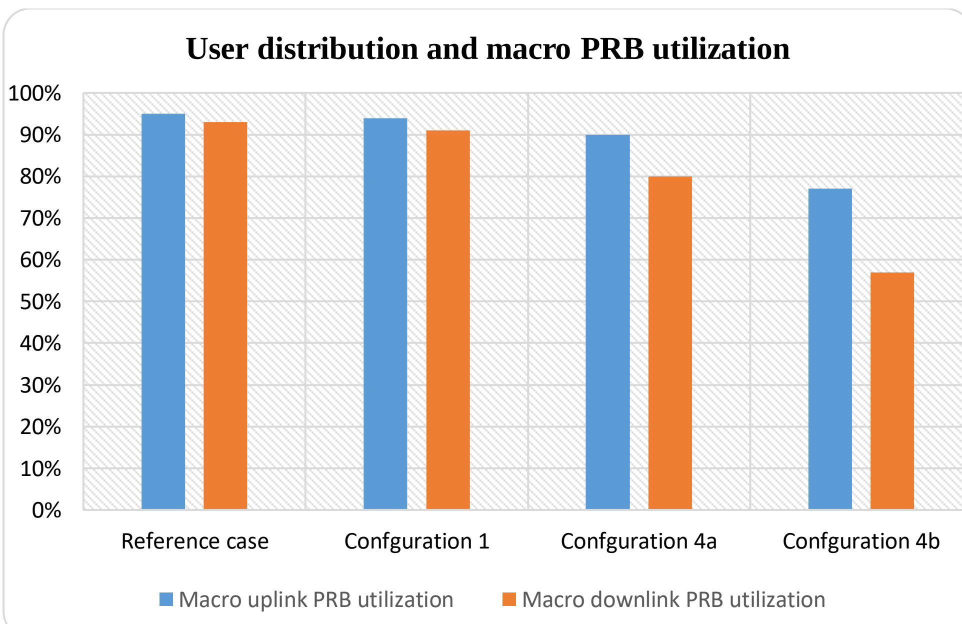

Fig 6.1: User distribution and macro PRB utilization graph

The user distribution and the macro PRB utilization, between macro site and low nodes and macro PRB utilization high load performance showed in Table 6.2.

	Reference case Low load	Configuration 1 Low load	Reference case High load	Configuration 1 High load
Macro uplink PRB utilization	95%	94%	90%	77%
Macro downlink PRB utilization	93%	91%	80%	57%

Table 6.2: User distribution and macro PRB utilization

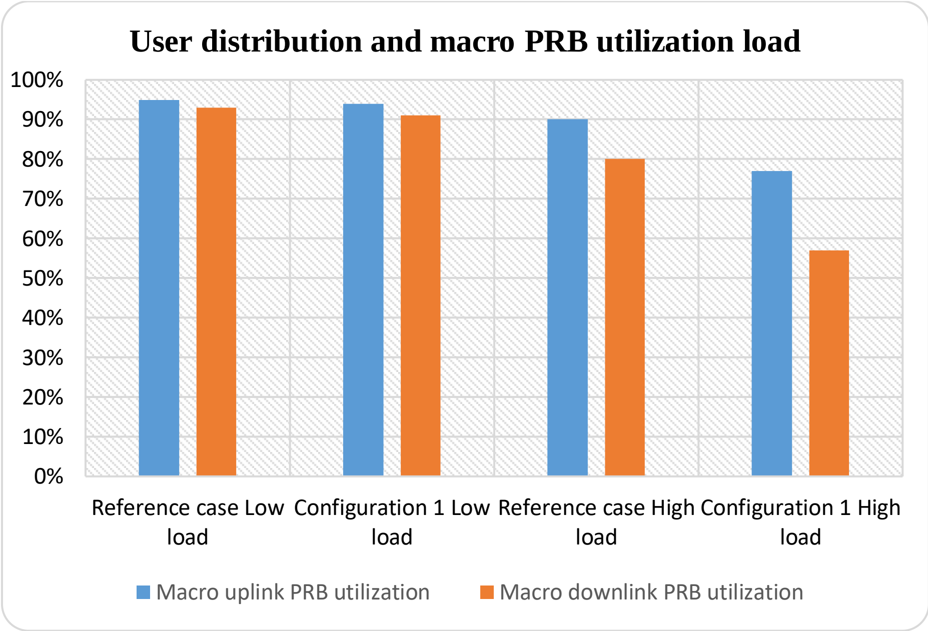

Fig 6.2: User distribution and macro PRB utilization graph

Fig 6.2 showing as per reference case configuration1 Macro uplink PRB utilization and Macro downlink PRB utilization is mostly utilized then other configurations.

6.3. Performance of Upload FTP time

FTP delays as they also will be referred to, for each configuration are found in table 6.3. The FTP delay is the time taken from when the user equipment sends the first data of a packet until it has transmitted the whole packet and disappears from the system. In the same table is the percentage of UEs who finish their transmission before the simulation.

	Reference case	Configuration 1	Configuration 4a	Configuration 4b
Finished upload	60.40%	63.00%	78.42%	93.00%
Finished upload macro	60.40%	61.00%	74.50%	93.00%

Table 6.3: Performance of Upload FTP time

Fig 6.3 showing as per reference case configuration 4b Upload FTP in finished download and finished download macro is higher than other configurations.

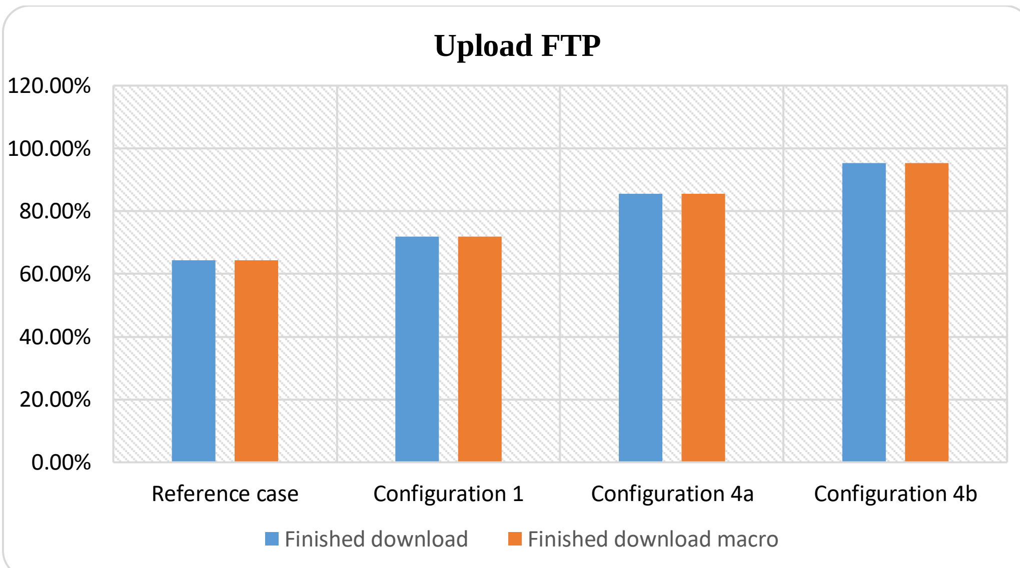

Fig 6.3: Performance of Uplink FTP time graph

6.4. Performance of Download FTP time

FTP downloads times in downlink shown. The figures in table 6.5 are approximates because the simulator logs the delay only for UEs which finish their upload. Therefore, the actual delays are expected to be longer than stated in the table.

	Reference case	Configuration 1	Configuration 4a	Configuration 4b
Finished download	64.40%	71.80%	85.50%	95.40%
Finished download macro	64.40%	71.80%	85.50%	95.40%

Table 6.4: Performance of Download FTP time

Fig 6.4 showing as per reference case configuration 4b Download FTP in finished download and finished download macro is higher than other configurations.

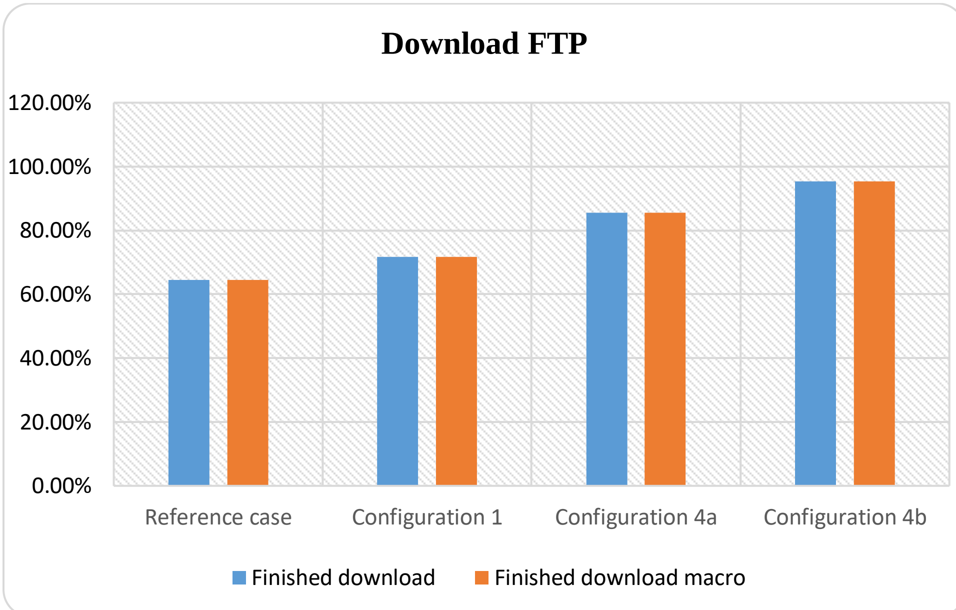

Fig 6.4: Performance of Download FTP time graph

6.5. Signal to Interference & Noise Ratio at Uplink and Downlink

In the following section configuration 1 will be compared with the reference case. The results from the study with the high load traffic model are displayed in parallel as comparison.

6.5.1. Uplink

UEs which are absorbed by the low power nodes get a gain of 5.04 dB and 5.45 dB in the low and high load case respectively. The UEs which are not absorbed by the low power nodes also get a higher SINR but the gain is lower; 0.31 dB and 0.12 dB in the low and high load case respectively. Averaging the gain over all UEs gives a gain of 0.59 dB and 0.44 dB.

	Reference case	Configuration 1	Gain
Low load	8.26 dB	8.85 dB	0.59 dB
High load	7.06 dB	7.50 dB	0.44 dB

Table 6.5: Average uplink SINR per UE

Fig 6.5 showing as per reference case configuration 1 low load and high load is higher than other configurations.

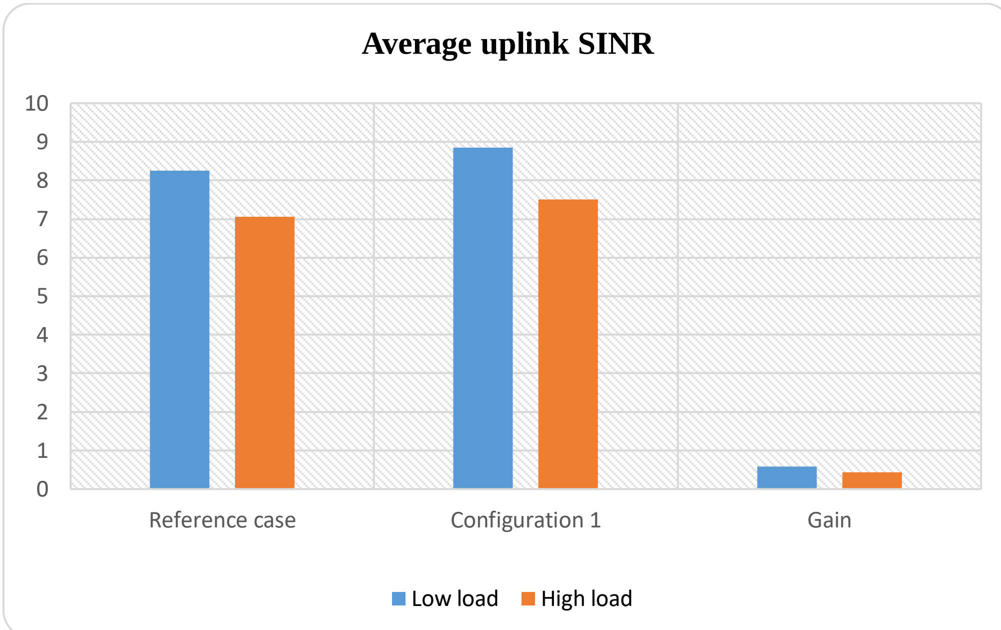

Fig 6.5: Average uplink SINR per UE

6.5.2. Downlink

In downlink the SINR gain for the UEs is also small. The average gain in UE SINR in downlink is 1 dB and 0.34 dB in the low and high load case respectively.

	Reference case	Configuration 1	Gain
Low load	11.6 dB	12.6 dB	1 dB
High load	7.82 dB	8.16 dB	0.34 dB

Table 6.6: Average Downlink SINR per UE

Fig 6.6 showing as per reference case configuration 1 Average Downlink SINR per UE low load and high load is higher than other configurations.

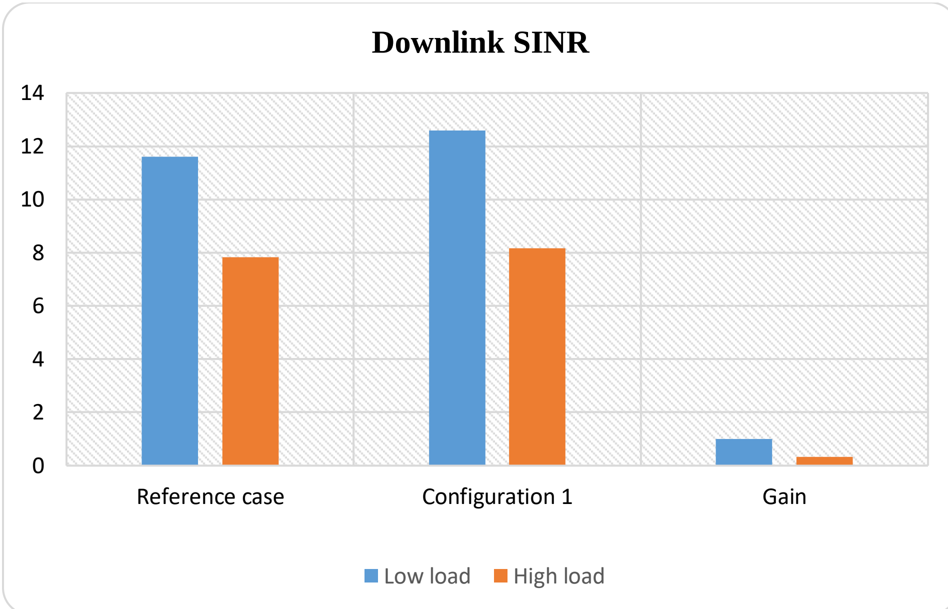

Fig 6.6: Average Downlink SINR per UE

6.6. Cell throughput performance

Adding low power nodes is to create gains by offloading the macro. When the UEs are uniformly distributed, high offloading.

6.6.1 Uplink Cell throughput performance

Only six percent of the UEs connected to the low power nodes in configuration1. This low offloading suggests only a small gain in served traffic simulations; there was no gain in the low load case and 8 percent gain in the high load case. Worth noting is that in the low load case almost 100 % of the offered traffic is served.

	Reference case	Configuration 1	Gain
Low load	5.8 Mbps	5.8 Mbps	0%
High load	7.4 Mbps	8 Mbps	8%

Table 6.7: Uplink cell throughput

Fig 6.7 showing as per reference case configuration 1 Uplink cell throughput low load and high load is higher than other configurations. Other hand, gain trending is better high load.

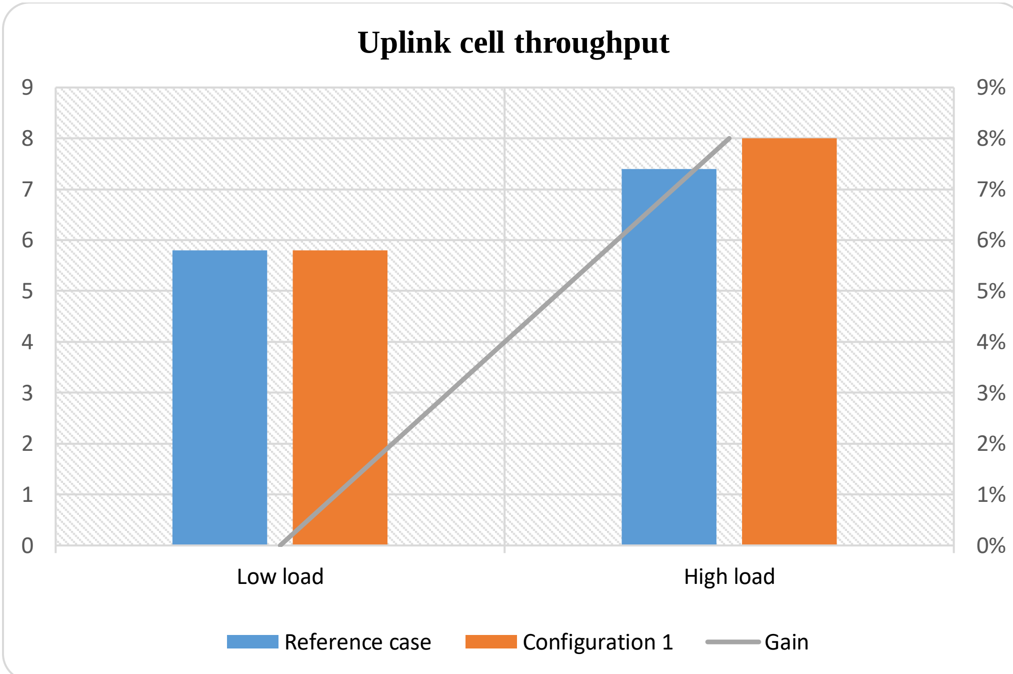

Fig 6.7: Uplink cell throughput

6.6.2 Downlink Cell throughput performance

Similar to uplink, the downlink shows a no gain in served traffic in the low load case while a gain of 9 % when the system is having a high load. See figure 6.8 and table 6.8. Also in downlink almost all offered traffic is served in the low load case.

	Reference case	Configuration 1	Gain
Low load	6.9 Mbps	6.9 Mbps	0%
High load	1.4 Mbps	2.2 Mbps	9%

Table 6.8: Downlink cell throughput

Fig 6.8 showing as per reference case configuration 1 Downlink Cell throughput performance low load and high load is higher than other configurations. Other hand, gain trending is better for high load.

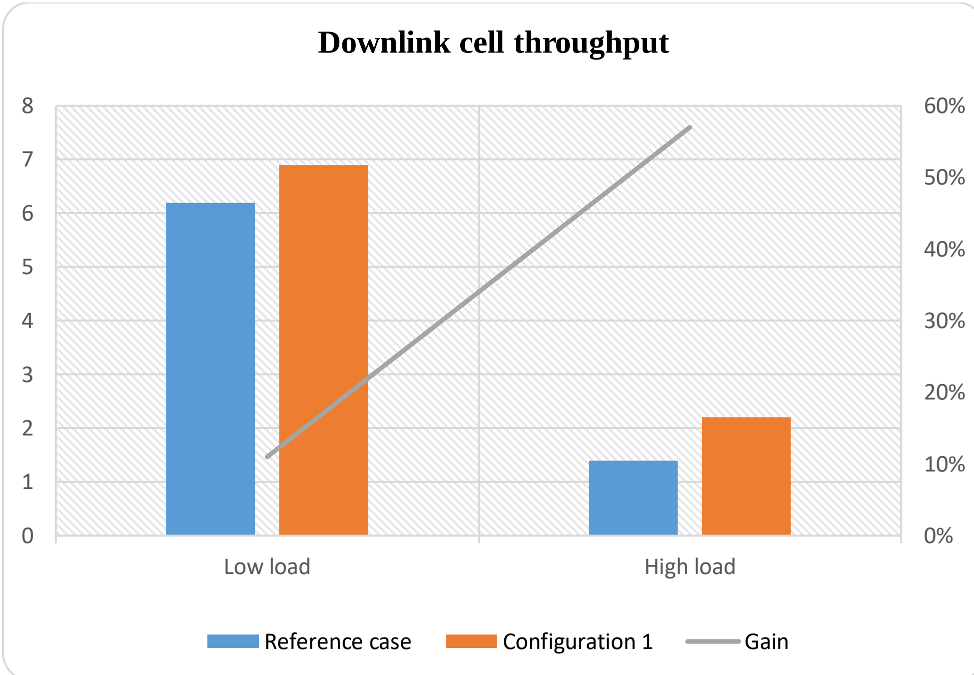

Fig 6.8: Downlink cell throughput

CHAPTER | 7

CONCLUSION

7.1. Conclusion

This Project is provided the performance of Uplink and downlink parameter in radio access network through a radio linkon highly loaded systems, both in terms of delivery nodes and the number of high traffic activity in user equipment. This study focused on specifically on the gain of transmission path. Uplink and downlink parameter's performance depends on the configuration of radio access network. In this project provides the analyzed performance like Macro PRB utilization, SINR, throughput, interference with respect to reference data of different configuration in Radio Access Network. It was also a problem of this project that the performance of UDS depends on the small cell density.

Cellular Access Networks have evolved significantly to meet demand, business, and new models from 1G to 4G. Study of evolution in RAN over the last few years and identify new trends in network compression. These include the evolution of BS, BS controllers, and backhaul networks.

7.2. Future scope of work

The existence of multiple applications requires a flexible, application-oriented and adaptive network that is difficult to support with existing infrastructure. These service providers and mobile operators are moving towards the separation from existing RANs. Modern applications requiring flexible networks are enabling the construction of standard open interfaces enabled by virtualization capabilities of AI-based networks. This paper describes the evolution of RAN, which is the background of O-RAN and its reference architecture. The RAN architecture is described in software-oriented networking. In addition, we have discussed various issues related to the uplink and downlink parameter of macro cell in Radio Access Network. In addition, the opportunities created by the advent of O-RAN were discussed.

CHAPTER | 8

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APPENDIX A

RAN: Radio Access Network

GSM: Global System for Mobile-telecommunication

MANET: Mobile Ad Hoc Network

QoE: Quality of End-user Experience

KPIs: Key Performance Indicators

BTS: Base Transceiver Station

IP: Internet Protocol

TCP: Transmission Control Protocol

iQoS: Individual Quality of Service

CSSR: Call Setup Success Ratio

SCCR: Successful Call Completion Rates

UMTS: Universal Mobile Telecommunication System

SMS: Short Message Service

GPS: Global Positioning System

QoE: Individual Quality of Experience

SIM: Subscriber Identification Module

MS: Mobile Station

BSC: Base Station Controller

IMEI: International Mobile Equipment Identity

IMSI: International Mobile Subscriber Identity

MSC: Mobile service Switching Center

PSTN: Public Fixed Network

HLR: Home Location Register

VLR: Visitor Location Register

MSRN:	Mobile Station Roaming Number
EIR:	The Equipment Identity Register
GPRS:	General Packet Radio Service
RTT:	Radio Transmission Technology
OFDM	Orthogonal Frequency-Division Multiplexing
OI	Overload Indication
PRB	Physical Resource Block
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase-Shift Keying
RE	Range extension
RNTP	Relative Narrowband Downlink TX Power
RSRP	Reference Signal Received Power
SIC	Successive Interference Cancellation
SINR	Signal-to-Interference-plus-Noise Ratio
TDD	Time-Division Duplexing
TDMA	Time-Division Multiple Access
TTI	Transmission Time Interval
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
WCDMA	Wideband Code-Division Multiple Access