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PLANNING OF SMALL CELL BASE STATIONS USING GENETIC ALGORITHM

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(M.Sc.In Communications Techniques Eng.)

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PLANNING OF SMALL CELL BASE STATIONS USING GENETIC ALGORITHM

THESIS

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Dedication

To whom Allah has bestowed dignity and honor, who taught me to contribute without expecting anything in return, and whose name I carry with pride, your words continue to guide me today, tomorrow, and forever. May Allah have pity on my late father, and may Allah have mercy on him always.

And to my life's angel, the meaning of love and mercy, the immortal smile, and the mystery of existence, my dear mother: I offer my deepest gratitude.

For those with whom I've spent the happiest days of my life and with whom I've had the greatest memories, for those who are happy for me and my success: my brothers.

I humbly commit my research to you, and I aspire to create a change in my life that you will be most pleased with.

SUPERVISOR CERTIFICATION

I certify that this thesis titled " **Planning of Small Cell Base stations using Genetic Algorithm** " which is being submitted by **Murtadha Hassan Naji** was prepared under my supervision at the Communication Techniques Engineering Department, Engineering Technical College-Najaf, AL-Furat Al-Awsat Technical University, as partial filament of the requirements for the degree of Master of Technical in Communication Engineering.

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Date : / / 2022

In view of the available recommendation, I forward this thesis for debate by the examining committee.

Signature:
Name: **Prof. Dr. Ahmad T. Abdulsadda**
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Date: / / 2022

COMMITTEE REPORT

We certify that we have read this thesis titled " **Planning of Small Cell Base stations using Genetic Algorithm** " which is being submitted by **Murtadha Hassan Naji** and as examining Committee, examined the student in its contents. In our opinion, the thesis is adequate for award of degree of Master.

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LINGUISTIC CERTIFICATION

This is to certify that this thesis entitled " **Planning of Small Cell Base stations using Genetic Algorithm** " was reviewed line- guistically. Its language was amended to meet the style of the English language.

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ABSTRACT

To serve more customers, cellular networks require higher power base stations to serve more users. The 5G uses high frequencies, such as millimeter waves, that are obstructed by obstructions, causing disruption to the 5G signals behind these obstructions. Small cells address this blocking problem, and 5G micro cells can easily be placed indoors and in areas of limited space. Several algorithms were used in this work, one of the main algorithms used in the optimization process is the genetic algorithm in order to find the optimal location for each base station to obtain (SINR maximization, ICI minimization, and maximum coverage area). The algorithm is allocating channels so that any cell that needs a channel is sent to the MSC where it allocates a channel to it according to the cell's request using an algorithm that works for this purpose, as this algorithm reduces the blocking of the connection and increases the channel usage and increases the capacity as well as all the channels in the MSC where it reaches all cells when they are needed.

This thesis examines the planning process that has led to the improvement of base station (BS) locations in a geographical area, such as residential neighborhoods, high-rise buildings, etc., such as residential areas, high-rises, etc. Suggested cases for system evaluation, 36 base stations and 110 base stations. In the first case 36 stations were installed, consisting of (12 micro cells and 24 pico cells), the coverage area increased as a result of applying the proposed algorithm from 68% to 80% which is a significant effect. Also, the mean value of the SINR increased to 18.67 db. The interference ratio between base stations has been significantly reduced.

In the case of 110 base stations where (9 micro and 101 Pico) were distributed. The coverage area increased due to the application of the proposed algorithm from 85% to 96% which is a significant effect. Also, the average value of the SINR increased to 19.7 db. It is clear from the two cases, that the optimal locations of the BSs can be used as a solution to the coverage area problem without the need to add additional BSs. The proposed algorithm can ensure that a good signal is obtained and that it reaches the user.

Obtaining the best locations for base stations and optimizing them using a genetic algorithm. Reducing the percentage of signal interference between the base stations using a proposed algorithm. Another case was also applied in a real environment to obtain the best coverage and the best signal for all users.

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All the people above, without whom I would not be the person I am today, those people who gave me the strength and motivation to complete this thesis.

DECLARATION

I hereby declare that the thesis is my original work except for quotations and ci-tations which have been duly acknowledged.

Date: / / 2022 Murtadha Hassan Naji

CHAPTER FIFTH : CONCLUSION AND FUTURE WORK

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LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation	**Description**
5G	Fifth generation
BS	Base station
4G	Fourth generation
SINR	Signal to interference noise ratio
ICI	Inter cell interference
MIMO	Multiple input multiple output
mm-wave	Millimeter wave
GBPS	Gigabits per second
IOT	Internet of thinks
UC	Use case
LOS	Line of sight
NLOS	Non line of sight
HETNET	Heterogeneous network
WVT	Weight voronoi tessellations
GA	Greedy algorithm
BILP	Binary integer linear programming
SP	Simple polygon
GIS	Geographic information system
QOS	Quality of service
DBF	Digital beamforming
RN	Radio network
MS	Mobile station

LIST OF SYMBOL

Symbol	Definition
d0	The close-in reference distance
PL(d0)	power path loss at a distance of d0
I_k	interference
N	NO. OF BS,
δ	environment factor
K	user
A	Area of sector of circule
A1	area of r1
r	radius
A2	area of r2
θ	angle
μ	Mean values
α	Variance Gaussian
X	a zero mean Gaussian random variable

CHAPTER ONE

INTRODUCTION

1.1 Background

Network planning is required for operators to spread coverage in cellular networks cost-effectively. Many factors affect the network architecture, including geographic area, expected number of users, base station startup configurations, and frequency reuse patterns. The literature on network mapping of difference cellular approaches is important. The network layout is examined in [1]. Both technologies reduced the number of BS and showed significant energy savings. It provides a method for estimating cellular networks that consider user density, service subscriptions, and interference mitigation [2].

The genetic algorithm was used to improve. adopted a similar strategy for cell selection in 4G cellular networks [3]. The authors assume that each mobile station requires less traffic than any other mobile station with which it can share coverage. in Finally, the authors develop general optimization models that may be applied to various wireless access methods in [4]. The predicted transition in the progress of 5G standards for mobile devices offers substantial issues for network planning as compared to current wireless networks. 5G networks, in particular, should provide very fast data rates of up to 10 Gbit/s and larger bandwidth than current cellular technology. This has prompted the usage of mmw frequencies, which offer a large quantity of potentially unlicensed spectrum for 5G cellular infrastructure. Because of the poor propagation quality, mm-wave frequencies have only been utilised for short-range wireless communications, such as the WiGiG standard, which can be improved by upgraded semiconductors and future development [5].

When compared to other GHz frequencies, the spectrum at 28 GHz is currently underutilised and has low air attenuation. This makes it equivalent to the frequency ranges employed in modern cellular technology in terms of free space path loss. Furthermore, at 28 GHz, Another benefit of 5G is the widespread availability of BS in networks[6]. According to research, 80% of clients are concentrated in 20% of network sites.

Furthermore, The comprehensive service stations cannot provide extensive coverage in such regions, most subscriber services are performed indoors, where coverage cannot be avoided. Smaller cells will be installed to handle heavy internal traffic, boost capacity, improve coverage, and minimise latency. BS brings the user closer to a smaller cell , and increases the number of resources available to active users [7].As in the following figure[1.1]

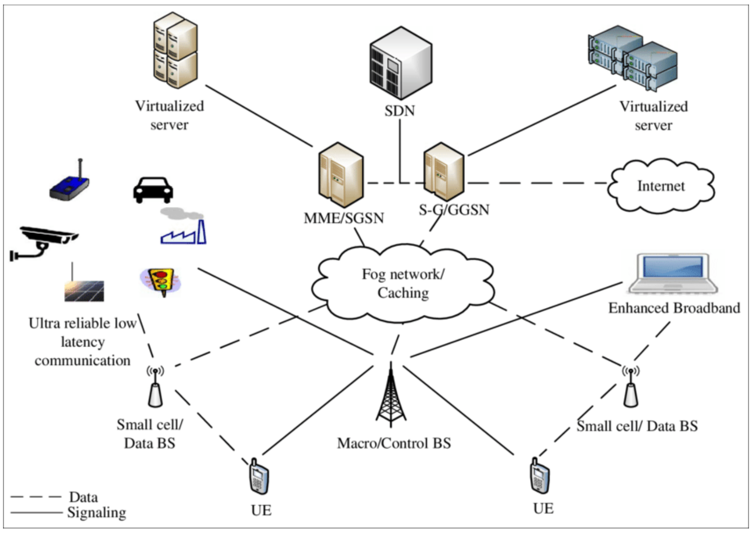


Figure 1.1 5G network architecture [37]

1.2 Problem Statement

The distribution of small stations on the sites have a great importance in terms of cost and signal quality. Therefore, the inaccurate distribution of these small stations can be considered a problem that needs improvement**.**

1.3 Thesis objective

- Creating an algorithm capable of calculating the ideal placements for small stations in order to maintain high signal quality as well as ensuring complete coverage of all spaces.
- Planning and test the algorithm on different environments such as residential areas and places of high towers, etc.

1.4 Scope of Work

Improving the signal quality of the fifth generation system within the proposed system. In my work, two integrated systems were used, each separately. Each system consists of base stations, whether 110 BS or 36 BS , and 500 users distributed in the work environment, and also contains obstacles represented by trees, houses, towers, etc., where Obstacles are propagated in this environment. To improve and distribute the base stations, three factors are evaluated: (coverage area, SINR, ICI). Using the genetic algorithm, the optimal location for each base station will be calculated to get the maximum fit (SINR maximization, ICI minimum, and maximum coverage area).

1.5 Contributions of Work

This study adopts the following contributions:

- Implementation of the process of designing a network environment that contains virtual obstacles(Home,Tree..etc) aimed at finding optimal locations for base stations and reducing interference in them to improve the deployment of fifth generation stations at the lowest cost and with better efficiency for all users using a the proposed algorithm(Genetic and Frequency allocation algorithm).
- Two systems were tested to choose the proposed algorithm. These systems are an integrated system. This systems contains 36 base stations and also 110 BS . and each of them is a complete system and an experiment for each case.
- The GA was applied on the real map to get the optimal location of base stations.

1.7 Layout of Thesis

The thesis is organized as follows:

- **CHAPTER 2:** "Theory and Literature Review" This chapter contains a general background about the 5G network as well related works
- **CHAPTER 3:** "The System model "This Chapter tackles The architecture of the work environment.
- **CHAPTER 4:** "Results and Discussion" Chapter provides this chapter results of the practical system and their discussion.
- **CHAPTER 5:** "Conclusions and Proposals for Future Work" this Chapter advances conclusions and future works.

CHAPTER TWO

THEORY AND LITERATURE REVIEW

2.1 Introduction

5G networks are digital cellular networks in which providers' service areas are partitioned into small geographical units called cells. The analogue signals that represent the phone's sounds and images are digitized, processed by an analogue-to-digital converter, and transferred as a bit stream. All 5G wireless devices in the cell communicate wirelessly via a local antenna array and a low-power automated transceiver, which selects frequency channels from a pool of frequencies shared by other cells. Local antennas use high-bandwidth optical fiber or wireless links to connect to the telephone network and the Internet [8]. As with other cellular networks, a mobile device that transfers from one cell to another is "handed over" to the new cell immediately. The 5G network can support one million devices per square kilometer, while the 4G network can only accept 100,000 devices per square kilometer. Due to the fact that new networks employ 4G to make the first connection to the cell, as well as in areas where 5G service is unavailable, new 5G wireless devices also support 4G [9].

Millimeter waves are utilized by numerous network operators to increase both capacity and throughput. Due to the shorter range of millimeter waves compared to microwaves, cells must be smaller [10]. Furthermore, millimeter waves have a harder time penetrating building barriers. Cellular networks formerly utilized enormous antennas; however, millimeter wave antennas are far smaller. Some are no longer than a few centimeters (inches). Massive MIMO (Multiple Input and Output) 4G was initially implemented in 2016 and typically employs 32 to 128 small antennas per cell. With the proper frequency and configuration, it can enhancement performance by four to ten. Multiple data packets are transmitted simultaneously. Beamforming is a technology in which a base station computer continuously determines the optimal path for radio waves to reach each radio device and organizes several antennas as phase arrays to create beams of millimeter waves that reach the device. Low-band 5G utilizes a frequency spectrum comparable to 4G mobile phones, 600-850MHz, in order to give somewhat greater download speeds than 4G, approximately 30-250Mbps. Low band cell towers cover the same area and have the same range as 4G towers [11]. The medium-band 5G network employs microwaves with frequencies ranging from 2.5 to 3.7 GHz, enabling speeds ranging from 100 to 900 Mbit/s, with each cell tower serving a radius of several miles. This is the most common service level, and it should be available in the vast majority of urban areas by 2020.This is the basic minimum of service because certain locations do not implement low band. High-band 5G runs at frequencies between 25 and 39 GHz, at the bottom of the millimeter-wave spectrum; however, higher frequencies may be employed in the future [12].

It routinely achieves download speeds comparable to cable internet, namely gigabits per second. Millimeter waves have a smaller range, requiring the use of several cells. Waves are made more difficult to pass through different materials by walls and windows. Due of their high price, these cells will only be utilized in dense urban locations and crowded venues such as sports stadiums and convention centers.

The speeds indicated above were achieved in actual testing conducted in 2020, and they are anticipated to increase upon launch [13].

2.2 What actually is 5G?

In 2019, mobile phone operators began global deployment of the 5G technology standard for broadband cellular networks in the telecoms industry. It is anticipated to replace the 4G networks that connect the majority of existing mobile phones. The International Mobile Network Association anticipates that 5G networks would have more than 1.7 billion users worldwide by 2025. 5G networks are cellular networks with service regions separated into small geographic units known as cells, similar to their predecessors. Through a local antenna, radio waves connect all fifth-generation wireless devices inside a cell to the Internet and telephone network [14]. The main advantage of the new networks is their increased capacity, which allows for faster download rates, which will eventually reach 10 gigabits per second (Gaps). The networks are intended to be utilized as a public Internet service provider for laptops and desktop computers, competing with incumbent ISPs both online and via phone. New Internet of Things (IoT) and machine-to-machine applications will be made possible by the network. Since 4G phones lack 5G capabilities, they cannot connect to the new networks. The enhanced speed is partially attributable to the usage of radio waves at a higher frequency than those utilized by earlier cellular networks. In contrast, radio waves with a higher frequency have a restricted physical range, necessitating fewer geographic cells [15~18]. 5G networks operate on three frequency bands: low, medium, and high. This enables them to provide a wide variety of services [19].

2.3 What exactly is a 5G SMALL CELL?

5G small cells are base stations that provide service to a specific portion of a coverage area. They are frequently implemented in dense metropolitan areas such as downtown, stadiums, train stations, malls, and other areas requiring high data capacity and coverage. Indoor macro base station penetration is limited, especially when metallic buildings interfere with network signals. As a result, the requirement for coverage indoors and in large venues such as stadiums etc. [20].

The enormous smartphone user market has contributed to greater data streaming services in the 5G era, resulting in the requirement for increased data capacity and coverage. 5G devices accounted for 35% of global smartphone sales. As a result, having a single macro base station covering a radius of a few miles is insufficient for coverage or capacity, hence smaller cells are also recommended for coverage [21]. The growing demand for data capacity and coverage has resulted from the increasing demands for flow, automation, industrial wireless network utilization, and the requirement for broadband Mobile, low latency, quality of service, and reliability [22].

2.4 What is Small Cell Technology?

A small cell is a wireless network base station that is small in size and has a limited radio frequency power output and range. These nodes use radio equipment to receive and broadcast data to smaller areas over low, medium, and high-band spectrum. Small cells in 5G networks connect to regular cell towers before relaying data from one cell to another, ensuring signals travel across long distances [23].

The small antennas are very directional and use a method known as beamforming to target specific areas around the facility. To connect to 5G networks, small cells require a power source and backhaul (fiber, cable, or microwave). Here are the three main types of small cells [24~28]:

- Femtocells are generally used as a low-cost alternative for improving in-building coverage. Femtocells have a (30-165) foot coverage range, accommodate (8-16) users, and employ a wired or fiber backhaul connection.
- Pico cells: These devices are used to provide extended indoor and outdoor coverage for small businesses such as higher education, offices, hospitals, and retail malls. Pico cells have a range of (330-820) feet, can accommodate (32-64) users, and use a wired or fiber backhaul connection.
- Microcells are used to give coverage to a specific area, such as hotels, shopping malls, and unique spaces within transit hubs. Microcells have a range of 1.5 kilometers, can accommodate 200 concurrent users, and employ a cable, fiber, or microwave backhaul link. Microcells cost more than femtocells and Pico cells.

2.5 Millimeter-wave propagation

New radio may operate at frequencies greater than 24.25 GHz, which corresponds to the frequency range (FR2). This frequency range is frequently referred to as millimeter wave (mm Wave) frequencies. The key rationale for using mm Wave is the vast quantity of spectrum accessible in these higher bands [29]. While bands below 6 GHz might have channel bandwidths of up to 100 MHz, the mm Wave range can have bandwidths of 500 MHz or even 1 GHz. [30~33] These frequencies are expected to support data rates in the order of Gaps; however, due to the high frequencies, mm Wave presents significant impediments, such as high path loss, increased effect of blockage due to weaker non-line-of-sight paths, and attenuation due to rain and atmospheric absorption [34]. Because the free space path loss is proportional to the square of the carrier frequency fc2, increasing the frequency from 3 GHz to 300 GHz will result in a power loss. regardless of how far the transmitter is from the receiver [35]. Because of its tiny wavelengths, the mm Wave band is susceptible to obstruction.

Furthermore, mm Waves signals are affected by a variety of atmospheric factors, including precipitation from rain, because raindrops are roughly the same size as the wavelengths; and power loss due to foliage obstruction caused by vegetation, as well as the effects of multipath dispersion, diffraction, and reflection. [36] Nonetheless, technologies such as massive MIMO and beamforming, which employ hundreds of antenna elements and hence provide significant yields, aid in overcoming the high route losses and obstructions. [37].

2.6 TECHNOLOGIES USED IN 5G

The key technologies that set 5G apart from prior generations are provided to be critical components of the technology [38].

A. Spectrum Sharing

For a better and more sophisticated network, bandwidth and spectrum sharing are necessary. For cellular mobile broadband networks, spectrum sharing aids system dependability and financial assurance.

B. Ultra-Dense Network

Different protocols and operating systems will be required to meet the demands of increased traffic caused by a rise in the number of users. If backhauling and interference become more prevalent, an additional layer of functions will be added to improve the performance of heterogeneous networks.

2.7 UPCOMING CHALLENGES IN 5G

5G is expected to have a big impact on technology like self-driving vehicles, intelligent houses, and extraordinarily fast internet speeds in nearly every aspect of our lives. Naturally, bringing this type of sophisticated technology to life has some obstacles. Here are some of the issues that need to be addressed [39~42]:

- Spectrum allocation: One of the difficulties that 5G will face is the high cost of the spectrum.

- Base station density: If MIMO technology is to be deployed, more antennas and base stations will be necessary to increase network connection.

- Heavy Costing 5G devices: To improve connection, deploying a huge number of tiny cells comes at a substantial cost.
- Energy Consumption: Huge volumes of data are transported and received in files, high-quality music, and HD movies, necessitating the adoption of new source coding such as to enhance throughput, resilience, and energy consumption while attaining the network's desired capacity.
- Cell size: Pico, Femto, and micro-base stations are used in heterogeneous networks. Inter-cell interference is a significant problem in HetNets. Therefore, the problem of interference should be solved as much as possible.

2.8 Genetic Algorithm and Facility Placement for Coverage Optimization

The sophisticated nature of the Genetic Algorithm (GA) has made it an efficient searching tool, as it has found application in complex business problems such as pattern recognition, scheduling, and so on [43]. The use of genetic algorithms in telecommunications can be justified by the fact that the factors that challenge optimal service are generic in nature; GA is an optimization tool capable of producing optimal results in situations where there are many conflicting options; this is due to its ability to search large spaces efficiently without the need for derivative information. They operate on a population of potential solutions, using the survival of the fittest principle to generate, hopefully, better and better approximations to solutions.

They always produce high-quality solutions because they are unaffected by the initial configurations. Furthermore, they are computationally simple and simple to implement. One disadvantage is that they may converge prematurely to a suboptimal solution [44].

GA utilizes a clearly defined procedure for solving problems with a finite time for termination.

Three major issues are addressed in the implementation of GA's these are;

- Coding of the parameters
- Development of the fitness function
- Chromosome selection strategy

Basic steps taken in the implementation of Genetic algorithm begins with defining the optimization variables, its constitution and cost. It ends by testing for convergence [45].

As shown in the general scheme of the genetic algorithm:

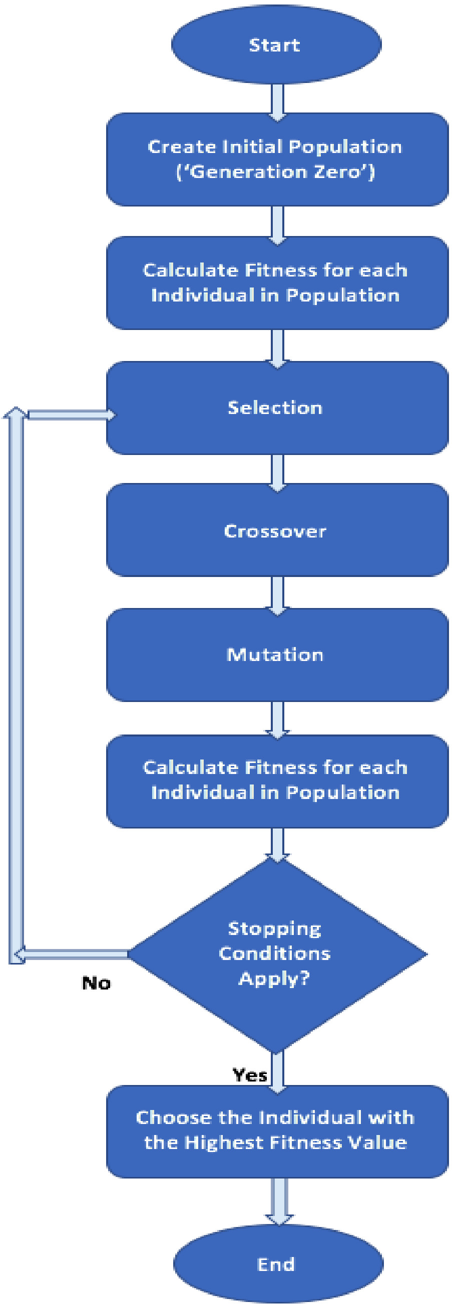


Figure.2.1 Flow chart showing the basic steps for implementing GA in location optimization problem

2.9 Population Initialization

The population is a collection of "candidate solutions," which are usually referred to as chromosomes or individuals. The first generation of a population is made up of individuals composed of 'genes,' which are the defining characteristic of that individual, allowing it to be referred to as a candidate solution for the optimization problem. The initial pollution size is usually based on an estimate of the site requirement, which includes determining the number of base stations needed to meet the coverage and capacity constraints adequately [46]. Typically, site estimates are based on cell computation using wave propagation models and basic cell planning calculations. The initial population is derived from a cell plan map, with the most likely base station location selected based on coverage. The longer it takes to run the algorithm, the larger the initial population, because the GA spends the majority of its time evaluating the population. The chromosome can be represented as an array of bits, a number, an array of numbers, a matrix, a string of characters, or any other data structure that must satisfy given precision and constraints and be suitable for genetic operator implementation [47].

2.10 Fitness Evaluation

The method of evaluating the fitness of a chromosome using a mathematical function derived based on the optimization objective is known as fitness evaluation. The fitness function definition is at the basis of designing a proper GA to solve an optimization issue; this function is made up of the evaluation function, which assesses whether the optimization goals have been met. The fitness function has been demonstrated to be a mixture of multiple functions for a multi-objective optimization problem in which certain design needs are defined as constraints that are seen through violation. These limitations are typically included into the algorithm and then used to evaluate the fitness function to assign a value to each chromosome [48]. The fitness function for most facility placement algorithm is multi objective, the objectives include coverage, economy; transmit power, and sometimes environmental impact.

For a single objective function, the coverage is given as:

F = traffic coverage area

$$= \frac{\text{Coverage traffic}}{\text{Total traffic}}$$

Having defined the objective function, the processor assigns a fitness value on each chromosome base on calculation results obtained using propagation models and function equations. The value assigned to an individual is relative to the rest of the population.

2.11 Genetic Operators/Reproduction

The reproduction process of the algorithm follows a sequence of selection, cross over and mutation, reproduction defines the rules for generating the gene sequence of offspring from the parent's chromosome.

2.11.1 Selection

The selection process is analogous to the survival of the fittest in the natural world [16], in the GA operation, based on the fitness value allocated to each chromosome, selection is done to select parents for crossover, and the system is expected to choose the more fit individuals in the population while still preserving the population diversity. Several means of selecting a population exist with their advantages and disadvantages [49],

In the Facility placement problems reviewed mention is made of rank-based, roulette wheel and tournament selections methods. Researchers have compared these three selection methods and from results based on fitness cost indicated that tournament selection utilizes a more efficient method of choosing fitter parents for mutation though choice could be problem dependent.

2.11.2 Cross over

Cross over is the process of inter linking two chromosomes where genes are exchanged resulting in new chromosomes carrying the features of both parents. It is analogous to combination of genes in biology resulting in a haploid, it can be referred to as the sexual combination with relation to life and evolution. It involves the introduction of sub solutions on different chromosome resulting in an entire new chromosome or generation. Cross over is done to accelerate search; the basic cross over methods include single point cross over, multipoint and uniform cross over [50].

2.11.3 Mutation

This is a word used to describe a genetic operation performed on a population in order to make adjustments. This operation is utilized in an attempt to allow the algorithm to search all feasible space and arrive at a global optimum. In the case of a binary GA, this entails randomly turning a 1 to a 0 and vice versa. Mutation is considered to as random when the solution is permitted to explore all conceivable search space with no problem particular knowledge, whereas directed mutation involves the application of problem specific knowledge to fine tune a solution. Mutation probability is advised to be as low as 0.1% to avoid early convergence and as high as 1% in other cases [51].

2.12 Ending Criteria

The complete process from population initialization to mutation resulting in the production of a new set of “candidate solution” can be referred to as one generation. The GA is run over several generations in order to determine the best set of solutions and typically ended at the best convergence; that is when the best fit converges to the average. There are however other stopping criteria which include

- Fixed number of generations reached
- Budgeting: allocated computation time/money used up
- An individual is found that satisfies minimum criteria
- The highest ranking individual's fitness is reaching or has reached a plateau such that successive iterations are not producing better results anymore.
- Manual inspection. May require start-and-stop ability

- Combinations of the above

Usually GA is ended with an output display of both data and graphs of best solutions to the facility placement [52]. One that will give best coverage and minimum number of facilities while takings environmental and safety constraints into consideration.

2.13 Related Works

Wissam EI-Beaino.2015 [53]. In the framework of 5G cellular networks, radio network planning was established in order to enhance the number and location of base stations in a given area. This study used 55 Macro cells and 36 Micro BSs because it was planned to use Macro and Micro BSs at 28 GH. took into account a network with 600 evenly dispersed users and four dense sites with 60 randomly distributed users each. On 5G networks, stadiums, shopping malls, train stations, and indoor workspaces will have high user counts. The results were obtained for a (5 km * 5 km) area. The average signal strength average (MEAN SINR is 0.56 dB) was determined during the first randomization, and the number of cells employed was reduced from 91 to 18 macro cells and 13 micro cells using the algorithm (Weighted Voronoi tessellations). These are congested areas such as retail centres, football stadiums, and sites with high indoor traffic.

Sebastian Szyszkowicz.2017[54]. In this study, Cell planning based on LOS coverage can be done using computational geometry and optimization tools, which may be the limiting factor in mmWave networks, so the purpose of the study is first to determine the locations of the base stations and then to choose a small subset of BS candidate sites to increase the external coverage according to the algorithms (greedy addition (GA) and binary integer linear programming (BILP)). Sites are chosen by After the extraction of the map data, nearby buildings are joined and the holes within them are filled to generate simple polygons (SPs). Then, for each SP, we assign a cell with points that are closest to that SP. If two SPs' connected cells contact, they are said to be natural neighbors (NNs). A link between any two NNs can be defined as the shortest line segment linking their SPs. Each SPs contour is divided into several regions. Then, for each region, a point with the highest LOS is found, and this point is deemed the location of the candidate base station. The study's results showed that an area of (1 * 1) K m2 was used, and a coverage area of 90 percent was reached. In addition, the SINR is 30 dB .

Margot Deruyck(2017). [55]. The study's goal is to attain the lowest cost while providing the most coverage. It is possible to provide coverage for every user in a given area while also minimizing network power consumption. The main challenge is evaluating the network's performance and determining the coverage ratio, capacity, and efficiency using multiple scenarios. Solve the issue of having two types of network architectures, one of which does not support packet shaping and the other which does. An method that determines the route loss depending on the distance between the new user in the examined region and the base station was used to run 40 simulations, with 40 networks established in total over a one-hour period. Over the course of a 24-hour period, 960 networks were established. The simulations show that, compared to the reference scenario, the 5G scenario with no packet creation demands a greater number of stations (4G). The research also revealed that 5G networks with packet creation are more energy efficient. Beamforming is a less energy-intensive option. It also uses half the energy of 4G and has twice the capacity; nevertheless, because to the area's 46 percent poor coverage, it is not a good option for network planning. Digital beamforming (DBF) outperforms the competition. The hybrid beamforming design achieves comparable coverage area, user count, and base station count while utilising less energy. This study's findings span the coverage area for these scenarios: a) no beamforming is 45.9%, b) digital beamforming is 91.4 percent, c) analogue beamforming is 81.9 percent, and d) hybrid beamforming is 80.6 percent. as well as SINR (7.39, 15.4, 17.5) db.

Oscar D. Ramos-Cantor(2018) [56] . The study's primary aim is to propose a cellular plane to improve the wireless communication network's resource efficiency while also considering the quality of service demands imposed by mobile phone services—propagation modelling Empirical, Urban. Candidate sites Existing sites, hotspot areas The scheme optimizes the distribution of resources among network slices and the assignment of cells to various slices. The proposed approach enhances resource efficiency and allows for a centralized network design model according to simulations. It also looks at how the use of orthogonal pools of numerous resources in cell architecture affects system resource efficiency. The subject addressed in this study is how to increase the efficiency of wireless network resources while also improving resource distribution among network segments. The NSGA-II Algorithm is used to solve the problem.

Shaded, R. Q [2019], [57] In this study, OMNET++ network simulation is used to model 23.2 square kilometers of a dense urban 5G network in the city of Ibb for the design of 5G wireless access. The millimeter wave (mm-Wave) band 28 GHz. To satisfy the densification network, simulation results reveal that require 223 micro cells to deliver services to 186532 customers in the covered urban area of Ibb city. that chosen an urban area of around 23.2 Km2. The results revealed that the SINR value is 74 db. Furthermore, the coverage area is 95%.

Georgia E. Ethan asiago, (2019) [58]. in This study, the scenarios are designed to work in a5 × 5-kilometre region. There are 400 control nodes in all, with 16 control nodes every square kilometer. To introduce a large coverage area and initial capacity requirements. Several control nodes have been shifted randomly by a few tens of meters to create a more realistic work environment. pick a subset of BS (macros, micro) and radio network (RN) where the least likely cost fulfils coverage and capacity restrictions using the NSGA-II genetic Algorithm. NSGA-II models natural evolution mechanisms and applies biologically inspired operators to a set of randomly chosen candidate solutions to an optimization problem. The selection operators and cost, cross, or mutation function are applied iteratively for fresh atomic results after the Genetic initialization algorithm (GA). The findings emphasize two key points:

1- Replacing giant cells with a slew of smaller ones is the first step toward high-capacity radio networks.

2- It is feasible to lower the cost of radio network implementation by improving it.

QiWang.2020.[59]. Based on the assumption that mmWaves loss is linearly related to propagation distance, this study simulates the LOS coverage of 5G BS stations. The deployment of ultra-dense base stations is required for the construction of fifth-generation (5G) cellular networks. These dense base stations have extraordinarily high construction and operating expenses. To model the propagation of 5G signals, this study utilised a geographic information system (GIS) and a heuristic optimization technique. The goal of this research is to provide a site optimization model to aid in the planning of ultra-dense 5G networks in urban outskirts and to assist in addressing the cost difficulties of 5G. The primary takeaway from these findings is that the number of base stations deployed does not increase coverage; in fact, when 50 base stations are placed in the research region, the maximum service coverage of base stations is only 75.06 percent. As increase the number of base stations, so does service coverage. When p is increased to 160, LOS services cover 95.88 percent of demand points. Effective service coverage increases from 95.88 percent to 97.99 percent as p increase from 160 to 200. As a result, despite an increase of 40 BSs (representing 25% of the BS), effective coverage in the study region increases by just 2.11 percent. The most critical factor is the location of the base station.

M. Sousa(2020). [60]. In this work, the primary aim is to develop a radio network planning method for 5G mm-Wave small cell topologies. The algorithm is separated into two sections: radio access network and backhaul network. The former seeks suitable placements for small cells to ensure coverage requirements, whilst the latter establishes backhaul linkages between small cells based on a certain topology and selects which of them should be gateways. The findings provide some insights into base station (BS) and gateway density, and show that the mesh network is the topology most likely to meet Quality of Service (QoS) needs while lowering the number of gateways. However, tree and star topologies can also be effective in some situations. The difference in frequency between 28 GHz and 60 GHz is obvious. At 60 GHz, the cell radius of each tiny cell drops dramatically due to increased propagation losses. As a result, a greater number of cells are required to fulfil the baseline 98 percent coverage requirement, as well as a greater number of gateways for all topologies.

Tun, H. M. (2021) [61]. in this study, focuses on the numerical examination of the network design and optimization challenge in the 5G communications system This work has been divided into two parts: network planning for efficient network models and optimization of power allocation in the 5G network. The radio network planning procedure has been finished for a certain area. The data rate need can be met by allowing the system to be densified by deploying tiny cells. The radio network design scheme is an essential foundation for establishing a wireless network that meets certain coverage technique, capacity, and Quality of Service requirements. In this study, eighty micro base stations and two hundred mobile stations are placed in a (15km*15km) broad area in Yangon's central area. The optimization techniques were also examined in relation to the 5G network's source and destination nodes. The linear programming technique is used to minimize and optimize the location of base stations in a specific geographical area.

CHAPTER THREE

THE PROPOSLE SYSTEM

3.1 INTRODUCTION

In this Chapter, the work environment is designed with several base stations distributed irregularly in the environment and according to the algorithm used due to the presence of obstacles, where small cells were used because they are accurate to ensure the quality of the signal and access to all users throughout the region, and also the coverage area where the stations were distributed. An estimated 4 million square metre setting in which numerous barriers such as buildings, trees, and so on were built in various locations to complete the design of the work environment. Millimeter waves were employed to transmit the signal from one tower to another (LOS), resulting in the deployment of tiny cells to achieve the best coverage.

3.2 The architecture of the work environment

In this section, mathematical models were clarified, building the environment in terms of obstacles through coverage area, distribution of base stations, and distribution of users.

3.3 Methodology

The 5G network layout model is developed to build a 4 million square meter virtual environment that contains the barriers of difference. These obstacles are personified as real obstacles. After the environment is established, base stations in the environment are initially distributed on a regular basis to see how many stations are required to cover the area regardless of obstructions. Then the base stations are randomly distributed in different environments according to the algorithm to reach the best distribution, where the distribution is in residential areas, high towers, etc. To improve and distribute the base stations, several algorithms were used in this work, one of the main algorithms used in the optimization process is the genetic algorithm to find the optimal location for each base station, as well as the use of the frequency allocation algorithm where the channels are distributed to users according to the user's need for communication. In its frequency, three factors are evaluated: (coverage area, SINR, ICI). Using the genetic algorithm, the optimal location for each base station will be calculated to obtain the maximum fit (SINR maximization, minimum ICI, and maximum coverage area). To maximize the QoS, due to the calculation of the best fit value, BS changes the location using the algorithm to reach the best distribution and get the best possible coverage while maximizing the signal strength and minimizing interference as much as possible and also GA was applied to the real map to get the optimal location of the base stations. As in the following figure [3.1]:

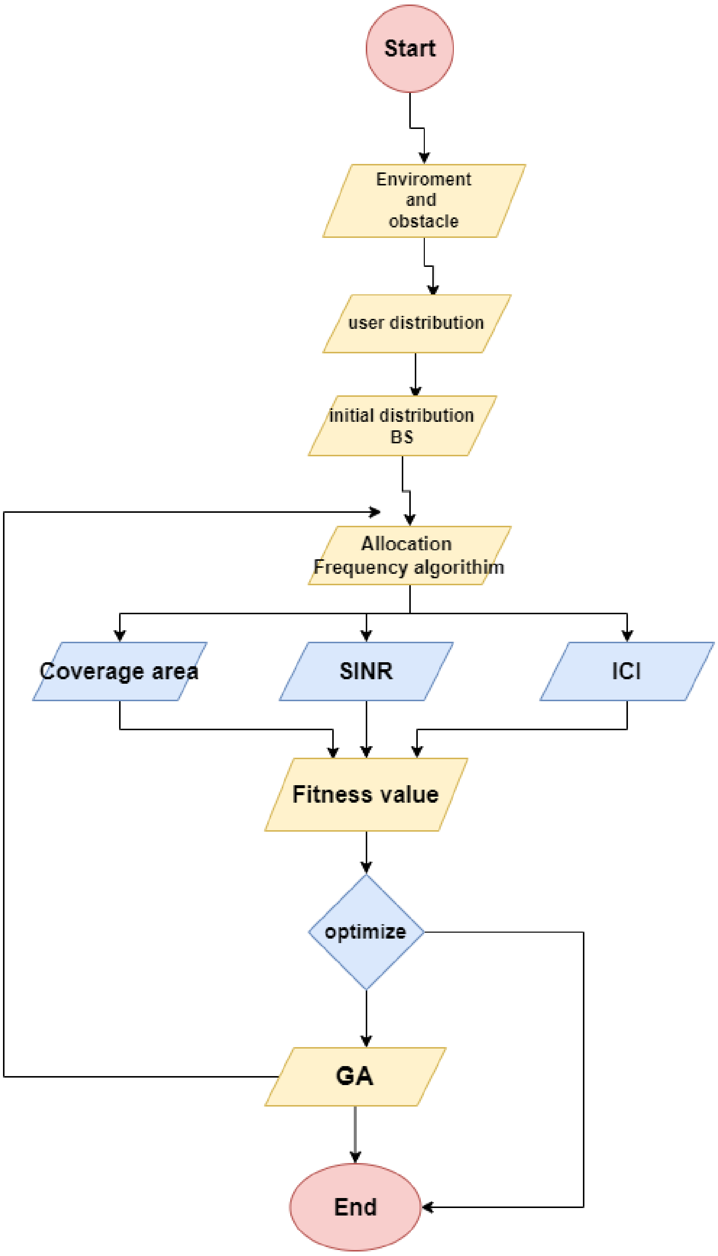


Figure.3.1 The general model of the algorithm's work mechanism

3.4 5G SYSTEM MODEL

The system model in 5G is an integrated environment of obstacles, users, and base stations. This section consists of several main Parameter (SINR, ICI, Coverage,5G Frequency Bands) Now, the parameter is explained:

3.4.1 SINR for 5G System

The signal to interference and noise ratio (SINR) consigned to user A can be exhibited as follows [51]:

$$SINR = \frac{P_{tx}G_s/P_L(d_0)}{\sum_k P_{tx}G_i/P_L(d_k) + WNF} \quad 3.1$$

where Gs and Gi are the serving and interfering antenna gains; W is the downlink bandwidth; N is the noise power density; and F is the noise figure We also calculate the 3D distance with the transmitter and receiver heights set to 15 m and 1.5 m, respectively, to find the distance (d). Understanding the impacts of interference and, more especially, the chance that mm Wave wireless networks would be limited by interference or thermal noise is a critical concern for the design of mm Wave networks. While advanced techniques such as intercellular interference coordination, coordinated beamforming, and dynamic orthogonalization can help interference-limited networks, they have minimal value in networks where thermal noise, rather than interference, is present.

$$P_L(d)[dB] = \alpha + 10\beta\log_{10}(d) + X \quad 3.2$$

Where:

PL is the path loss in dB, d is the distance from the transmitter, α and β are the linear tuning parameter sets, and X is a zero mean Gaussian random variable with variance σ.

3.4.2 Inter cell interference for 5G System

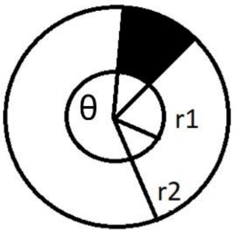
It is the cumulative power received from all other base stations that have used the same channel except for the base station communicating with the user. Mobile networks are limited to a specific number of frequencies, and signal interference presents significant challenges. When two sites have the same frequency or are close to each other, interference occurs, signal and call quality drops dramatically, and significant interference can cause communication to be interrupted. The interference calculation for each user is defined as in the following expression [37]:

$$I_k = \sum_{\substack{i=1 \\ i \neq M}}^{N} P * d_{ki}^{-\delta} \qquad 3.3$$

Where N = NO. OF BS, P: Power Transmit, d: distance, M = The base station which user "k" is associated. δ= environment factor.

3.4.3 Coverage for 5G System

The system coverage area can be calculated as the sum of the individual coverage of each base station and subtracting the common areas wherever they are found in the environment. also see in the figure below that the spherical center is the locus (mini BS), where this sphere is the maximum covered by the base station. For example, in this black section in the figure is the area that will cover the place and according to the distribution of stations and their optimal location according to the algorithm used. Therefore, it will have an irregular shape. Each piece of this shape resembles a (disk). So, the total area of the area covered by the base station by this (sub-disk) which is its area that contains coverage. We will use the following laws with clarity as below:



A : Area of section of circule

$$A = \left(\frac{\theta}{360}\right) * (\pi r^2) \quad 3.5$$

But in our case :

$$\theta = \theta_2 - \theta_1 \quad 3.6$$

$$A = A_2 - A_1 \quad 3.7$$

A2 **:** area of r2

A1 **:**area of r1

$$A_2 = \left(\frac{\theta 2 - \theta 1}{360}\right) * \pi r_2 \qquad A_1 = \left(\frac{\theta_2 - \theta_1}{360}\right) * \pi r_1^2 \quad 3.8$$

$$A = \left(\frac{\theta 2 - \theta_1}{360}\right) * \pi(r_2^2 - r_1^2) \quad 3.9$$

3.5 5G NR frequency band

5G wireless technology employs many frequency bands within the (RF1) and (RF2) bands for 5G NR radio. The following table details the precise frequency bands for 5G NR used in this study, the channel bandwidth supported by each band, and the cell radii. Its height, the type of cells employed, and the proportion of energy produced by each cell type.

Table3.1 Major simulation parameters used

Parameters	**specification**
Frequency For BS	28GHz
Frequency For user	3500MHz
Cell radius	100 m ,250 m
High BS	15 m
Micro BS TX Power	33 dBm
Pico BS TX Power	24dBm
No.of user	500
Area	2000*2000 m2
Uplink and Downlink band for RF1	(3300-3800) MHz
Uplink and Downlink band for RF2	(26.5-29.5)GHz

3.6 Building environment For 5G System

In the environment, there are many base stations irregularly distributed due to obstructions, which are accurate to ensure signal quality and reach all users throughout the area. The environment area is estimated at 4,000,000 square meters.

Where the obstacles are embodiment in a way that simulates the real reality, where many scenarios can be made with the test because it simulates different environments, and this includes the environment (coverage area, distribution of stations, users, and obstacles included in the environment) and will explain each of these paragraphs with the following steps. As in the following figure [3.2]:

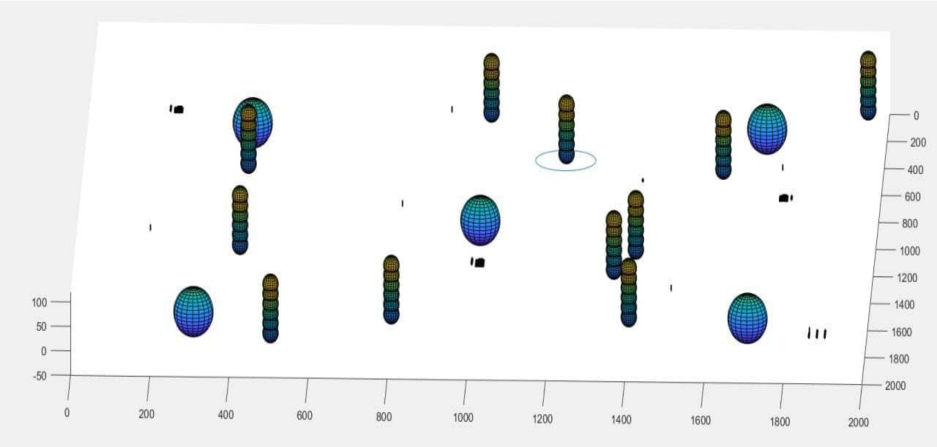


Figure 3.2 Obstacles within the environment

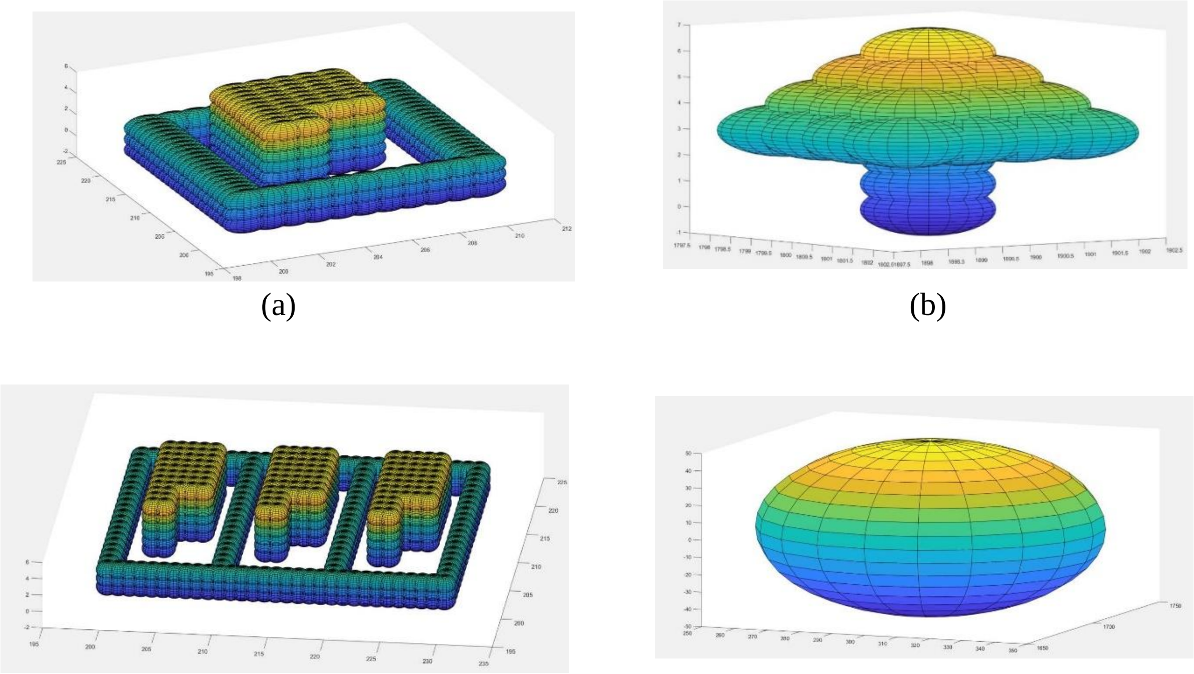
3.7 Coverage area determination for 5G System

The system coverage area can be calculated as the sum of each base station's unique coverage area where these stations were distributed throughout a (2 × 2) Km2 environment. Micro and pico cells were used in this study. Micro cells are a type of radio coverage cell used in cellular networks. They can cover a distance of up to (250 meters) depending on the frequency and bandwidth of the signals and the obstacles in the area. Their performance can also be increased by increasing the efficiency of the transmitter and receiver for each microcell in this environment. This type of station is located along highways and in rural areas where coverage is scarce.

Pico cells are another type that is used in this context, it is a base station that has a range of approximately (100 meters) and transmits at lower power than other cells. Typically, they have Omni-directional antennae and are used both indoors and outdoors. The transmitting power is approximately 2 watts. As you know, each base station covers a specific area in the environment, and the environment contains numerous obstacles. Wherever an obstacle exists within the boundaries of any base station, the obstacle will block the signal, effectively cutting off coverage in that area.

3.8 Obstacle For 5G System

Various obstacles such as trees, houses, skyscrapers, etc. were added in different locations of the work environment, as shown in the following figures:



(a) (b)

(C) (d)

Figure 3.3.a)side of the house, b) Tree ,c) Several houses, d) one mall

3.9 Base station distribution

Distribution of cells in densely populated places where small cells are added to these places with a lot of users to get better coverage as this distribution of cells enhances the quality of service and the efficiency of the energy received for the user. As for large cells, they are used and deployed in rural areas with low population density, where the percentage of users is less compared to urban areas. As for the distribution mechanism of the base stations, the algorithm will choose randomly to get the best distribution. As for the uniform distribution, there are many advantages and disadvantages. The benefits are possible for any expert to distribute the base stations by dividing the space into equal parts based on individual Bs or randomly distribute the stations in environment. As for the disadvantages, they are It ignores the presence of obstacles, so the base station may be adjacent to a certain obstacle that prevents the signal from reaching the user, which leads to a weak signal or prevents it from reaching the user, which leads to insufficient coverage in that area. Therefore, it is preferable to use an algorithm that distributes the small stations in a way that guarantees the quality of the signal and obtains the best coverage even if a certain obstacle is found.

3.10 Probability Distribution of Cell’s LOS Fraction

Cell's LOS Fraction Probability Distribution Another useful piece of information is the percentage of LOS coverage in the cell. That instance, if a cell is appropriately positioned, there is a greater chance of a larger line of sight area. Following network planning, we compute the cumulative density function of the fraction of LOS and provide its mean and variation in Table 4.4. The LOS coverage data, in conjunction with path loss models, can be used to compute link budgets and rate coverage for outside urban areas.

3.11 Users distribution in environment

The distribution of the number of users per cell in the area is important to evaluate the performance of the cellular network. Where the distribution of users in the work environment is according to the density of distribution in the areas that contain mall, skyscrapers, and others. As for rural areas, parks, and roads, the distribution of users is less and randomly, as in the following figure [3.10]:

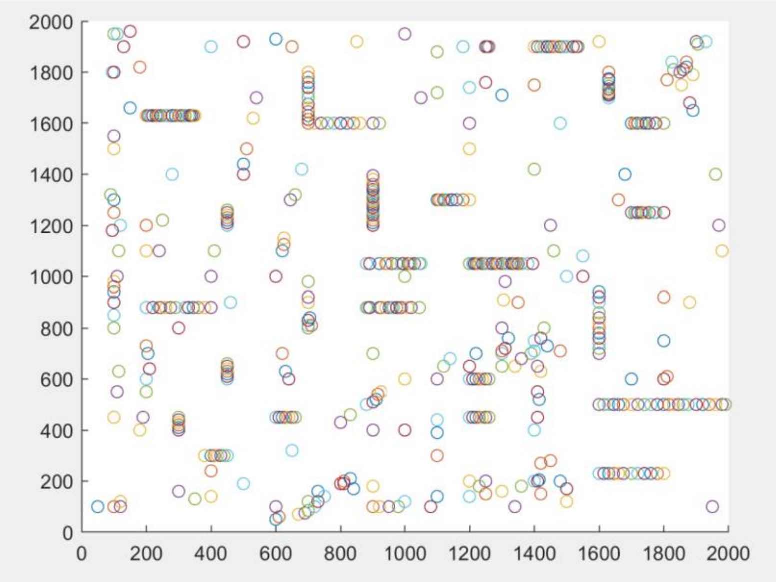


Figure 3.4 Distribution of users in the environment

3.12 objective function

In order to get the best locations of each base station, there is an objective function must be used that depend on summation of coverage areas of all base stations as well as the ICI appear.

We define the vector z to be a vector of n binary variables, where n is the total number of points distributed in outdoor areas. z is the state of all distributed points, that is zj = 1 if the point j is covered and zj = 0 otherwise. We define a vector y to be a vector of m binary variables, where m is the total number of candidate locations; yi = 1 if a BS is placed in candidate location i and yi = 0 otherwise. All the coverage information of the points and candidate locations is summarized in the matrix M:

$$M = \left[m_{ij}\right]_{m\times n}, m_{ij} \in \{0,1\} \qquad 3.10$$

where mij = 1 if the point j is covered by the candidate BS location i, and mij = 0 otherwise. Having this information, the GA can be written as the following:

Maximize

$$\sum_{j=1}^{n} z_j + \frac{\beta}{ICI} + \gamma * SINR \qquad 3.11$$

Subject to

$$\sum_{i=1}^{m} m_{ij} y_i \geq z_j, j \in \{1, \dots, n\} \qquad 3.12$$

$$\sum_{i=1}^{m} y_i = k, \qquad 3.13$$

$$z_j \in \{0,1\}, j \in \{1, \dots, n\} \qquad 3.14$$

$$y_i \in \{0,1\}, i \in \{1, \dots, m\} \qquad 3.15$$

If point j is covered (zj = 1), at least one of the candidate BSs covering it should be deployed, giving constraint. We want to use k BSs in total, so the summation over y should be k, giving. The number of points covered can be found by a summation over z, giving the objective function.

Where:

$\propto, \beta, \gamma$: importance ration of coverage area , ICI, and SINR respectively and $\propto + \beta + \gamma = 1$

Chapter Four

RESULT AND DISCUSSION

4.1 Introduction

In this chapter, two cases of the distribution of base stations were dealt with, case 110 and case 36, where the percentage of coverage area, signal strength, and interference ratio were found, as well as a graphical calculation of the interference rate relative to the base stations, and all cases were found before and after the improvement process. The result of the GA algorithm also applies on real map and demonstrated in this chapter.

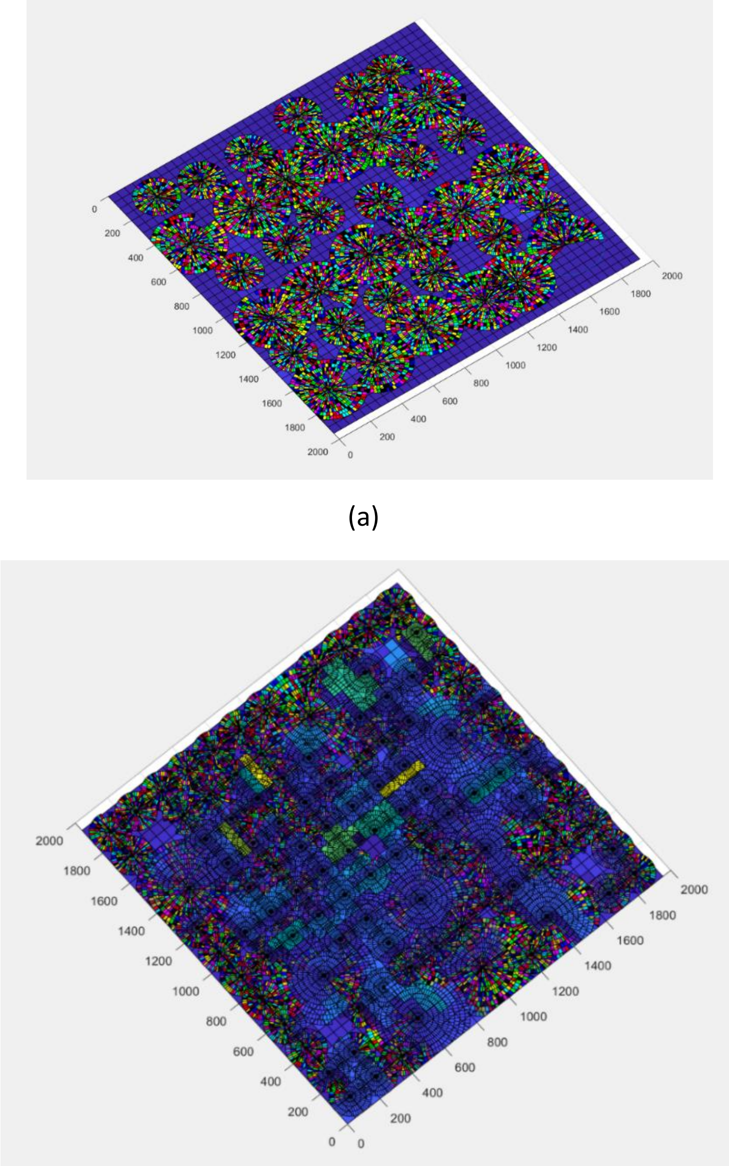
4.2 Result

The results here will be extracted from several cases in two environments, the first is a virtual environment, where we use the genetic algorithm on an area of 2 * 2 km² to find the mean value of SINR, standard deviations, coverage, in the first two cases 36 stations and 110 other base stations.

As for the second environment, we will use a real environment with space (4Km*1.3Km) where the base stations are distributed using the genetic algorithm.

4.2.1 Workspace with coverage area

The coverage area of the system can be calculated on the basis that the sum of the coverage area you get from each base station across the intersection area subtracts the total area because it would not be useful to cover the same area from the base station, so the figure below is the area covered by the base stations after optimization which you calculate For this purpose, through a 5G distribution network by a small base station to obtain the best possible coverage, where we notice the colored areas in the environment are the places of coverage and the purple ones are the areas where there is no coverage.So in the following figure, the working environment in terms of improvement in the case of 36 stations and in the case of 110 stations [4.1]:



(a)

(b)

Figure 4.1. The coverage area of the optimized a) distribution of (36) BS

b) distribution of (110) BS

4.2.2 Evaluation techniques for 36 BS and 110 BS

Pico and Micro BS cells were used at frequencies of 28 GHz. In each case, consider a network of 500 users randomly distributed in urban and rural areas. As small base stations are deployed in densely populated areas such as stadiums, retail centers, etc., SG networks will have an incredible number of users. In this case, the algorithm will choose the optimal places for the base station based on the signal intensity and quality. The purpose is to determine the locations and quantity (BS) to be placed while achieving quality of service standards, in particular (SINR), at the lowest cost and with the least amount of interference.

The results obtained before and after the optimization process are shown in the table below. In the case of 36 small stations, it can be seen that after optimization, the signal covered about 80% of the area. It is calculated by comparing the coverage area before and after the improvement process. In the case of 110 stations, 96% coverage was obtained, where we notice a significant increase in coverage after the improvement. SINR is the average signal strength of the user after optimization. Since the skew rate of the slope is perfect, the closer the values are to the slope and the lower the value, so the efficiency of the system will be better. The results are shown in the following tables:

Table 4.1 Parameter results used after optimization for 36 BS

BEFORE OPTIMIZE [36 BS]	**AFTER OPTIMIZE [36 BS]**
COVERAGE AREA : 68 %	COVERAGE AREA : 80%
MEAN ICI: 9.3691*10^-8	MEAN ICI : 5.2148*10^-9
MEAN SINR : 14.2 dB	MEAN SINR : 18.67 dB
STANDARDIVATION SINR : 0.21 dB	STANDARDIVATION SINR : 0.15 dB

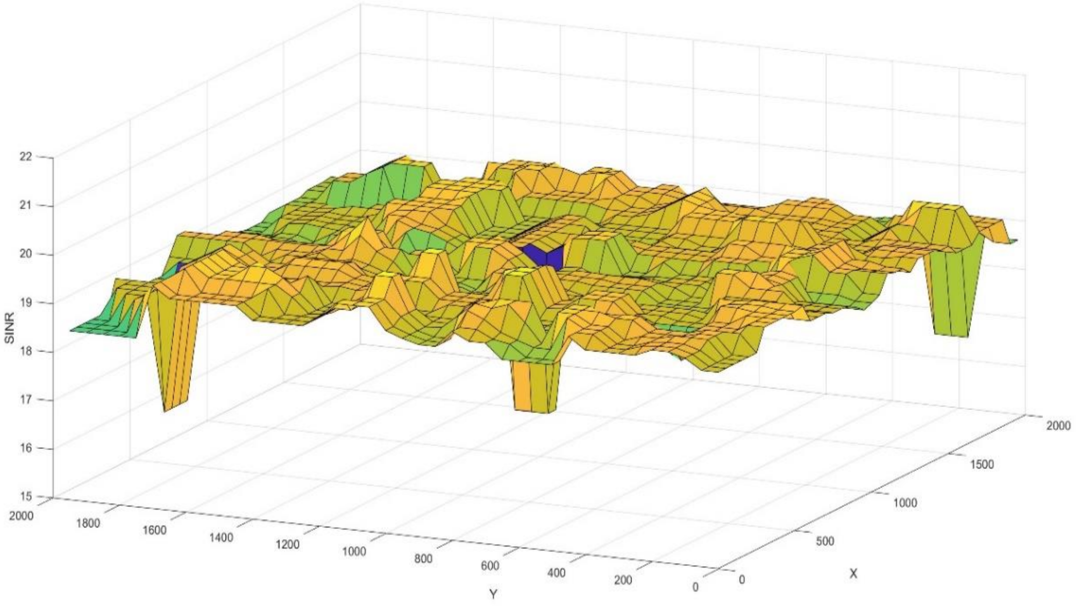
Table 4.2 Parameter results used after optimization for 110 BS

BEFORE OPTIMIZE [110 BS]	AFTER OPTIMIZE [110 BS]
COVERAGE AREA : 85 %	COVERAGE AREA : 96 %
MEAN ICI : 1.5637*10^-6	MEAN ICI : 1.5346*10^-6
MEAN SINR : 17.1 dB	MEAN SINR : 19.9 dB
STANDARDIVATION SINR : 0.18 dB	STANDARDIVATION SINR : 0.079 dB

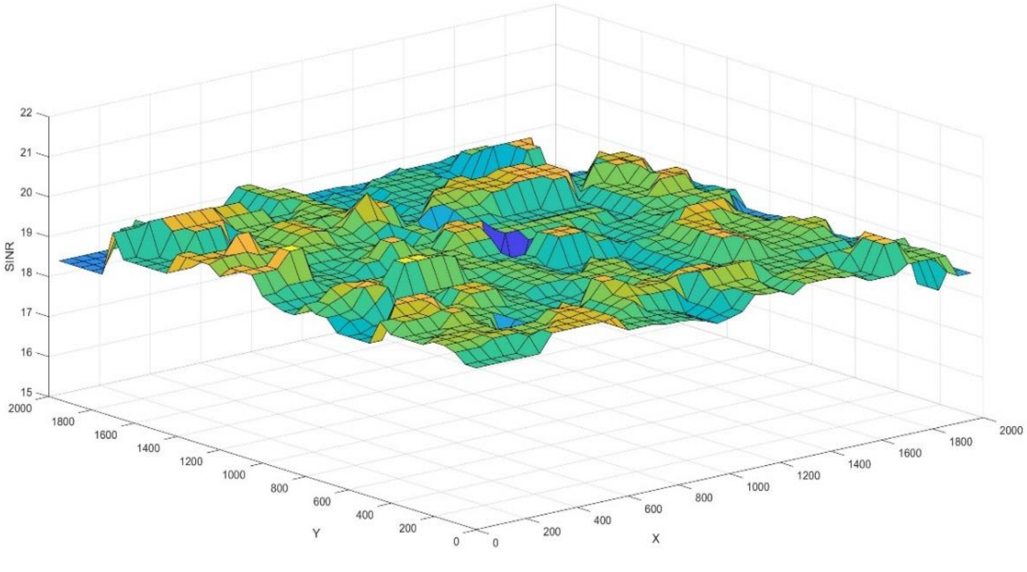
4.2.3 Work environment and signal strength for all users in each station

Signal strength depends mainly on the user's location, as signal varies according to the proximity of the user's location to the base station. When any user is close to the base station, the signal will be strong, but if the user is far from the BS, the signal strength will be weak, if you want to draw this figure, note that every point in the map has a SINR coverage. We conclude from this that in the figure we have to keep the signal strength at fixed values for the receiver or within the specified range, which means we have to keep the signal strength as much as possible because if we find some areas have higher signal strength, and others are weak, thus Weak signals may be lost at any moment. For this reason, it is preferable that the values be constant or within the specified range. In the graph we see a slight decrease in signal strength and it has several reasons, including the user may be far from the station or there are obstructions in that area and also places where noise collects. As in the following figure before and after optimization [4.2]:

:

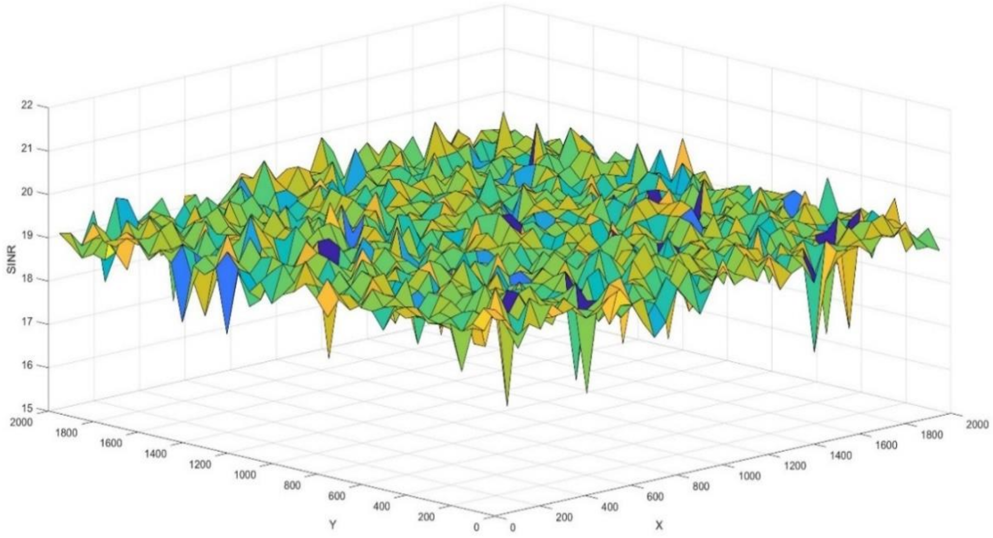

SINR
22
21
20
19
18
17
16
15
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Y
0
500
1000
1500
2000
X

(a)

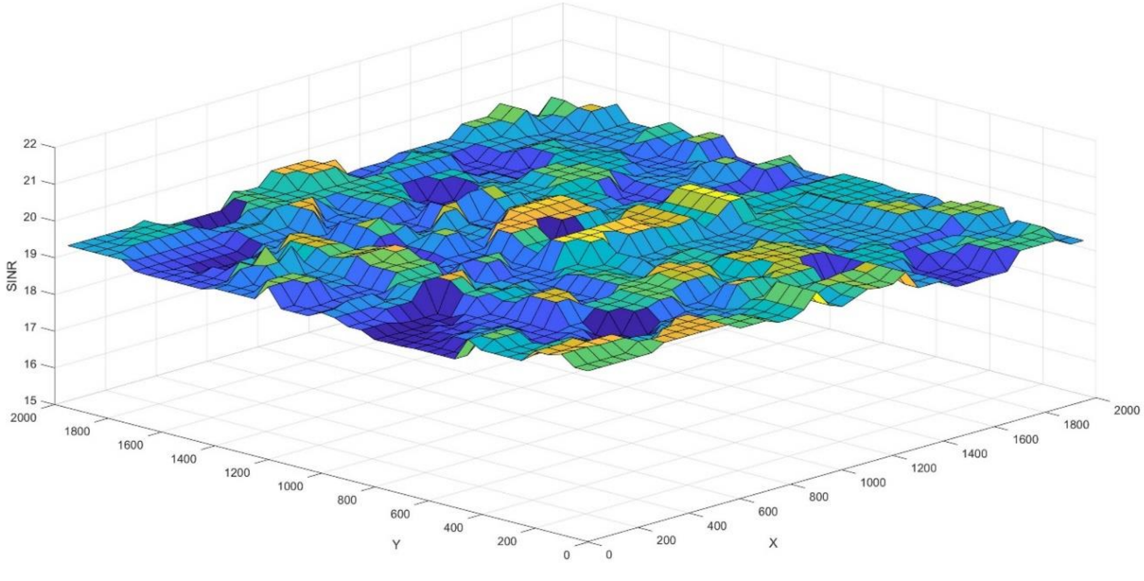

SINR
22
21
20
19
18
17
16
15
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Y
0
200
400
600
800
1000
1200
1400
1600
1800
2000
X

(b)

We note in the following figures the signal strength of 110 base stations before and after the improvement:



(c)



(d)

Figure 4.2. Signal strength a) Before optimize for 36 BS b)After Optimize for 36 BS c) Before optimize for 110 BS d) After Optimize for 110 BS

4.2.4 Inter cell interference and SINR calculations

These tables are a model for a certain number of base stations, the results of 13 BTS was presented in the table 4.2 to demonstrate the situation in state of display the overall table of 36 rows or 110 rows. There are 500 users distributed in the environment in all cases. that note the low quality of the signal due to obstacles and also the inaccuracy of the distribution of the stations so that the interference rate is very high. But after optimization, notice a significant increase in the (SINR) value and also a decrease in the interference. The near far problem is also solved by the GA algorithm by keeping SINR constant or in acceptable range. When the distance between the base station and the transmitter and the receiver decreases, or between the receiver and the transmitter, the path loss will decrease, thus reducing the interference and also increasing (SINR) so that it maintains its ratio in terms of signal strength and noise

Table 4.3. Relation Between (ICI, PR AND SINR)

a) After Optimize for 36 BS, b) After Optimize for 110 BS

BS	**Inter cell interference**	**PR**	**MEAN SINR(db)**
1	2.8330*10^-9	2.5093 *10^-6	11.31
3	3.2064*10^-9	5.9831*10^-6	12.10
6	3.8205*10^-9	6.0296*10^-6	12.72
9	4.9231*10^-9	4.1118*10^-6	13.90
12	1.1822*10^-8	7.1974 *10^-6	14 .15
15	3.7996*10^-9	5.2926 *10^-6	14.92
21	5.4482*10^-9	7.1228 *10^-6	16.12
24	7.7878*10^-9	7.4290 *10^-6	16.77
27	5.7992*10^-9	5.4298 *10^-6	17.20
30	9.8197*10^-9	8.1092 *10^-6	17.93
32	6.8216*10^-9	8.6220 *10^-6	18.84
34	5.6163*10^-9	6.7295 *10^-6	19.38
36	7.9971*10^-9	5.1093 *10^-6	19.99

(a)

BS	**Inter cell interference**	**PR**	**MEAN SINR(dB)**
1	3.3212*10^-8	8.4119 *10^-6	9.10
4	2.7764*10^-8	8.8819 *10^-6	9.95
9	1.3875*10^-8	3.9982*10^-6	10.22
24	5.7141*10^-8	5.3026 *10^-6	11.47
44	2.1531*10^-8	8.2034 *10^-6	12.60
51	3.7422*10^-8	5.2994 *10^-6	13.83
59	3.3669*10^-8	6.1872 *10^-6	14.10
64	7.7111*10^-8	7.5211 *10^-6	15.10
77	8.7492*10^-8	4.8042 *10^-6	15.98
90	1.7267*10^-8	8.0551 *10^-6	16.61
97	4.0226*10^-8	5.6913 *10^-6	17.88
100	2.6323*10-8	6.7173 *10^-6	18.22
104	4.0529*10^-8	3.0931 *10^-6	19.04
106	1.8222*10^-8	9.2256 *10^-6	19.31
110	5.9153*10^-8	9.6701*10^-6	20.27

(b)

4.2.5 Coverage in The Case Studies

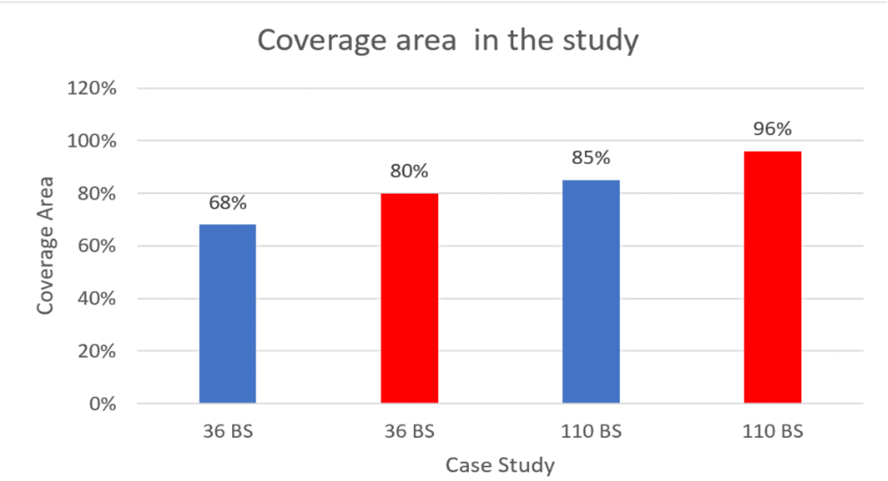


Figure 4.3 Coverage area Before (blue color) and After (red color) optimize

The above figure [4.9] shows the effect of the proposed algorithm on the coverage area in two cases: 36 base stations, and in the other case 110 stations.

4.2.6 Base station localization in real environment

The GA was applied on the real map to get the optimal location of base stations. As shown in figure 4.4 the blue circle represents the optimal position of the base station and according to the coordinates obtained after the optimization process using the genetic algorithm. The red lines represent the LOS link between the base stations.

Figure 4.4 real environment

4.2.7 Density of BSs for Different LOS Coverage Percentages

Dense BS deployment is a possible theme in next-generation cellular networks. The BSs density affects many properties of the network, and directly affects the deployment, maintenance, and hardware setup costs. Having a general idea about the possible BS densities is essential for a network designer. In this section, we find the densities required for the different LOS coverages, based on our planning method. The results are found by running the planner over 20 maps and taking the average over all of them. That is, to sweep the values of K from 0 to 33 BSs per km2 and record the ratio of the number of points covered and the total number of points distributed in the outdoor area. Fig. 4.5 shows the results.

We found that around 27 BSs per km2 are needed to cover 93 percent for Map1and 88 percent for Map2

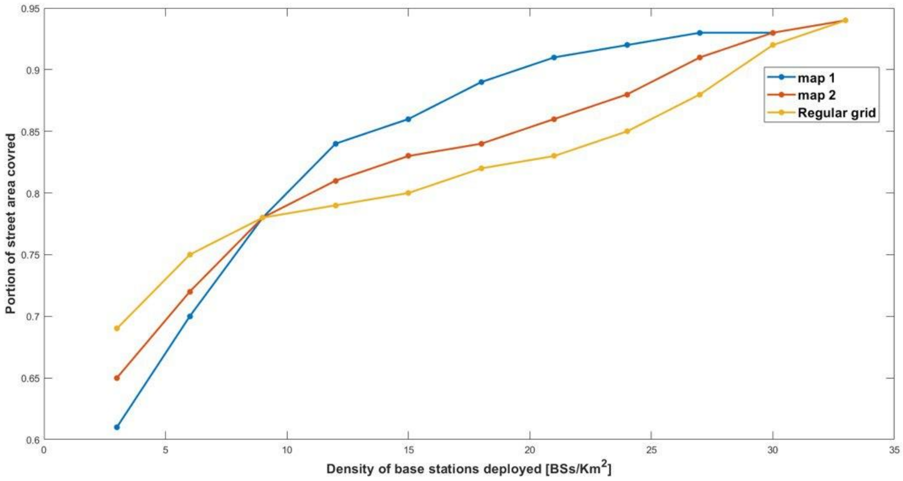


Figure 4.5 relation between portion of street area covered and density of BS deployed [BS/Km2]

of the outdoor. The different densities are the result of differences in city layouts, whereby streets are straight and long, while the bending streets reduce the chance to have long LOS links.

4.2.8 Noise and Interference Analysis in Millimeter Wave Networks

one important feature of any network is its power analysis. In this section, we calculate the signal-to-interference-plus-noise ratio (SINR) in our planned map. As we plan the network to establish LOS coverage, there are some parts in the map where different cells overlap. Fig. 4.6 shows the number of times an area is covered in the map. The results indicate that each area is covered an average of 1.3 times, which means that in dense urban BS deployment. Which as we have wide spectrum space in mm Wave one can use some frequency reuse pattern or wider bandwidth that allows for automatic coordination.

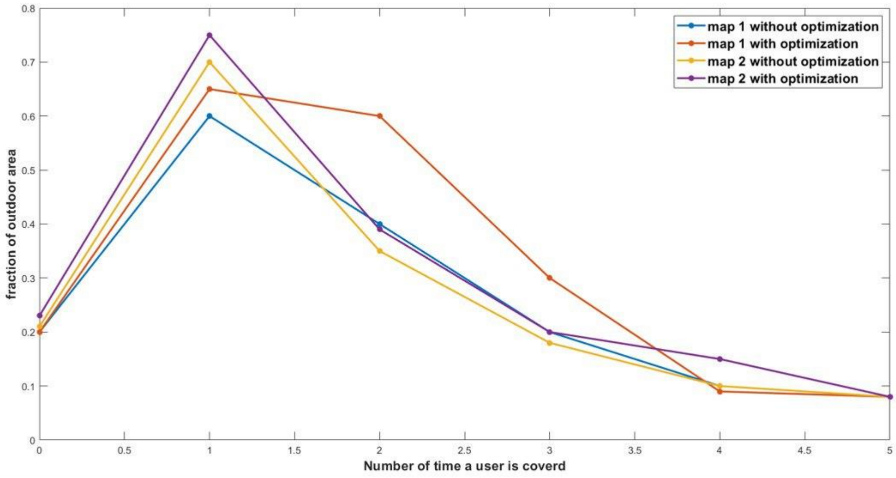


Figure 4.6 Relation between fraction of outdoor area and No. of time user is covered

Figure 4.6 shows the Number of times a certain area is covered, for 93 percent outdoor area coverage. A typical outdoor user is covered by about 1.3 base stations on average, meaning that the number of strong interferers (both line-of-sight and within coverage circle) is about 0.3 on average. There are almost never more than 3 strong interferers.

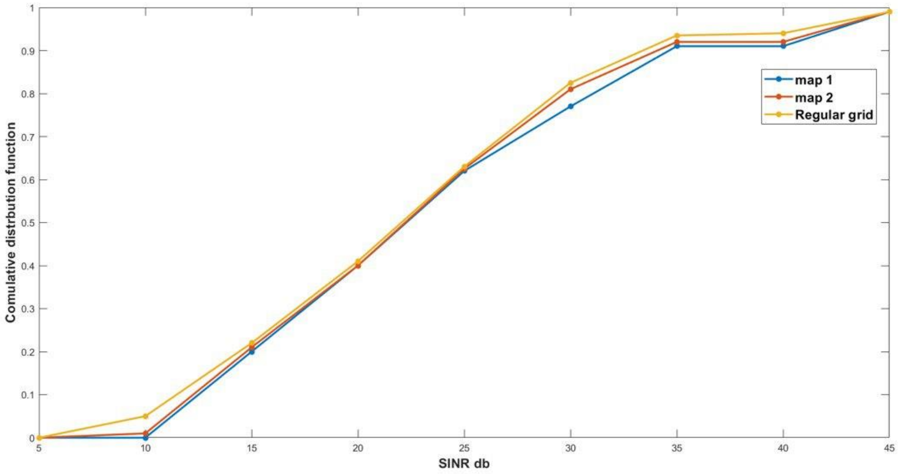


Figure 4.7 show the relation between cumulative distributor function and SINR

Figure 4.7 shows the distributions of SINR for the millimeter waves for different type of cities with the coverage area around 93%. It's clear the cumulative distribution function will increase when the SINR increase. This is the resultant of decreasing the effect of the interference.

Using the genetic algorithm and the formulation given in this letter, we plan the network on several maps, where two maps were used, each map with its own coordinates and obstacles, taken from Google Maps. Where the locations of the base stations in the map are the coordinates obtained from the results of the algorithm, and we note in the table below a summary of the parameters and Mean values μ and Variance α.

TABLE 4.4 Simulation Setup and Results Summary for Real

Urban area	Map1	Map2
Map Size	4Km * 1.3Km	4Km * 1.3Km
User grid spacing	10 m	10 m
LOS area		
60 m	μ =60.4%, α =9.1 %	μ =44.2%, α =8.1 %
120 m	μ =48.7%, α =8.0 %	μ = 36.9%, α =7.4 %
180 m	μ =32.1%, α =5.5 %	μ =17.7%, α =5.1 %
250 m	μ =18.6%, α =4.9 %	μ =11.2%, α =4.2 %
Parameter	Meaning	Value
P_{tx}	Transmit power	30 dB
G_s	Serving link antenna gain	16 dB
G_i	Interfering link antenna gain	5 dB
W	Downlink bandwidth	500 MHz

N_0	Thermal noise	-174 dBm/Hz
F	Noise figure	7 dB

4.3 Discuss the results

In the results of the current study, where two cases were used, the first case is the application of a virtual environment with an area of 2 * 2 (km2 containing real rendering obstacles, where 28 GHz millimeter wave frequency band was used to find the best locations for base stations using the proposed band) Algorithm (frequency assignment and genetic algorithm) for all users through which two systems were studied, the first in the case of 36 base stations and the other system 110, where the results mentioned earlier in this chapter were obtained .

the second case is the application of a real environment where the genetic algorithm was applied on a real map to determine The optimal location of the base stations, where the map contains blue circles and red lines, with the blue circle representing the optimal location of the base station and the coordinates obtained after the optimization process using the genetic algorithm. The red lines of the map represent the LOS link between the base stations. The results are explained as follows Explanation of the relationship between a part of the covered street area and the density of the published base station [BS / Km2] where the signal strength in the streets is higher due to the density of the area and the concentration of the You serve there.

The relationship between the outdoor space portion and the user's number of time is also covered which shows how often a given area is covered, to cover 93 percent of the outdoor area. A typical outdoor user is covered by about 1.3 base stations on average, which means that the number of strong interference sources (on line of sight and within the coverage circle) is about 0.3 on average.

There are no more than 3 strong overlap factors. The relationship between the cumulative distribution function and SINR. Which shows the millimeter wave SINR distributions for different types of cities with about 93% area coverage. It is clear that the cumulative distribution function will increase when the SINR increases. This is the result of reducing the effect of interference.

CHAPTER FIVE

CONCLUSIONS AND PROPOSALS FOR FUTURE WORK

5.1 Conclusions

5G are Small Cell, low-power base stations are scattered throughout the area. Because of its modest size, it may be simply put in both indoor and outdoor aeas. As a result, it aids in boosting cellular coverage and filling in minor coverage gaps. Cellular networks, as you may know, employ high power base stations to reach greater distances and service the largest number of customers. Because 5G employs higher frequencies like millimeter waves, which are hindered by obstructions, mobile phone users will not be able to receive 5G signals behind these impediments.

Small cells solve this blocking problem. The distribution of small stations to sites is of great importance in terms of cost and signal quality. Therefore, the inaccurate distribution of these small stations can be considered as a problem that needs to be improved. As the 5G network is planned in a virtual environment that contains obstacles as the base stations are distributed in different environments such as residential areas, high tower places, etc. Using a proposed algorithm, the locations (BS) are changed to reach the best distribution and obtain the best possible coverage while increasing the signal strength and reducing the interference.

For this systems focus on building the environment and the distribution of users and base stations with the presence of obstacles, there is a significant impact on the location of the base stations in the coverage area. The signal quality of the 5G system has been improved within the proposed system, this system consists of two studies, the first is BS 36 and the second is BS 110, and also 500 users and groups of obstacles were distributed and based on these systems we are doing this study. The GA was applied on the real map to get the optimal location of base stations.

From this work can comprehensively conclude several points, including:

- Using the genetic algorithm, the best locations for the base stations were obtained and optimized. Where a good signal was obtained and ensured that it reached the user, where we note the figure before and after the optimization process, where after the optimization it was noted that there is no significant difference in the distribution of the signal between one place and another.
- This thesis studies the planning process that leads to the improvement of BS sites in a geographical area containing different environments. In this case 36 stations consisting of (12 Micro and 24 Pico cells) were used, the coverage area increased as a result of applying the proposed algorithm from 68% to 80% which is a significant effect. Also, the average SINR value increased to 18.67 db.
- In the case of 110 base stations where (9 micro and 101 pico) were distributed. The coverage area increased due to the application of the proposed algorithm from 85% to 96% which is a significant effect. It is evident in this case, the use of optimal locations of BSs as a solution to the coverage area problem without

the need to add additional BSs. The proposed algorithm can ensure that a good signal is obtained and that it reaches the user.

5.2 Proposals for Future Work

In our next study:

- **improving performance of 5G Cellular Networks by employing Logistics Drones to minimize congestion problem**

This work addresses the problem of congestion in cellular networks with the help of parcel delivery drones. Base transceiver stations in the cells can allow ground user equipment to communicate directly (machine-to-machine communication) through in-band signals between them. The communication is with drones, as this plane contains a simple integrated system for communication between the base station and the user. This work proposes a new algorithm to improve the network trajectory, performance, and altitude of in order to deliver physical parcels, increase network capacity and reduce network interference.

- **Number of hops to reach the shortest route to the main station**

Dijkstra's algorithm is mainly used in road calculating applications such as Google Maps. use to this algorithm, the shortest path between two locations is found. Where the road network is represented in the form of a graph and the locations in the form of nodes or points in this network, and then the closest distance in this network is calculated between any two points in it.

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LIST OF PUBLICATIONS

➢ Conferences

1. Murtadha.Hassan .N, Bashar. Jabar .H, Ahmed. Fahem ." A Survey - comprehensive study of 5G architecture" 1st International Conference on Achieving the Sustainable Development Goals.

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➢ Journals

1. **Murtadha Hassan Naji** , **Bashar Jabbar Hamza** , **Ahmed Fahim Al-Baghdadi** /"An optimized distribution system for the 5G Base stations depends on genetic algorithm to improve performance "NeuroQuantology *Journal*, Jul 2022 | Volume 20 | Issue 7 | Page 2374-2381 | doi: 10.14704/nq.2022.20.7.NQ33307. https://www.neuroquantology.com/article.php?id=4659

2. **Murtadha Hassan Naji** , **Bashar Jabbar Hamza** , **Ahmed Fahim Al-Baghdadi** "optimize coverage area of a 5G networke based on Genetic algorithm " *Journal* optoelectronics laser .Volume.41/Issue 8,2022.Doi:10050086.2022.08.60 . http://www.gdzjg.org/index.php/JOL/article/view/948

الخلاصة

لخدمة المزيد من العملاء، تتطلب الشبكات الخلوية محطات قاعدية عالية الطاقة لخدمة المزيد من المستخدمين. يستخدم 5G ترددات عالية، مثل الموجات الملي مترية ، التي تعيقها العوائق ، مما يتسبب في تعطيل إشارات 5G الموجودة خلف هذه العوائق. تعالج الخلايا الصغيرة مشكلة الحجب هذه، ويمكن بسهولة وضع خلايا 5G الدقيقة في الداخل وفي مناطق محدودة المساحة.

تم استخدام عدة خوارزميات في هذا العمل، إحدى الخوارزميات الرئيسية المستخدمة في عملية التحسين هي الخوارزمية الجينية من أجل العثور على الموقع الأمثل لكل محطة أساسية للحصول على (تعظيم SINR، وتقليل ICI، ومنطقة التغطية القصوى) . وخوارزمية الأخرى هي تخصيص القنوات بحيث أي خلية تحتاج قناة سوف ترسل الى MSCحيث يقوم بتخصيص قناة لها وحسب طلب الخلية باستخدام خوارزمية تعمل لهذا الغرض، حيث تقوم هذه الخوارزمية بتقليل حضر الاتصال وزيادة استخدام القناة وزيادة السعه وأيضا كل القنوات موجوده في البدالة حيث تصل لكل الخلايا عند الحاجه لها.

تدرس هذه الرسالة عملية التخطيط التي تؤدي إلى تحسين مواقع المحطات القاعدية (BS) في منطقة جغرافية تحتوي على بيئات مختلفة، مثل المناطق السكنية والأماكن الشاهقة وما إلى ذلك. تم اقتراح حالتين لتقييم النظام، 36 محطة قاعدية و110 محطات قاعدية. في الحالة الأولى، تم تركيب 36 محطة، تتكون من (12 خلية ميكروية و24 خلية بيكو)، زادت مساحة التغطية نتيجة تطبيق الخوارزمية المقترحة من 68٪ إلى 80٪ وهو تأثير كبير. أيضًا، زاد متوسط قيمة SINR إلى 18.67 دي سيبل. في حالة 110 محطات قاعدية حيث تم توزيع (9 ميكرو و101 بيكو). زادت مساحة التغطية بسبب تطبيق الخوارزمية المقترحة من 85٪ إلى 96٪ وهو تأثير كبير. يتضح من الحالتين، يمكن استخدام المواقع المثلى لل BSs كحل لمشكلة منطقة التغطية دون الحاجة إلى إضافة BSs إضافية. يمكن أن تضمن الخوارزمية المقترحة الحصول على إشارة جيدة وتضمن وصولها إلى المستخدم. الحصول على أفضل المواقع لمحطات القاعدة وتحسينها باستخدام الخوارزمية الجينية. تقليل النسبة المئوية لتداخل الإشارة بين المحطات القاعدية باستخدام خوارزميات المقترحة. وأيضا تم تطبيق بيئة حقيقيه لإيجاد افضل تغطيه وافضل قوه اشاره لكل المستخدمين في كل المحطات .

تخطيط محطات الخلايا الصغيرة باستخدام الخوارزمية الجينية

الرسالة

مقدمة الى قسم هندسة تقنيات الاتصالات كجزء من متطلبات نيل درجة الماجستير

تقدم بها

مرتضى حسن ناجي

إشراف

الأستاذ الدكتور

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تخطيط محطات الخلايا الصغيرة باستخدام الخوارزمية الجينية

مرتضى حسن ناجي

ماجستير في هندسة تقنيات الاتصالات

2022