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Proposed Base-Station Location Optimization with Genetic Algorithm Scheme for Lte Network Radio Planning

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Abstract. Long-term evolution (LTE) is used widely in inefficient network technologies which serve billions of users. These technologies have the following features like higher bandwidth, high spectrum efficiency and less latency. This paper proposes minimizing the cost of a cellular network, which usually includes the optimum selection and base-station locations that meet certain capacity and coverage constraints. In the LTE wireless network framework, coverage and capacity planning are interrelated in terms of interference. Moreover, the ever-increasing capacity demand for non-uniformly distributed users makes base station location optimization an important action. This paper adopts one type of improvement, which is a genetic algorithm-based methodology that optimally performs the task of base-stations location by minimizing the cost of the network while fulfilling the coverage and capacity criteria planning by using ATDI ICS TELECOM. Reducing 19.95% of the overlap of the area will result in good coverage of the proposed GA thus, improving efficiency of the network.
Keyword. LTE network, Base-station location, Optimization by genetic algorithms, ICS telecomm radio network planning, Baghdad.

1. Introduction

Cellular networks have been evolving at a rapid pace for the increasing demand of transferring media over the last thirty years. The ever growing number of users is an on-going concern due to increased capacity. For instance, the rapid development in cellular networks, like the long-term evolution (LTE) enables higher bandwidth and connection to users [1] . On the other hand the development of different radio access technologies and architectures is aimed at providing large cell capacity, high peak data rates and low latency [2]. The standard 4G wireless broad band technology is LTE, which has been created by 3GPP (Third generation partnership project). It has several advantages like speed and higher network capacity, especially for users of cellular devices, low latency, scalable bandwidth capacity as well as backwards-compatibility with the current GSM and UMTS technologies [3].

The higher layers of LTE are based on TCP/IP links. Just as the present state of wired transmissions, an all IP network will be the possible result. The mixed data, voice, video and messaging movement are supported by LTE [4]. There are recent demands for different data services such as social media, web browsing, download, etc. Up to 100 Mbps peak rate is currently offered by LTE deployments (Rel. 8/9), including data traffic from cellular phones and other mobile devices [5]. To achieve the capacity targets

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and coverage, the base station (BS) numbers will be a major factor in shaping the complexity and costs of the network. Using a minimum number of BSs coupled with their optimum location is a difficult task where a number of factors are present. When an optimization problem of high complexity is resolved, this means that the optimal network deployment is found. Thus, the exhaustive search for all candidate solutions would be impossible. At the same time, the modeling of the cellular system that allows assessment of the rapid performance and importance of correct selection of a wide number of candidate solutions is imperative. The literature reviews of some of the published papers have been done, which is briefly described below:

This study used the ATDI radio software not only for designing the LTE network but also, for the purpose of spectating area coverage, as well as comparing various propagation models [6]. The authors have studied the LTE e-government network, which is designed to a predetermined location in Baghdad, for achieving the best procedure based on the PSO algorithm with less interference with a greater number of subscriptions [7]. It is therefore proposed by the author ,that the planning cell problems part choice of placement (BS) be optimized using GA [8]. This paper [9] uses mathematical programming models for supporting the installation of new base stations, as well as selection of configurations such as pilot, signal, emission power, height, tilt, etc. to be used as to maximize distance coverage while lowering initial costs.

This paper [10], shows varying parameters of issues pertaining to the placement of a mobile base station (BS) such as coordinates and energy transmission.

Height and tilt angles are calculated by utilizing a transformative multi-objective algorithm in order to obtain a greater solution. By the use of dynamic crowding distance, as well as controlled elitism, operators are presented in the non-dominated sorting genetic algorithm- II (NSGA-II). In recent studies, different algorithms have been used for optimizing antenna configuration (e.g. power control parameters, antenna tilts, and azimuth orientations of tri- sectored macro BSs) in LTE systems [11, 12]. In this paper, the target of optimized LTE network best possible coverage, and good performance can be achieved GA with optimal numbers and locations of sites whilst still serving SSs through capacity network. Section 2 of this paper outlines the network model optimization with genetic algorithm. Section 3 describes the network result presentation. The main conclusions of this work can be found in section 4.

2. Proposed network model optimization with genetic algorithm scheme

The Network Model is divided into three-stage; stage one is designed for the network from selected 24 locations within Baghdad City, stage two optimized the network design by using Genetic Algorithm (GA), stage three shows LTE network planning.

2.1. Network model

Below is shown the targeted locations for planning of the LTE network, as displayed in Figure1. The selected cities are shown below (24 locations) within Baghdad City amount to $1078KM^2$. Table 1 below, outlines the most commonly utilized parameters of the LTE network. The UEs of the LTE network represents 1000 SS's. The most loaded period known as Busy Hour (BH) is determined by the traffic model, which determines the demands during (BH) of the users' service demands. Depending on customer profiles, the LTE network has the capability of generating population of mobile users. Users can specify per mobile according to different service types [13].

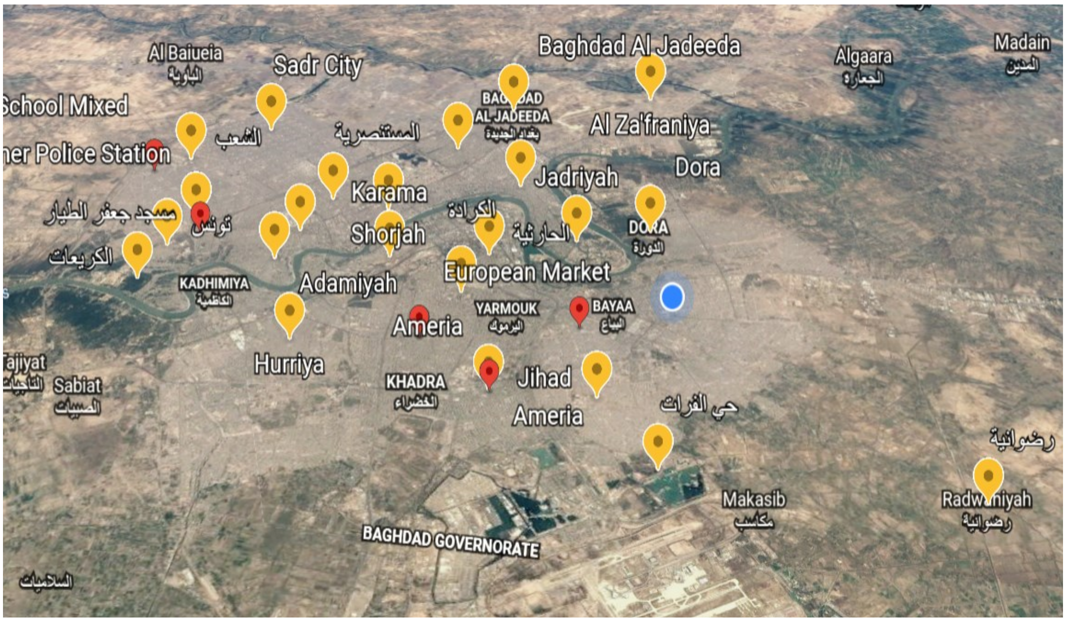


Figure1. The selected cities in Baghdad using ICS telecom.

ICS Telecom software was used to determine the locations and network simulation, being the most powerful networking planning tool [7]. A tool used for radio planning, known as ICS Telecom, is used for modeling systems in the extensive countryside or rural and urban areas [14]. To replicate coverage utilizing various radio propagation models, the ATDI ICS Telecom software was used [15]. The ICS telecom nG program is one of the most powerful network planning aids for a network. It has the ability to provide precise design simulates and scrutinizes up-to-date the latest in complex surroundings, dense and urban, open spaces, services like voice or information, mixes indoor and outdoor situations, etc.[16].

Table 1. LTE network nominal parameters.

Parameter	Nominal Values of Macro cell
Height of BS antenna	45m
Gain of BS antenna	15 dBi
Power transmitted by BS	9 W
TX antenna of BS	Omni-Three directional
Band width of channel	5 MHz
Frequency of carrier	2.6 GHz
Time interval of Symbol Guard	normal
Cable losses of Tx/Rx	2/2 dB
Parameter	UEs
Height of UE antenna	8m
Gain of UE antenna	5dBi

2.2. Genetic algorithm (GA)

GA was discovered in the 1960s. It is a research technique established on basics taken from genetic and developmental mechanization present in naturalist systems and groups of living beings[17]. It is an implementation utilized to resolve the improved trouble. It supplies success resolutions for a difficult multi-border optimization problem [18-20]. The trouble involves detecting the most appropriate solution,

which is the solution that suits all possible solutions of the optimization technology. GA acts on a range of potential solutions where each chromosome is represented.
Briefly, the main steps of GA are the following:

1. Production of a genetic group randomly from a chromosome.
2. Estimating a fitness f (x) from every chromosome x of a population.
3. Create a new community using the following:
    - Choosing two origin chromosomes to create their fitness.
    - Formation of new offspring because of the crossover from parents, the admittance from new offspring of a population.
    - Change from newly created population to the sum from algorithm.
    - End while a preferable solution is returned [21].

In this paper, the proposed GA is utilized to create a minimum of overlap and power exhaustion during the stage of planning as well as operation. This is achieved as met by the UEs' requirements as different traffic load (TL) hours in interference aware manner.

2.3. LTE Network planning
The population determines the distributed sites within this phase. The best sites to install LTE network turrets are selected by use of optimization GA approach. The locations are selected in such a way manner that it reduces interference and the UEs show a good percentage. The interference percentage is determined by the number of covered UEs. The highest power to the UE is recognized firstly, which is represented by the fitness function (serving BS). This is represented by the equation under the terms stated in Eq.(1).

$$Serving\ (j) = MAX\ (PrUE) \tag{1}$$

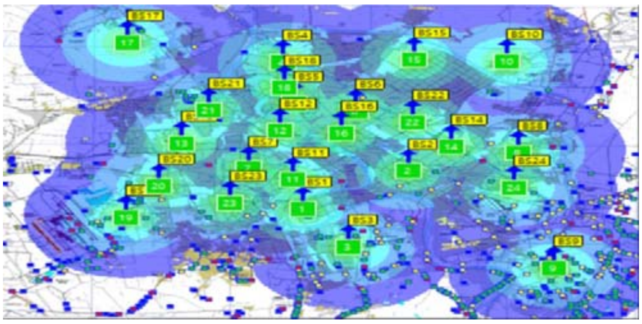
Where ($PrUE$) is the power obtained from BS (j)
Secondly, the interference will be defined by *ING* ($m\times m$) matrix, where *ING* (*j,j'*) is the result of the *j'th* BS on the *jth* BS and j≠j' in terms of interfered area percentage, which can be identified by simulation from ICS telecom software before optimization. The verification process through the process stated earlier where sets of BS turned off and on, causing weaker stations to be cancelled. The number of locations to be established is determined by the coverage condition. Simulation as evaluation of planned network is carried out in terms of served UEs and capacity. The Eq. (2) details the summation of interfered areas.

$$Fitness\ function = Min \sum_{j}^{m} \sum_{j`}^{m} ING(j, j`).\, x_j.x_{j`} \tag{2}$$

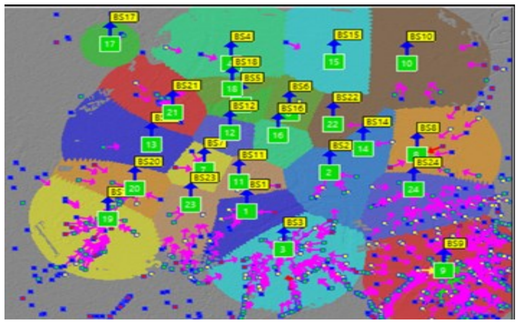
$$\text{where } x_j \begin{cases} 0 & if\ BS_j\ is\ deactive \\ 1 & else \end{cases} \tag{3}$$

3. Network result presentation and discussion
There are two stages in this stage, analysis and LTE network capacity, as shown below.

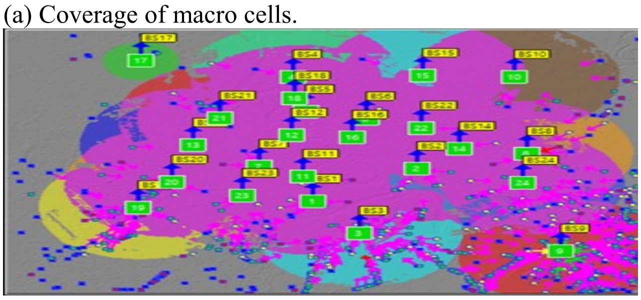
3.1. Sites selection analysis
The first phase of planning found 24 sites to be chosen for input. In Figure 2a, the power received at points in the covered area is shown by the color bar. In Figure 2b, each distinct color is shown as per best coverage within that area. Small arrows directions state the UEs associations, while color arrows state the affiliations, as given in Table (1). As shown in Figure 2c, the sites overlapping with each other are shown in pink. The GA is then used for optimization and site selection under specific constraints to minimize overlapping, but still maximize covered UEs.



(a) Coverage of macro cells.



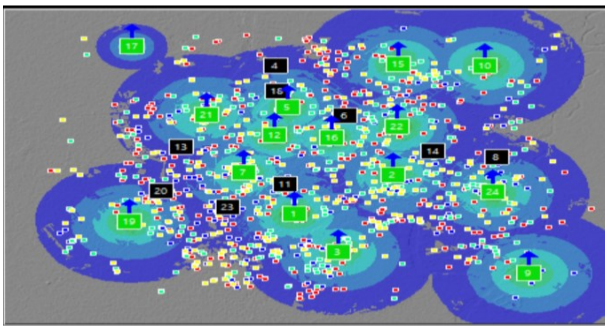
(b) Best sites for macro cells.
Area Total=1078 Km^2
Area Covered =862.96 Km^2
Area Covered = 80.05%
Overlap = 36.35%
Total UEs = 1000
UEs parented with cell = 71.9%



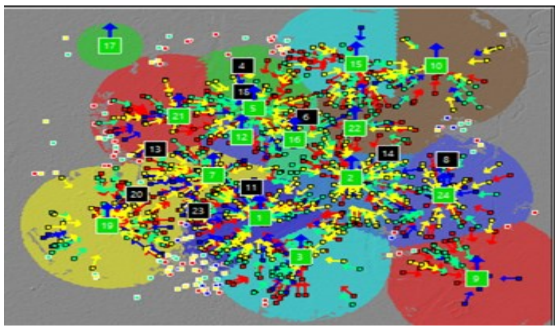
(c) Macro cells overlap.

Figure 2. Before optimization of LTE sites.

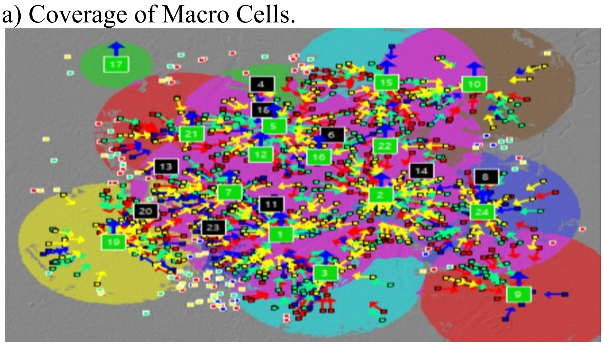
By use of GA algorithms, nine sites are eliminated. These are shown in black cubes in Figure 3. An overlap 19.95% is then able to be reduced by using the remaining fifteen sites.



a) Coverage of Macro Cells.



b) Best Sites of Macro Cells.
Area total =1078Km^2
Area covered =741.93 Km^2
Area covered = 68.83%
Overlap = 16.4%
Total UEs = 1000
UEs parented with cell = 87.2%



c) Overlap of Macro Cells.

Figure 3. After optimization of LTE sites.

Every site is built from 3 sectors, each with a directional antenna and 5MHz provided by every cell. In order to minimize the CCI, the FRS of 1X3X3 was implemented. Figure 4 below shows simulated LTE network.

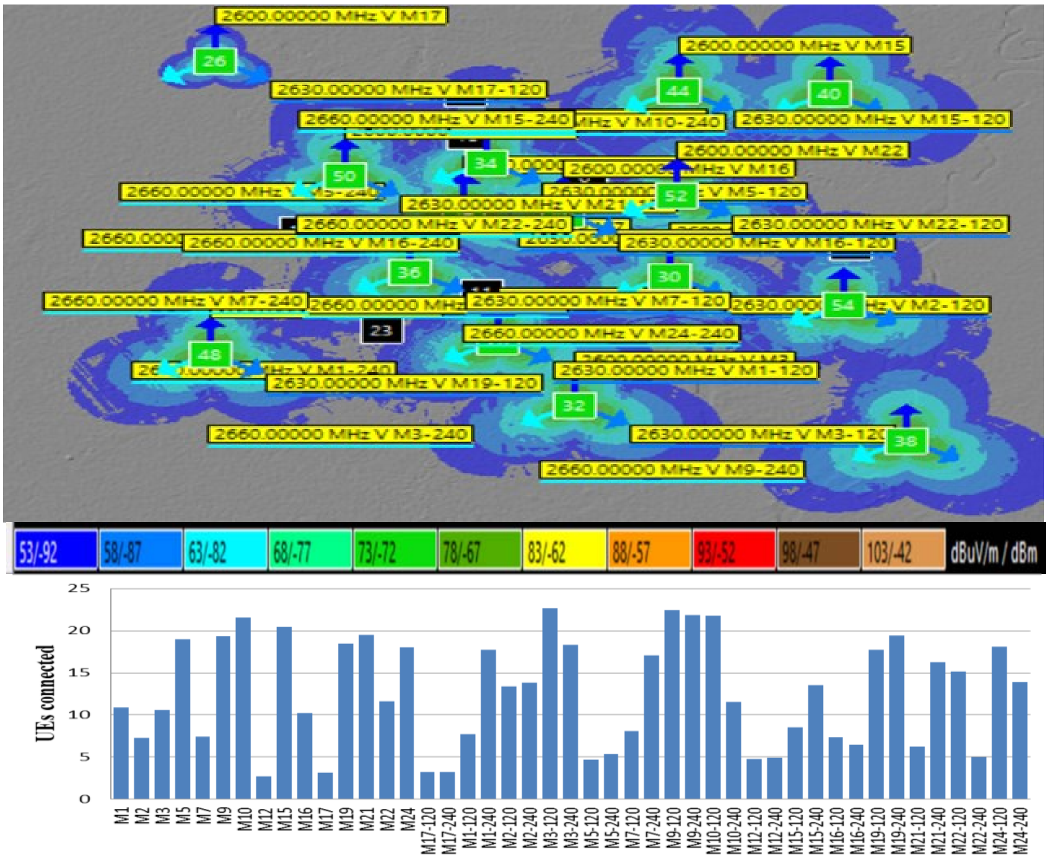


Figure 4. The 3 sector-1x3x3 LTE network and UEs of fifteen sites.

3.2. Analysis of the proposed LTE network capacity

As per conditions of served UEs and capacity of cells for different Traffic Load profiles, network performance has been evaluated and analyzed as illustrated in Table 2 below.

Table 2. Twenty-four hours traffic profile.

Traffic Load	Heavy	Moderate	Low
Demand percent %	100	60	30
Duration (hours)	10am-1pm	8am-10am and 1pm-3pm	3pm-7am

The results of simulation of performance of LTE network design are shown in Figure 5. Figure 6 below shows the QoS analysis in terms of throughput associated with traffic during daily working times. FIFO of the ICS telecom software has been used, so that the user is given full demands as shown by 75% QoS. Figure 7 reveals that as the UEs activity is increased, the network performance is reduced, specifically during the business hours. Further processing is needed to resolve this issue.

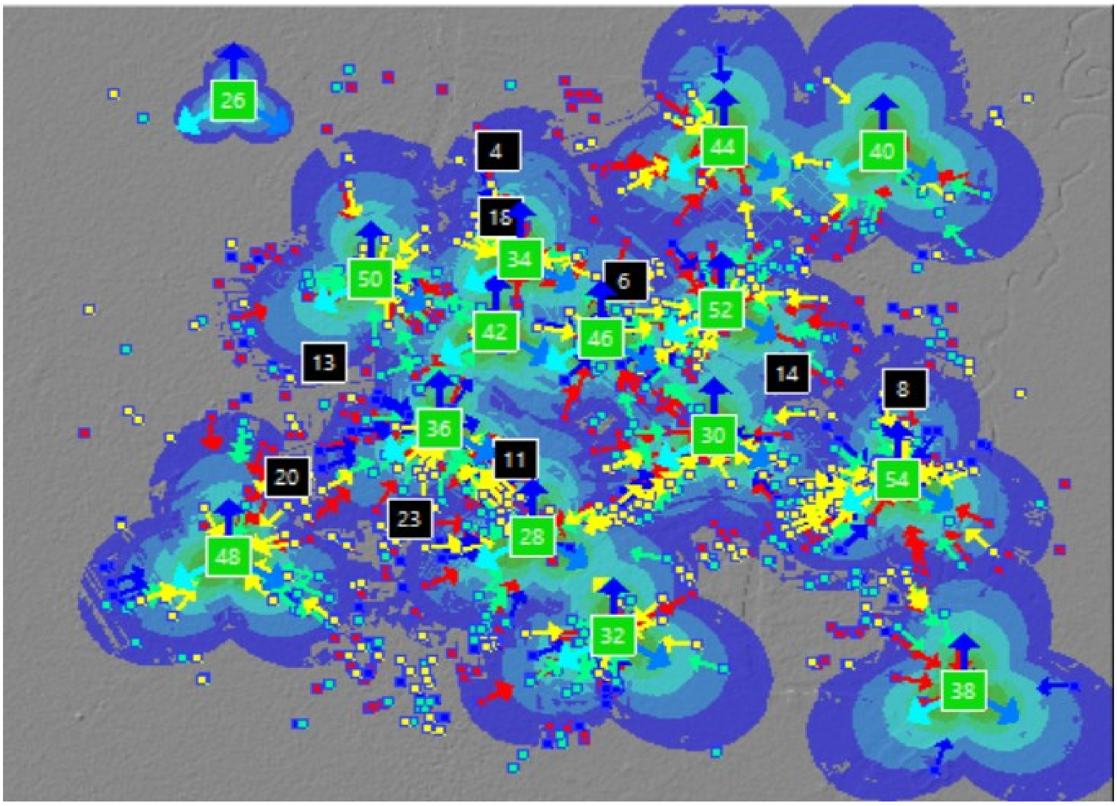
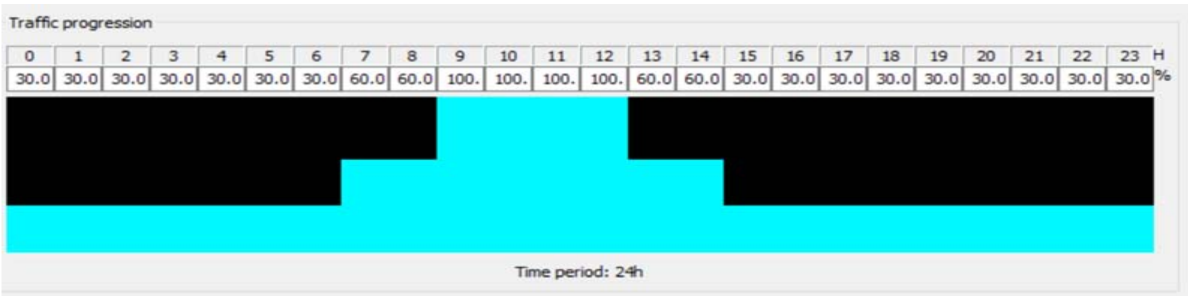


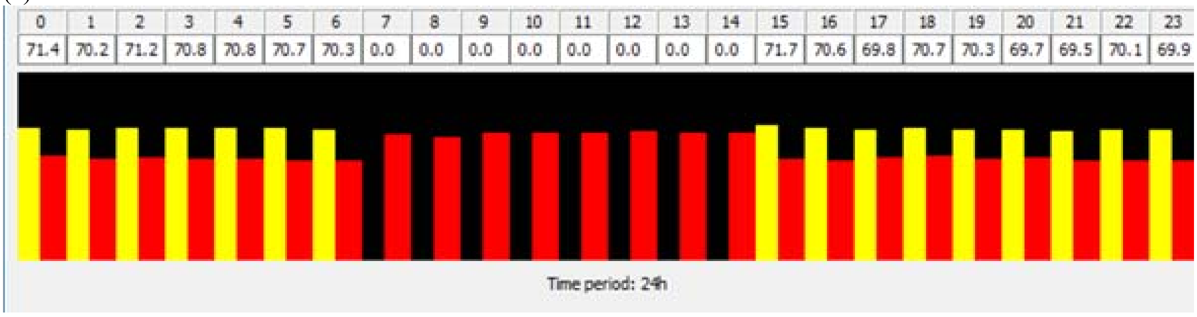
Figure 5. Proposal of finalized LTE network profile.



(a) Traffic profile during 24 hours.

(b) Heavy.

(c) Moderate.



(d) Low.

QoS No. of served UEs %

Figure 6. UEs traffic progression for 24 hours.

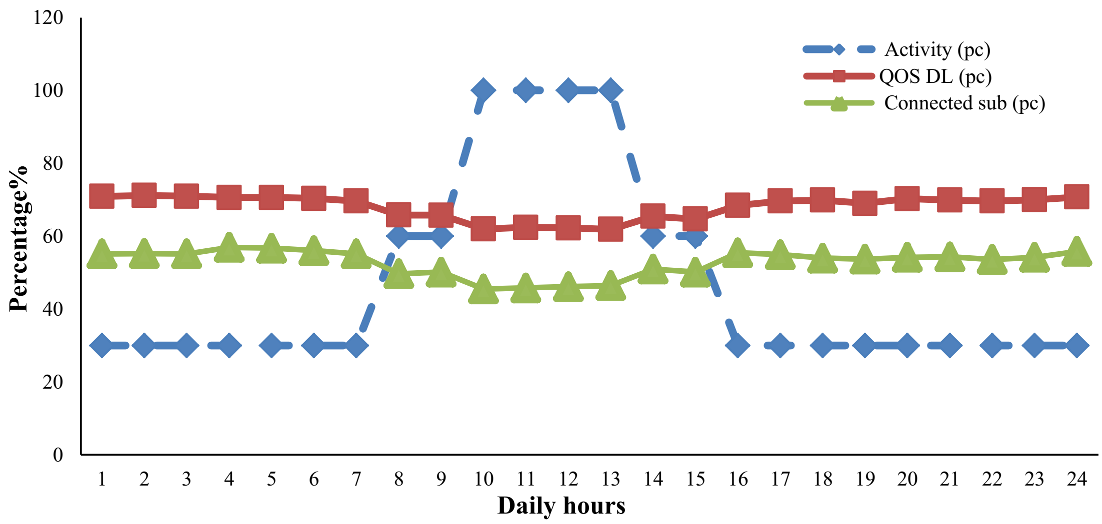


Figure 7. UEs and their activity during the daily busy hours**.**

4. Conclusions

Cellular networks are essential as they offer a variety of connectivity solutions. LTE provides reliable and fast wireless network service. This study proposes improving coverage while minimizing signal interference between base stations by using a genetic algorithm to reduce overlap. The GA optimization was proposed here for optimized site selection to minimize the overlap and therefore bring location management in LTE networks to a qualitatively new level to achieved objective maximum coverage with UEs of macro for an LTE network with user requirements. Good coverage is attained as 19.95% overlap is minimized by selecting the fifteen sites. The methodology exploits LTE planning by ICS Telecom optimization with a double scope: satisfy coverage and capacity requirements by the user served with higher demands induced by more than 70% QoS, minimizing the cost of the network. The results for two case studies showed a successful performance of the methodology while presenting useful insights for future radio planning adjustments.

Future Work: Using algorithms of other calibers, like stochastic hybrid GA, bee colony algorithm, an ant colony algorithm, and comparing them with the proposed optimization methods based on GA which may be used to further identify better performance. Using other LTE BSs such as: Pico, Micro and femto for scenarios can also be identified.

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