IOP Conference Series: Materials Science and Engineering

Performance Evaluation of 2G and 3G Networks in the City of Baghdad

Performance Evaluation of 2G and 3G Networks in the City of Baghdad

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***Abstract*:**

Communication networks have evolved dramatically in recent years and for a perfect network, there are several factors to focus on to get the perfect coverage and ideal network. Although the network has been installed, the mobile operators' company keeps reconfiguring the network parameters to achieve the best performance. Even so, some network parameters can't be modified (tower length, tower position, etc) but other parameters can always be modified due to results of site survey. Also, ICS Telecom was employed to analyze the network performance in terms of coverage and interference due to different values of power and antenna tilt. In this paper, studied the effect of the antenna tilt on the coverage and amount of power from BS to the user in a particular area in Baghdad is studied and it is found that the change in the inclination angle and power have a significant impact on the solutions of the problem of coverage and interference.

A comparison field measurement data and simulation data in terms of RSS results in acceptable value equals to 3.24 and 7.45 for 3G and 2G respectively.

The performance of the adopted networks is analyses after collecting the data of more than 200 points via two methods: experimentally via drive test and simulation-based on ICS telecom software.

***Keywords*— ICS Telecom, Tilt, 2G, 3G.**

1. Introduction

The world is quickly turning into a world village and a necessary tool for this method is that the communication of that telecommunication may be a key player and certainly, the great development in communication is a significant driver of any economy.

Mobile network operators aim to introduce the best mobile services to the customers to prove themselves in the market among competitors, hence they work continuously on achieving the best performance materialized by the best coverage.

The main aim of coverage planning is to estimate the coverage distance of a BS with parameter settings derived from actual cell boundary coverage requirements sequentially to meet network size requirements, the best coverage is determined by many factors including the network configuration parameters.

Developed first generation (1G) wireless communications systems that were foremost focused on voice communication services, to second-generation systems (2G) primarily focused on limited data services,

voice services, to third-generation (3G) systems that we're dealing with multimedia applications and internet connectivity [1].
In this paper, the analyses and modeling of the impact of the antenna tilt and power in the literature will be introduced as below: In [2] those antenna parameters which have a significant impact on capacity and coverage of long-term-evolution (LTE) networks.
Therefore, the adjustment of the tilt of the antenna a promising approaches to increase the capacity and coverage.

The author in [3] formulate adaptation of antenna tilt angle as a utility fair optimization task, on the cellular network in Dublin, Ireland, and is found to yield considerable performance gains.
The authors in [4],[5] studied The analysis and modeling of the impact of the antenna tilt angle on cell performance It is shown that the incorporation of antenna tilt at an appropriate angle can provide better coverage probability and the average rate as compared to that of the omnidirectional antenna deployed system.
The author in [6] studied the impact of antenna height, tilt and power on network coverage and system capacity, and it was found the best coverage is obtained at 38m height, 46dB power, and 2° tilt.
On the other hand, the authors in [7], [8], and [9] have realized that a practical antenna can target its antenna beam towards a given direction via down tilt in the vertical domain, which may be exploited to improve the network performance.
Network planning is an analytical and practical approach implemented through a complex procedure to achieve the main objective, where the signal strength and the antenna inclination are the most influential factors affecting network coverage.

In this work, a real network is adopted to analyze its performance based on both practical and simulation tools.
Practically a drive test was conducted to collect data from 30 BS of the case in 2G cells and 33 BS in 3G cases.
Then the collected data was employed to simulate the network via ICS Telecom, after that, the network performance is assessed due to different parameter values.
The rest of this paper is organized as; section two will introduce theoretical aspects, material and methods will be discussed in section three. Results will be discussed in section four and finally the main concluded points will be illustrated in section five.

2. Theoretical Aspect

2.1. Cellular Network

The cellular network is a communication network wherever the last link is wireless. The network is distributed over the area of land, called (cells), each served by a minimum one fixed-location transceiver, but more normally, 3 cell sites or base transceiver stations. These base stations provide the cell with the network coverage which can be used for transmission of data, voice, and other kinds of content. Cellular networks like 2 Generation, initially introduced in 1992, is that the initial to use the digital encryption of conversations, it's the first to offer SMS text messaging and data services [1].

As for the Three Generation networks providing faster data transfer rates and are the first to enable video call. This makes them particularly suitable for use in modern smartphones, which require a constant high speed internet connection for several of their applications.

2.2. Network Planning

The network planning is a complicated process consisting of several phases. The ultimate target for the network planning process is to define the network design, which is then built as a cellular network. The difficulty in network planning is to combine all of the requirements in an optimal way and to design an economical network. The first step in network planning is it provides the determine the suitable propagation model thus satisfy the network with the real adopted environment. There are 2ways in which radio planners can use propagation models. They can either create their own propagation models for different areas in a cellular network, or the radio planners can use the existing standard propagation models. The usage of the standard models is economical from the time and money perspective. The empirical models use Existing equations obtained from the results of several measurement efforts, such as the Cost 231 Hata Model, which is exploited in this work to simulate signal propagation in the adopted case study.

$$P_L(dB) = 46.3 + 33.9\log_{10}(h_b) - a(h_m) + [44.9 - 6.55\log_{10}(h_b)]\log_{10}(d) + C_m \quad ---------(1)$$

$$a(h_m) = 3.2[\log(11.75h_m)]^2 - 4.97 \quad --------------(2)$$

C_m=0 dB for suburban areas

C_m=3 dB for urban areas

Where PL is the path loss, f_c,h_b,h_m and d ,is the carrier frequency in (MHz), the mobile station antenna height in (m), the base station antenna height in (m), the distance between base station and the mobile station in (Km) respectively[10].

2.3. Network Performance

Network performance refers to measures of service quality of a network. There are several different ways to measure the performance of a network, as each network is different in design and nature. One of for most vital measures of network performance is network coverage and interference.
The receiver sensitivity plays an important it governs the coverage area limitation of the cell, determines the RSS at the receiver in a telecommunication system by link budget.
It accumulates all the gains and losses during the signal propagation through the medium in order to calculate the signal attenuation.
The received power (P_r) is given by:[11]

$$P_r = P_t + G_t + G_r - L_t - L_r - \mathrm{PL} \quad (3)$$

Represent P_t the transmitted power (dB), Gt is is the transmitter antenna gain (dB), G_r is the receiver antenna gain (dB), L_t and L_r are the cable and other losses on the transmitter and receiver side (dB) respectively, PL is the path loss (dB).

2.4. Parameters that Affect the Performance

There are several parameters that affect network performance. Some cannot be changed if the network already exists, such as tower height or location. But there are some parameters that we can change by affecting the performance of the network such as the antenna tilt and the transmitted power the two most important performance tuning parameters of a cellular network since are have a strong impact on the inter-site interference level in the system [3].

3. Materials and methods

There are 3 major cellular network operators in Iraq; Asiacell, Zain, and korek. In this work, the cellular network of Asciacell was adopted for the research's analyses. The area was selected in Baghdad as cases studies; Al-Amreya quartier at the west of Baghdad.
It may also be noted that, the selected network is currently employing the Enhanced Data Rates of GSM Evolution (EDGE). Even EDGE is considered as the 2.9G, it will be referred to it as 2G network in this work. In addition to 2G, this operator company is also employing 3G services materialized by the Universal Mobile Telecommunication System (UMTS), which in some sites overlaid the 2G sharing the same infrastructure.
Data were collected from 200 test points in the adopted area from 30 base stations for 2G cells, and 33 base stations for 3G cells.
The author used the capabilities of modern Android software in many operating the modern available applications based on smartphones for signal quality measurements. (Cell Coverage Map), (Cell Tower

Locator), and (Network Cell Info Lite) software are used to collect data in terms of a signal received power for 2Generation and 3Generation as shown in figure (1).

Fig1: the software used to collect data in terms of signal received power for 2G and 3G cell

4. Results and Discussion

4.1. Network performance analysis results and discussion:

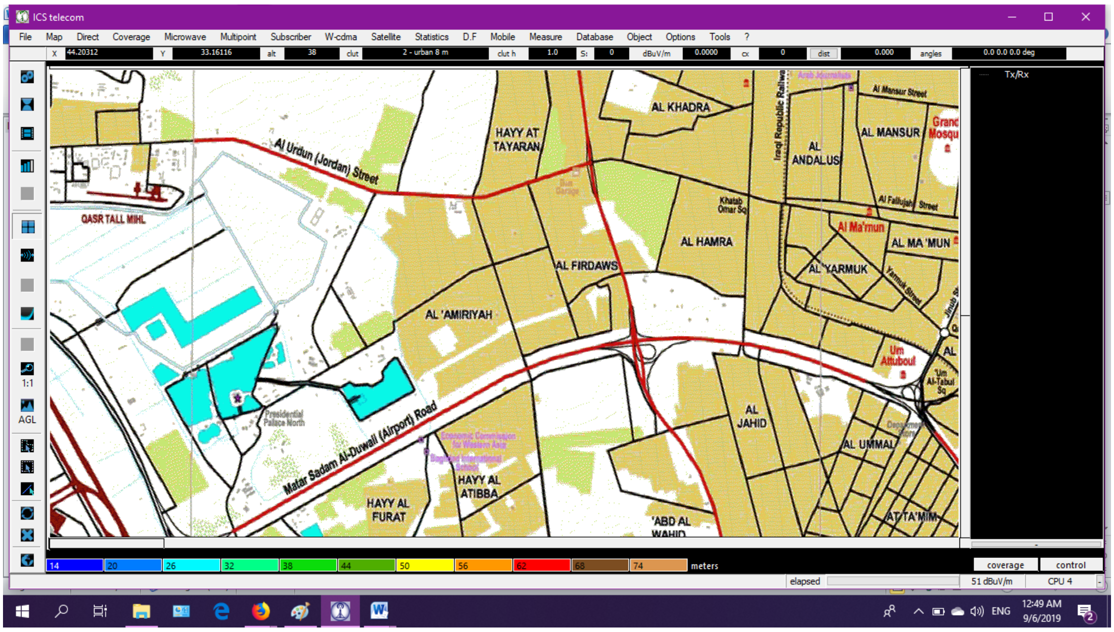
In this work, the network performance analyses were conducted via simulation and test drive. Moreover, the role of the network significant parameters are investigated and discussed as will be explained through next sections.

Coverage and interference are chosen as the most powerful metric to evaluate network performance.

Interference is materialized by (carrier to interference) C/I. The minimum C/I ratios show within each element respective best server coverage. The wanted elements are the active elements and are facing the deactivated elements considered interferers (unwanted).At each point of the coverage, the following calculation is done: wanted field strength - unwanted field strength. All frequency combinations are treated. Protected zones and unprotected zones are shown in accordance to the C/I legend [12].

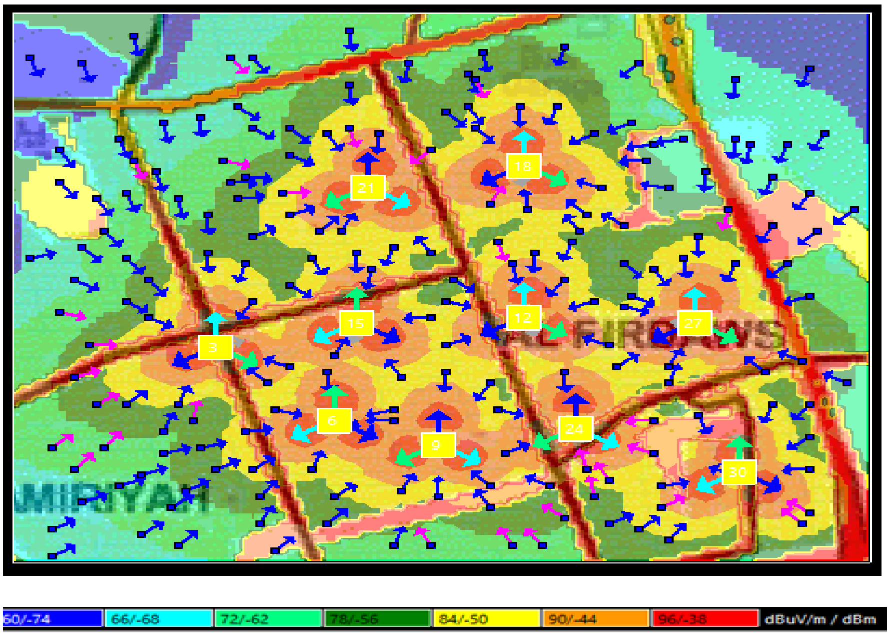
4.1.1. Simulation and analyses:

ICS telecom program as shown in figure (2) is used to calculate the coverage and interference between the towers.



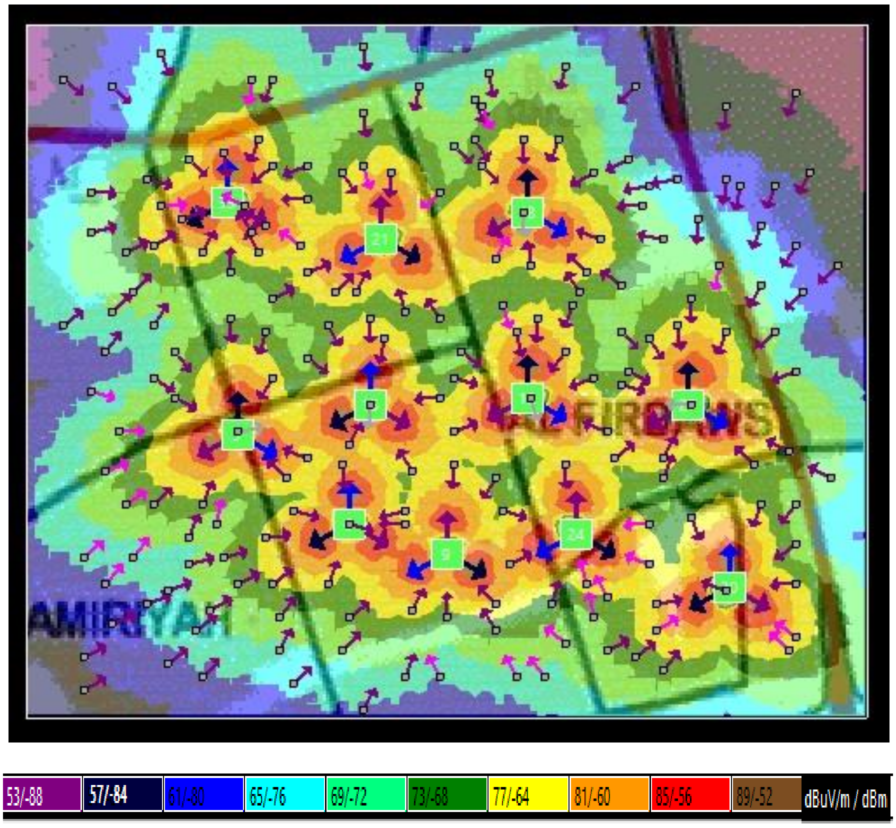
Fig(2) ICS Telecom program interface

10 towers are deployed in real locations 2G and each tower contains 3 sectors, as well as more than 200 test points, are published by ICS Telecom program, as shown in figure (3):



Fig(3) coverage area(2g)

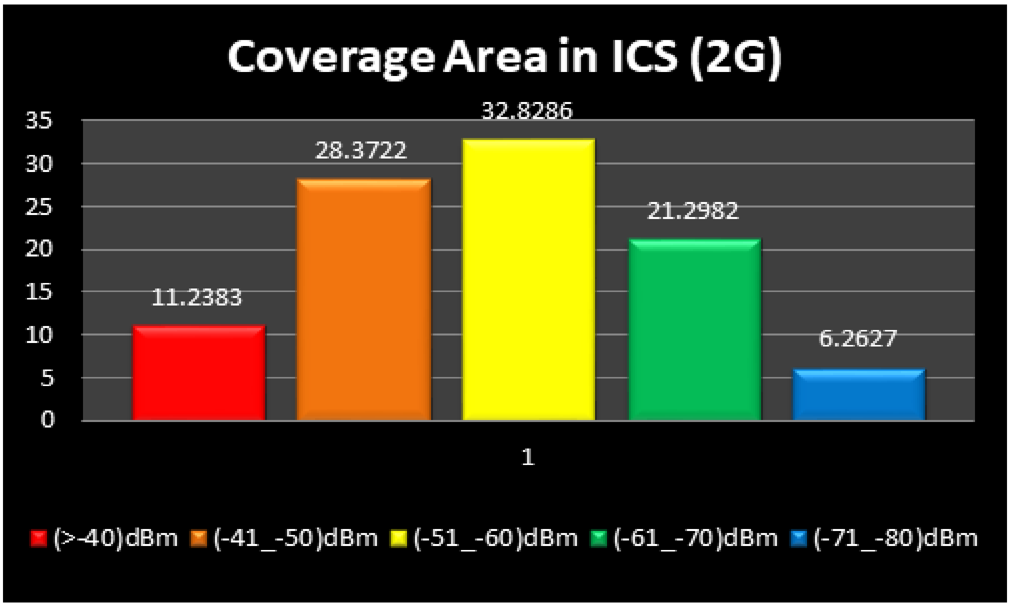
11towers are deployed in real locations 3G and each tower contains 3 sectors, as well as more than 200 test points, are published by ICS Telecom program, as shown in figure (4):



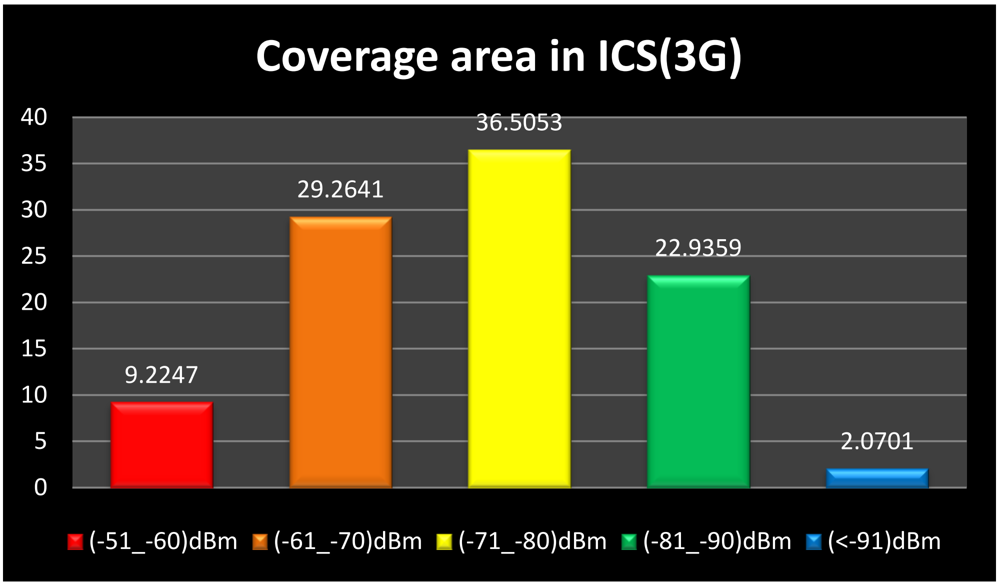
Fig(4) coverage area(3G)

The cell coverage is governed by the power received at the cell edge. Accordingly, the percentage of coverage versus received power of the 2G and 3G networks are compared for the city of Amreya in ,Baghdad as shown in figure (5) and (6)

It can be seen that for a 2G cell, the highest percentage network coverage value is 32.8% of the total area, for the received power between (-51_ -60) dBm, while in the 3G cell for this same received power the coverage percentage is 9.2% of the total area, which represents the Three Generation cell center. The lowest coverage percentage the area of the 2G cell is 6.3% in which the power received between (-71_-80) dB, and represent the 2G cell edge while in the 3G cell for this same received power represents the highest network coverage value is 36.5% of the total area, while the lowest coverage area of the 3G cell is 2. % of total area, for the received power less than (-91dBm).



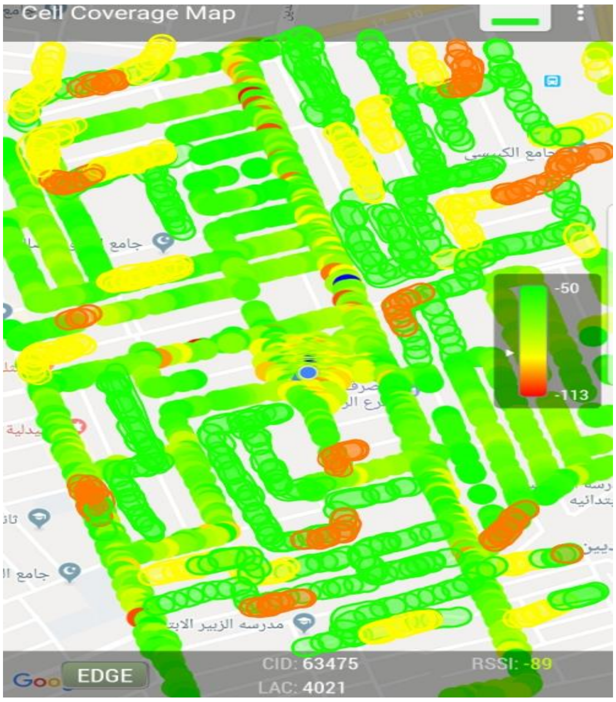
.Fig(5) Simulation of coverage area for 2G network (power=20w, Tilt=-10)



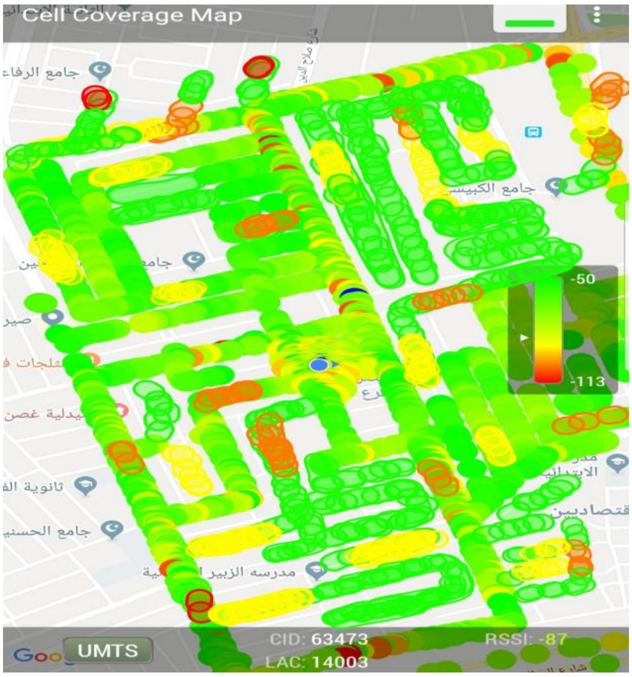
Fig(6) Simulation of coverage area for 3G network (power=20w, Tilt=-10)

4.1.2. Drive test results:

More than 200 test points were determined which is sufficient to predict the coverage area of a base station in all direction, the walking test and driving test were conducted to collect data for both 2G cell and 3G cell as shown in Figure (7) and (8).

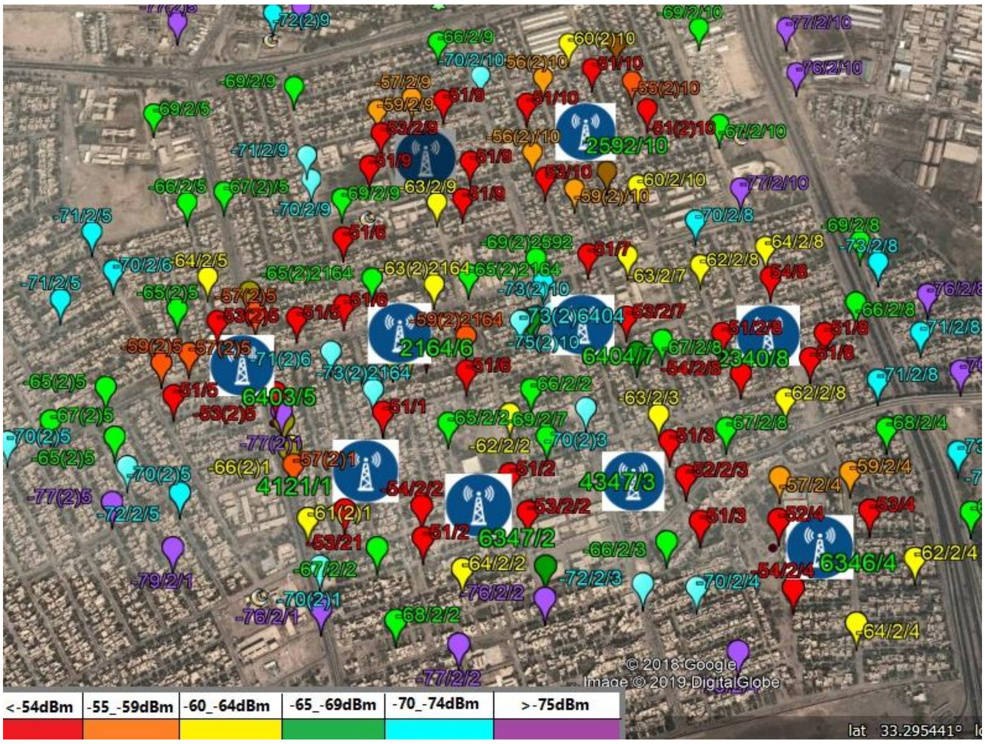


Fig(7) Drive test and walk test to collect data from 2G cell

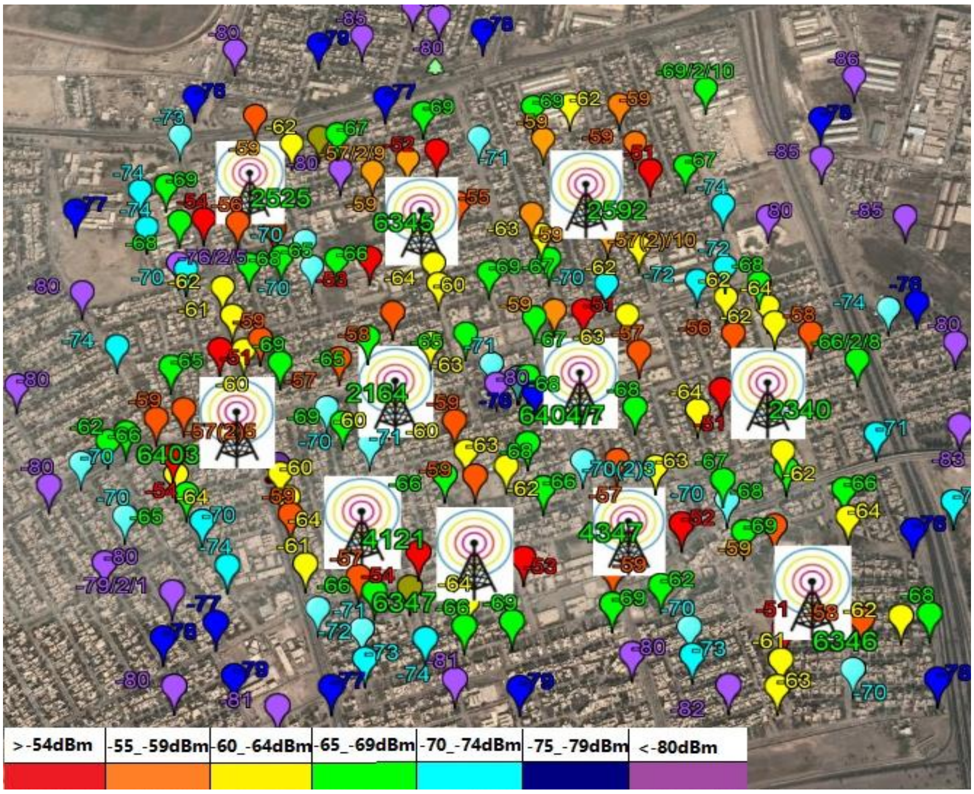


Fig(8) Drive test and walk test to collect data from 3G cell

These test points have been clarified on Google Earth as depicted in figure (9) and (10).
Test points with different color indicate a range of receive power. The red color for both 2G, 3G network reflects the maximum received power equals to (-54dBm).
At the cell edge, the minimum received power equals to (-75 dBm) and (-80 dBm) for 2G and 3G respectively.



Fig(9) coverage area in Google earth (2G)



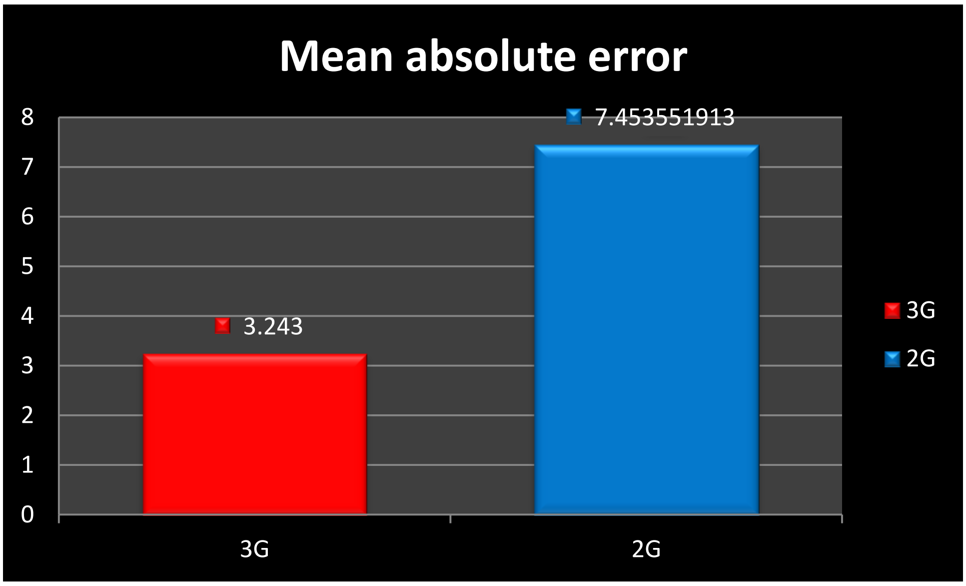
Fig(10) coverage area in Google earth (3G).

In this work, the deviation between the field measurement and the predicted data from the simulation can be evaluated based on (Mean Absolute Error) MAE, which can be determined as below:

$$MAE = \frac{\sum_{i=1}^{N}(P_{mi} - P_{si})}{N}$$

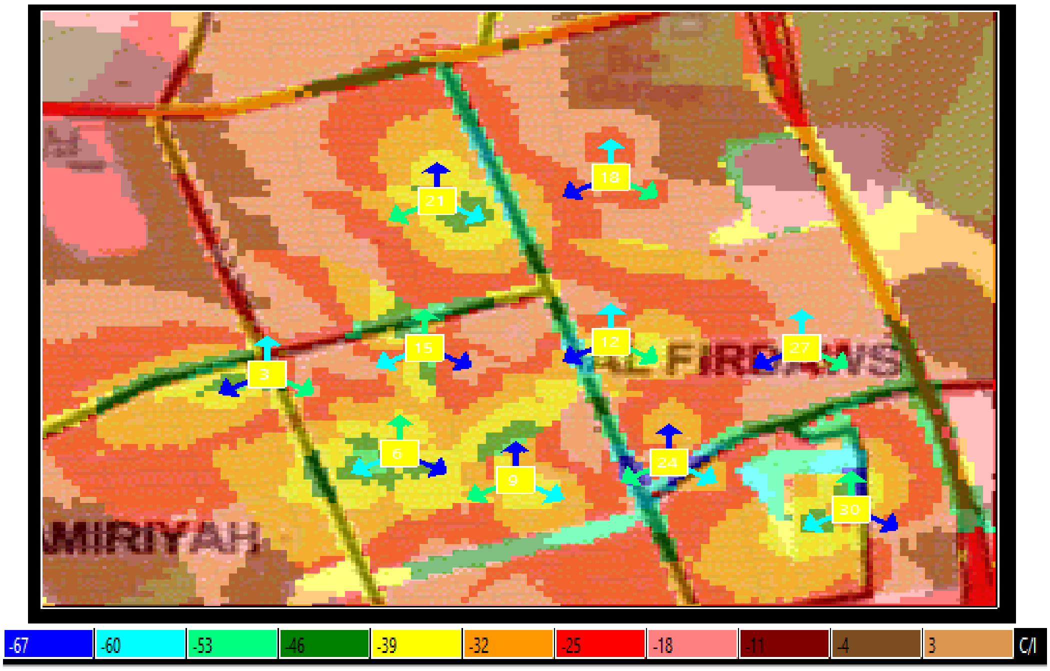
Where, P_m and P_s are the power measured and simulated respectively, N is the data set size.

Performing the comparison in terms of MAE is depicted in figure (11) It is obvious that is MAE equals to 3.243 dB for 3G network. On the other side, the MAE equals to 7.453551913 dB for 2G network. These results indicate a good correlation between the simulation results and practical results.

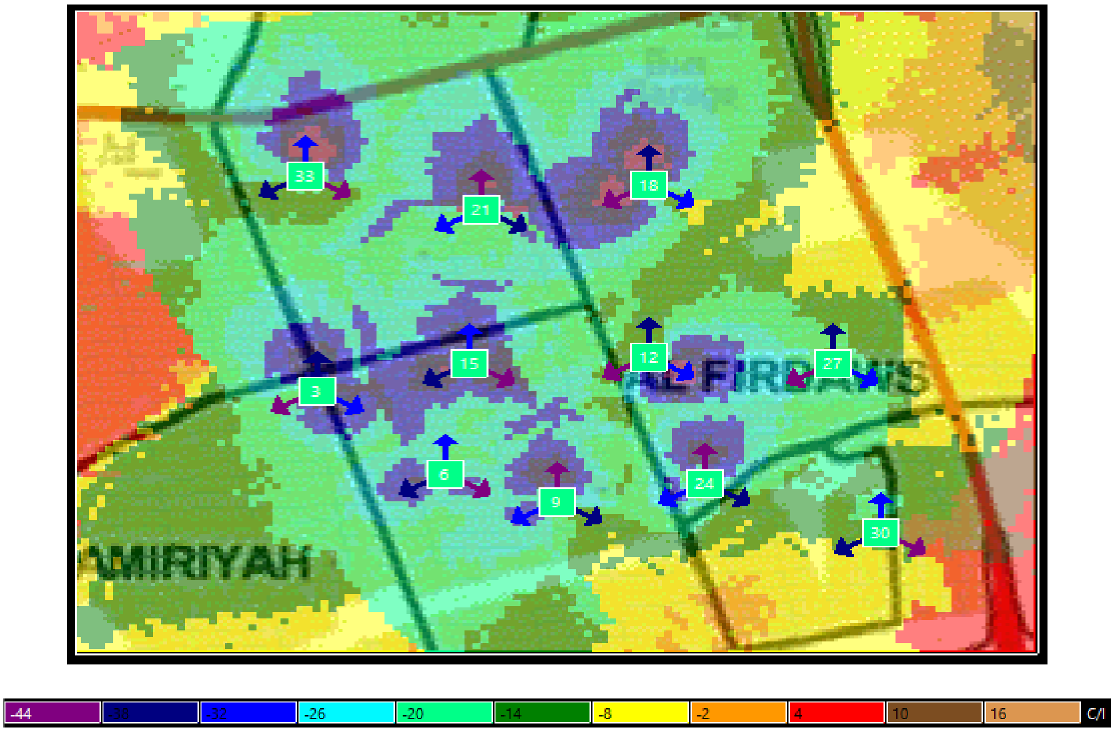


Fig(11) Mean absolute error between the field measurement and empirical model in (ICS)

On the other hand, the minimum C / I of 2G and 3G cells is illustrated in Figures (12) and (13) respectively by using ICS Telecom.

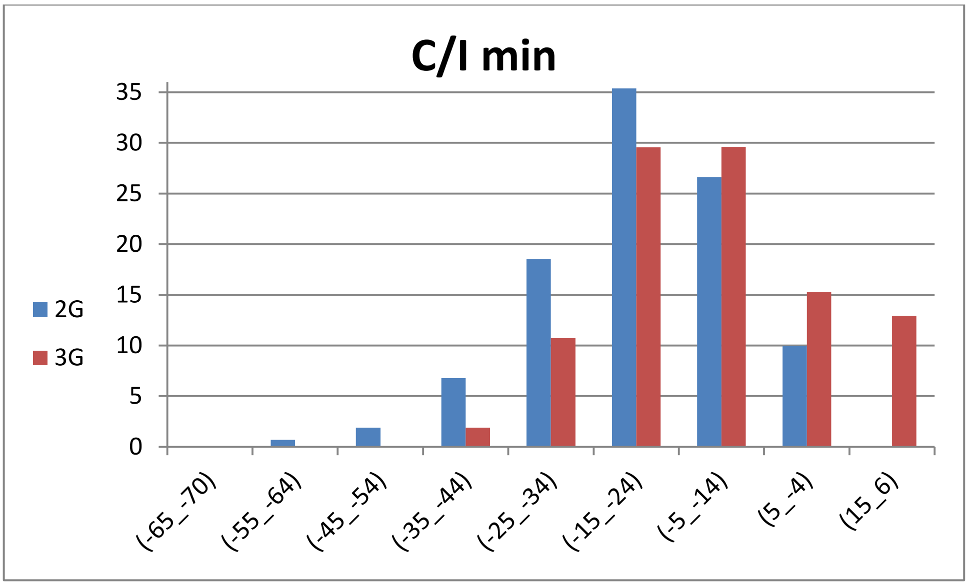


Fig(12) C/I (2G)



Fig(13) C/I (3G)

When compared between 2G and 3G in terms of minimum C / I, it is obvious that 3G achieved the high minimum C/I in the ranges of (16 dB to -44 dB). While for the 2G network, the minimum C/I range between (3dB to -67dB).



Fig(14) Comparison C/I between 2G and 3G cells

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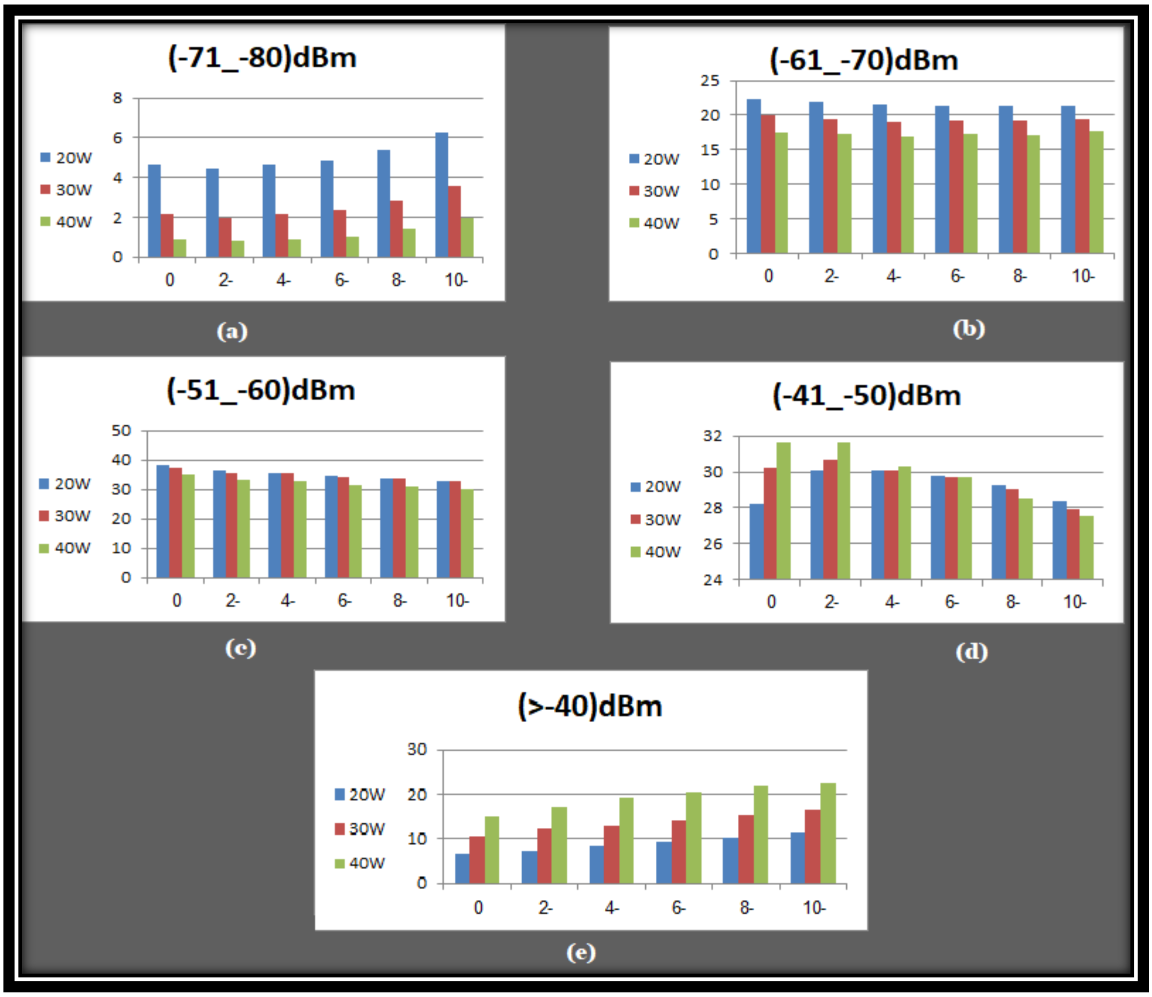
4.2. Parameters Effect on Network Performance:

Network performance is affected by many parameters.Therefore; network engineering must accurately consider this parameter during network planning and even after its installation.
Some of these parameters are configured for one time such as tower height, others are kept tuning continuously according to certain criteria in order to enhance the network performance. BS antenna power and tilt are examples of such parameters, which have a significant effect on determining the cell size and signal quality.

Fig (15) depicts the effect of antenna power and tilt on coverage as explained below:

- It can be seen that in the range of low received power (-71_-80) dBm the coverage in the power 20w is higher than the 40w coverage ratio and increases as the antenna tilt decreases to (T= -10°).
- Note that at the range of received power (-61_-70) dBm and (-51_-60) dBm, the coverage at 20w is higher than the coverage at 40w, but it decreases as the tilt increasing.
- In the range (-41_-50), we notice that the coverage at 40 w begins to increase compared to the coverage at 20 w, where the maximum coverage is gained at tilt=-2. At tilt -4 to -6 both 20w, 40w have the same effect on the coverage. Finaly, as the tilt decreas from -8 to -10 the coverage in 20w and 40 w is decreased.
- At the cell center (15-e), the high quality covered area (>-40 dBm) increased as the power increased or as the tilt decreased. As a result, the largest covered area in this range can be achieved at (p=40W and T=-10°).



Fig(15) (a, b, c, d, and e) : Percentage of Coverage for each range within a different power and tilt

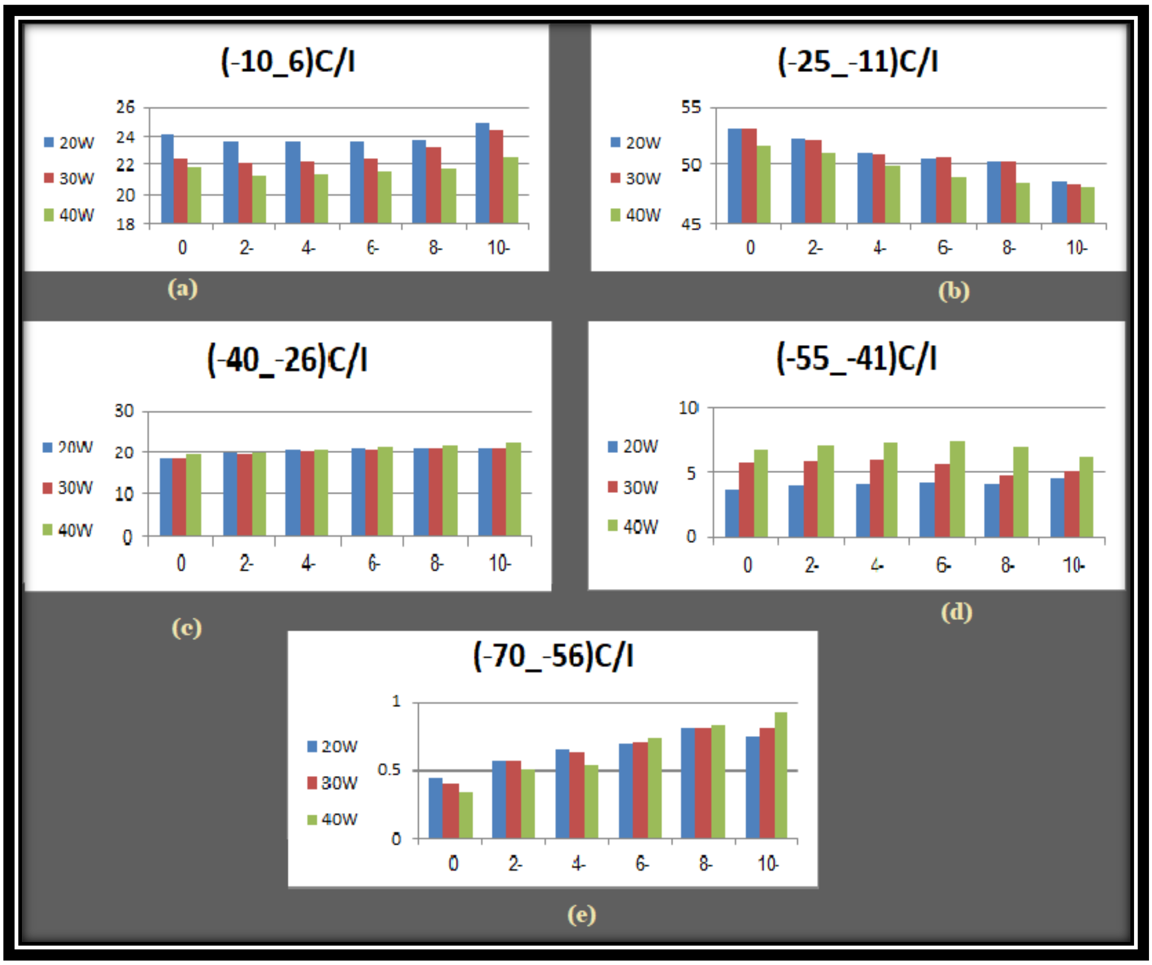
Figure (16) depicts the relation between the interference in terms of minimum C/I and network parameters (Power and Tilt). However the following points can be noticed:

- At the cell edge layer (-70dB_-56dB) the interference is reduced as the tilt increasing. As well as the effect of higher power (40w) over comes the case of (20w) with the tilt approach -10. The effect of (30w), (40w) are almost the same for the 3rd layer coverage area and for all tilts values.

- At the cell center layers (6dB_-10dB), the less interference is achieved at tilt=-10. Moreover, the effect of low power (20w) is significant over other power cases for all tilt values.

- The maximum (C/I min) is noticed with zero tilt value and for (20w) power case.

- The effect of all power cases are almost the same for the 3rd layer coverage area and for all tilts values, while the effect of (30w) case is significant for the 4th layer.



Fig(16): Percentage of minimum C/I for each range within a different power and tilt

5. Conclusions

In this work was studied and collected the network data in a particular area in Baghdad.
The analyses were practically carried out via a driving test and simulate the results theoretically via ICS Telecom. The effect of tilt and power change was observed and their effects on the performance of the 2G and 3G networks in terms of coverage and interference were investigated. It was noted that the coverage area of the high-quality area increases with increasing power to 40w, and the tilt to -10.
It was also observed when calculating C/I, that the greater the antenna slope (equals to -10), the less interfering between cells, is gained.

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