Built Cellular Network For Baghdad City With Smart Antenna Technique

Dr. Hussain Ibrahim Alwan
Al-Turath University College /Department of Computer Technologies Engineering

, Eng.Marwa Moutaz Ismaieel
M.Sc. studies of University of Technology/ Communication Department
Email:Eng_marwa72@yahoo.com

ABSTRUCT

In this work we built a large cellular network for Baghdad city by using switched beam smart antenna technique (SBSA) to have optimum coverage, min interference, and Max capacity Instead of the conventional techniques that have many disadvantages that limit the performance of the network.

Our work are divided into two stages: in 1st stage we change the parameter of one BTS (cell) for 3 path loss models and show how the coverage is changed by changing Broadcast parameter, this is the 1st step that must be understood by any engineer how want to design a large cellular network. (Broadcast parameter is taken from ASII Cell Company), MATLAB is used to simulate and present the result.

In the 2nd stage we built cellular network by dividing Baghdad city into 11 parts and distribute cells on it, changed broadcast parameter for each cell until we have an optimum coverage with min SIR .

By used SBSA technique and with Keeping the same range we reduce the transmitted power by 4 which mean low pollution and low power saving cost, interference reduced by 4 so by keeping the same C/I ratio we can reduce the frequency reuse from 7 to 4 ,and by keeping the same cell area, the capacity for the whole network increased by 75%, utilizing the higher gain offered by smart antenna technique we can cover vast areas by using a minimum number of BTS

, in extremes areas of Baghdad city ,1BTS with SA technique cover areas of 7 BTS . We use a special program "Radio Mobile Program" to extract the coverage and present the result.

الخلاصه

في هذا العمل قمنابناء شبكة اتصالات خلويه لمدينة بغداد بأستخدام تقنية الهوائيات الذكيه.للحصول على افضل تغطيه, اقل تداخل واعلى سعة بدلا من استخدام التقنيات التقليدية التي لها العديد من المضار التي تحد من اداء الشبكه.

العمل قسم الى جزأن : في الجزء الأول قمنا بتغيير عوامل البث لمحطه واحده ل 3 انواع مختلفه من موديلات خسائر الأنتشار وتوضيح كيقية تغير التغطيه مع تغيير مواصفات البث.هذه هي الخطوه الاولى التي يجب ان تكون مفهومه من قبل اي مهندس يريد بناء شبكة اتصالات خلويه.(عوامل البث اخذت من شركة اسيا سيل), برنامج الماتلاب استخدم لعمل وتقديم النتائج.

في الجزء الثاني قمنا ببناء شبكة خلويه بتقسيم مدينة بغداد الى 11 جزء وتوزيع الخلايا عليها, تغيير عوامل البث لكل خليه الى ان نحصل على افضل تغطيه بأقل قيمه ل نسبة الاشاره الى التداخل.

بأستخدام تقنية الهوائيات الذكيه وبلمحافظه على نفس المدى قللنا القدره المرسله بمقدار 4 والذي يعني تلوث أقل وكلفة توفير كهربائيه اقل,التداخل قل بمقدار 4 ,لذا بلمحافظه على نفس قيمة الاشاره الى التداخل استطعنا تقليل مدى اعادة استخدام الترددات من 7 الى 4,وبلحفاظ على نفس مساحة الخليه فأن سعة الشبكه بلكامل ازدادت بمقدار 75%,بلأستفاده من الكسب العالي الذي توفره تقنية الهوائيات الذكيه استطعنا تغطية مساحات واسعه بأستخدام اقل عدد ممكن من الخلايا ,على اطراف مدينة بغداد ,خلية واحده استطاعت تغطية مساحة لسبع خلايا. استخدمنا برنامج خاص "برنامج النقال الأذاعي" لأستخراج التغطية وعرض النتائج

Keywords: smart antenna, cellular network, Baghdad city, radio mobile, SBSA, cell coverage, path loss model.

1. INTRODUCTION

Most countries still until now, including cellular networks in Iraq used conventional techniques (directional-ominidirectional) antennas at BTS that have many disadvantages that limit the performance of the cellular network. These techniques radiate the power randomly in all directions in order to cover the entire area and to communicate with mobiles within the cell range. This power will produce interference for other BTS and mobiles (in –out) the cell range, and since GSM network is interference limited this will led to limit the performance of the whole network.

In this work we built a large cellular network for Baghdad city without used the conventional techniques that limit the performance of the network as illustrated above. Instead we use the last technology that 4th generation tends to use "SA" technique. Here we will give a simple definition of what it means.

A smart antenna system combines multiple antenna elements with a signal processing capability to optimize its radiation and/or reception pattern automatically in response to the signal environment. Smart antenna systems are customarily categorized as either switched beam or adaptive array systems [Ivica Stevanovi´c and others 2003].as shown in Fig.1.

SBSA is the simplest technique, and comprises only a basic switching function between separate directive antennas or predefined beams of an array [J. Rugamba and others 2004].while An Adaptive Antenna is a set of antenna elements that can adapt their antenna pattern to changes in their environment [Ivica Stevanovi´c and others 2003].

Any network designer dream is to design a cellular network with optimum potentials and services and to push the network capability in to its max pound, three key elements that must take in accurate study when design the network is coverage, interference and capacity.

Coverage is the 1st critical key element that depends on many parameter, we must choose the path loss model that suit the geographic area and broadcast

parameter that give us an optimum coverage. Interference is the 2nd key element that must take in accurate study or it will lead to network fail. It depends on frequency assignment and channel distribution and many other factors. Finally capacity is function of the two factors above.

So in order to built not just successful network but network with optimum performance we must take all these factors in accurate study and find the best technologies that give us the best result.

Here we take these three factors in precise study to design virtual network for Baghdad city with optimum standards and services. Our work is divided into two stages in 1st stage we study coverage and all factors that affect it, MATLAB is used to simulate and present the result. In the 2nd stage we take the entire key element in precise study and built cellular network for Baghdad city with the last technology that give us an optimum coverage, min interference and max capacity. Radio Mobile Program is used to present the result.

2. FLOW CHART AND SIMULATION RESULT

The received signal strength (link budget) is equal to [Dr.S.A.Mawjoud 2008]:

$$Rxmim\text{-}level = EIRP - LPA\,B - IDM - LSM - LMCC + GMS \quad (1)$$

Where EIRP is the effective isotropic radiated power and equal to

$$EIRP = PBTS - LCFI - LAFC + GBTS \quad (2)$$

Where:

PBTS = Output power of BTS.

LCFI = Combiner / filter / isolator loss (4 dB), GSM at 900 MHz

LAFC = BTS transmitter antenna feeder / connector loss (2 dB), GSM at 900 MHz

GBTS = BTS transmitter gain

Rxmim-level= MS Sensitivity

LPAB = Propagation loss + 3 dB antenna (body loss).

IDM = Interference degradation margin (3 dB).

LSM = Log normal shadowing margin for 90% coverage area (5 dB) [Jean-Paul Linnartz 2000].

LMCC = MS antenna cable and connector loss (0 dB).

GMS = MS antenna gain

So by knowing the mobile receiver sensitivity, the transmitted power, antenna gain, and the system loss we can use equation (1) to calculate the maximum affordable path loss, the maximum affordable path loss when substitutes in path loss models will give the cell range (d), see flow chart in Fig.2, Adding penetration loss (15 dB as per GSM recommendation) to the path loss and a gain substitute in path loss models, will gives the indoor coverage range.

Here we use 3 path loss models that are most well known in design cellular network, this is (Hata-Lee-Clutter factor) path loss models to calculate cell range and extract coverage, as we can see from the result Figs(3-11) that coverage depend on many broadcast parameter and path loss models, we should take the path loss model that suit the propagation environment or we will have inaccurate result, different broadcast parameter have different effect on coverage so in design cellular network we must change each parameter until we have an optimum coverage with min SIR , as we can see coverage increase by increase antenna height, transmit power , antenna gain and each one have different effect on coverage , here Hata give more accurate result than Lee that give more accurate result than clutter because Hata and Lee are design for urban area but clutter factor model is design more for medium city or sub-urban areas.

3. BUILT CELLULAR NETWORK FOR BAGHDAD CITY AND RADIO MOBILE PROGRAM.

In this work we built a cellular network of hexagonal cells by using MATLAB and combine MATLAB result with Radio Mobile program in order to distribute cells on it by using frequency reuse rule, In this work we use switched beam smart antenna technique (SBSA) with 4 beams per sector to cover almost all Baghdad city in all BTS. We divide Baghdad city into 11 part and distribute cells on it using frequency reuse equal to 4 ,dense urban area are filled with cells of 500 meter radius , extremes areas of Baghdad city are filled with 1 BTS with (SBSA) technique that cover areas of 7 BTS. We changed all broadcast parameter for each (cell) until we have an optimum coverage with min SIR, we use Radio Mobile Program which is a computer simulation program used for predicting radio coverage of a base station, repeater or other radio network[Brian J. Henderson, P. Eng 2011] to present the result. Besides :The wide range of simulations it performs makes it very useful software [Juan Joes, Pablo M.Olmos 2011], we built Baghdad city with 4 different elevation data layers with different resolution in order to have accurate and high resolution maps. By used (SBSA) technique in the whole network we achieve the following objectives that would never have been obtained when conventional techniques used. By keeping the same range inside urban areas we reduce the transmitted power of each BTS by 4 which mean low pollution and low power saving costs (since using low power (i.e. cheap) amplifiers and minimized air conditioning in the base station cabinets.), interference is reduced by 4 so by keeping the same C/I ratio we reduce frequency reuse from 7 to 4, keeping the same area the system capacity increased by 75%, utilizing the higher gain offered by SA technique the range extended to cover large areas with min number of BTS, in extremes areas of Baghdad city ,1BTS with SA technique cover areas of 7 BTS .See Figs (12-22), green areas with good coverage, red areas with no coverage, These red areas may be caused with many reasons like obstruction that block

the way between transmitter and receiver and caused shadowing or multipath effect that reduce the signal quality and reduce coverage. any engineer should know that inaccurate Broadcast parameter will affect the coverage more than any other reason, so in order to reduce these areas they must choose the right Broadcast parameter that give optimum coverage, as we know increase (gain, power, antenna height) will increase coverage but they must take into account system loss because increase height will increase system loss as well, they can also reduce receiver threshold to cover areas faraway from BTS that have low density, in this case they may cover large area with 1 BTS , but if the number of blocking calls increased i.e. (people density increase) then they must added BTS to that area to handle the increase demand on the network and to increase coverage.

***important note: Unfortunately the program gives a red back-ground for BTS this mean it's just back-ground not "no coverage"**

*** please give attention to this note when see the result.**

4. CONCLUSION

In this work we built a cellular network for almost all Baghdad city to have optimum coverage, min interference and Max capacity. Instead of using conventional techniques that limit the performance of the network, we use the last technology that the 4th generation tends to use "smart antennas technique". Our work divided into two stages; in 1st stage: we took one BTS (cell) and changed the parameter of BTS for 3 path loss models and show how the coverage is changed for each Broadcast parameter, MATLAB is used to simulate and present the results.

In the 2nd stage, we built cellular network for Baghdad city by use (SBSA) technique with 4 beams per sector,

By Keeping the same range we reduce the transmitted power by 4 which mean low pollution and low power saving cost, interference reduced by 4 so by keeping the same C/I ratio we can reduce the frequency reuse from 7 to 4 ,keeping the same cell area the capacity for the whole network increased by

75%, utilizing the higher gain offered by smart antenna technique we can cover vast areas by using a minimum number of BTS , in extremes areas of Baghdad city ,1BTS with SA technique cover areas of 7 BTS .

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BTS: Base transceiver station
C/I: carrier to interference ratio
EIRP: effective isotropic radiated power
GSM: Grouped special mobile

IDM: interference degradation margin

LSM: log normal shadowing margin

SA: smart antenna

SBSA: switched beam smart antenna

SIR: signal to interference ratio

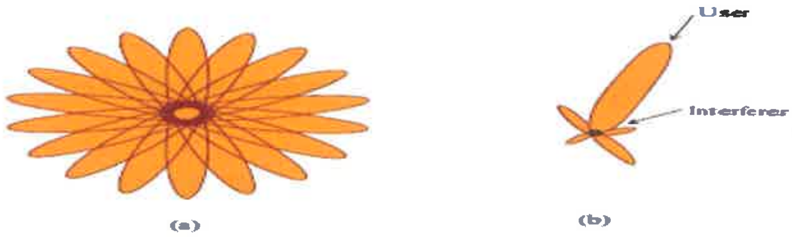

Fig. 1: (a) switched beam coverage pattern, (b) adaptive array coverage.

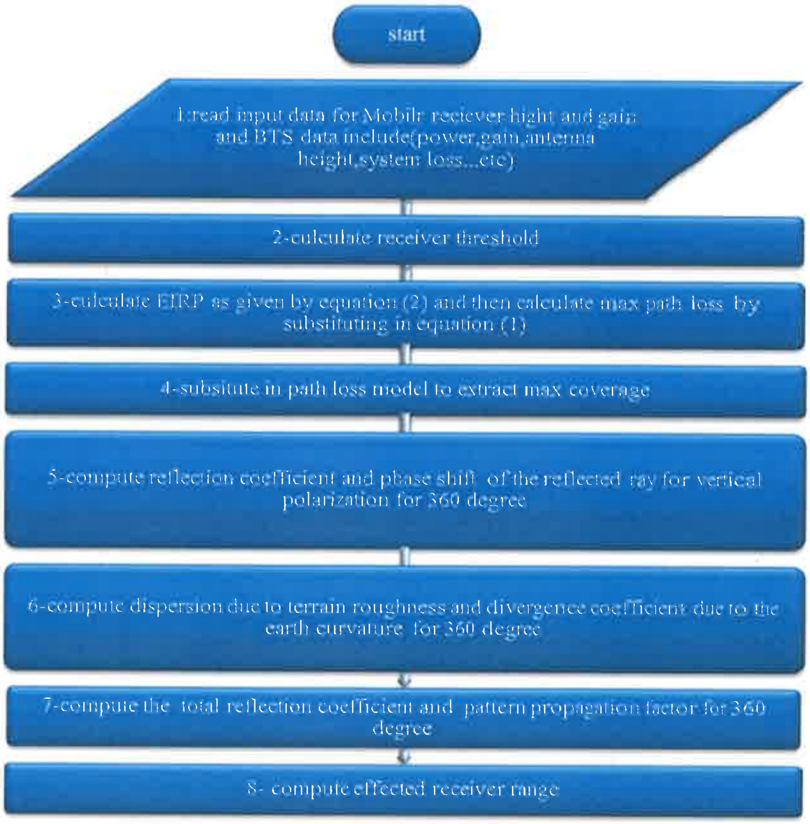

Fig. 2: Flow Chart for Extract Coverage

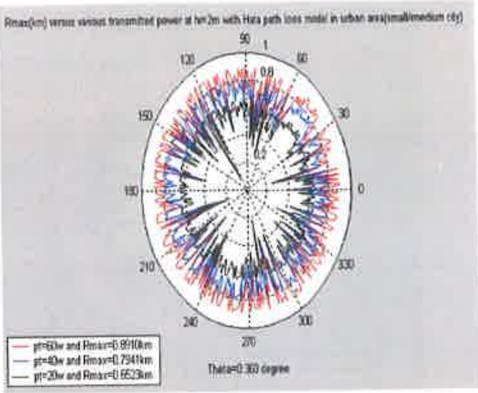

Fig.3: Cell Coverage with Hata Path Loss Model and Various Transmit Power

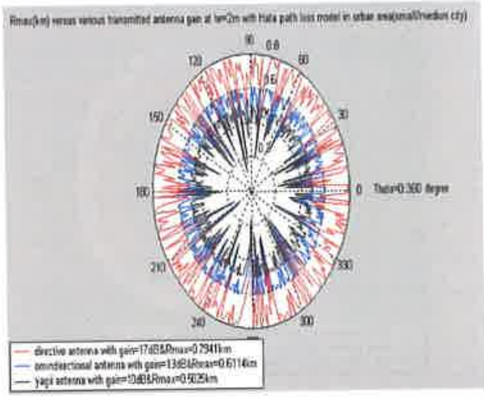

Fig.4: Cell Coverage with Hata Path Loss Model and Various Antenna Gain

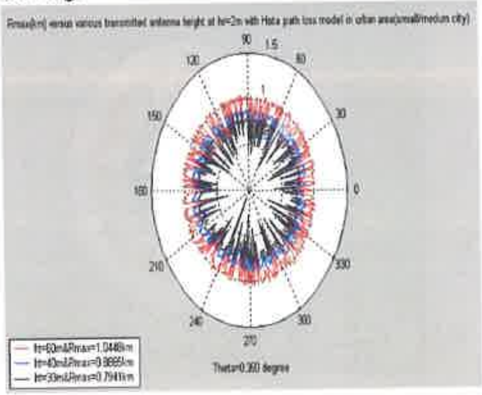

Fig.5: Cell Coverage with Hata Path Loss Model and Various antenna heights

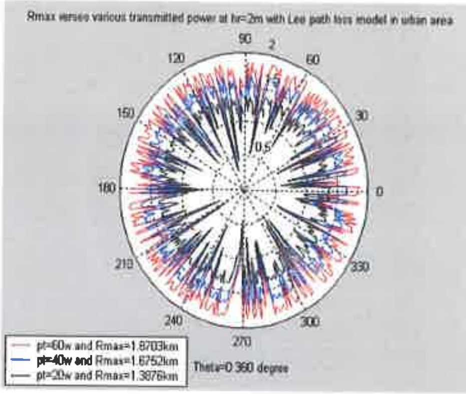

Fig.6: Cell Coverage with Lee Path Loss Model and Various Transmit Power

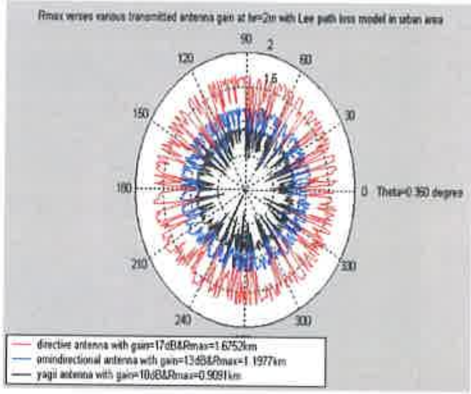

Fig.7: Cell Coverage with Lee Path Loss Model and Various Antenna Gain

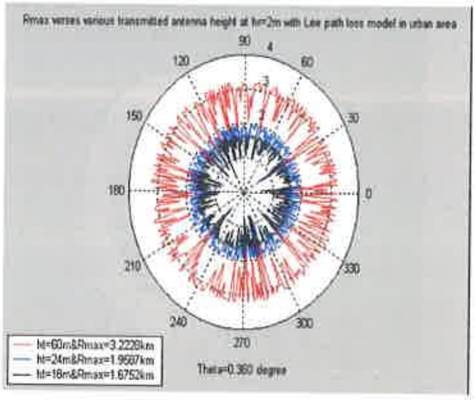

Fig.8: Cell Coverage with Lee Path Loss Model and Various antenna heights

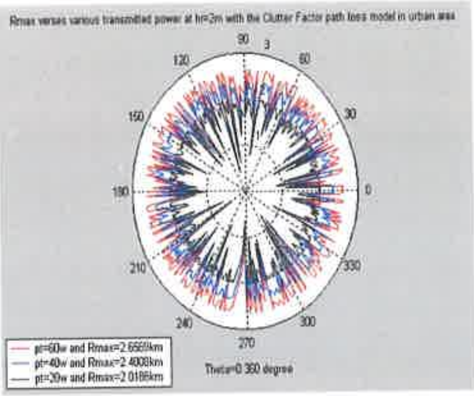

Fig.9: Cell Coverage with Clutter Factor Path Loss Model and Various Transmit Power

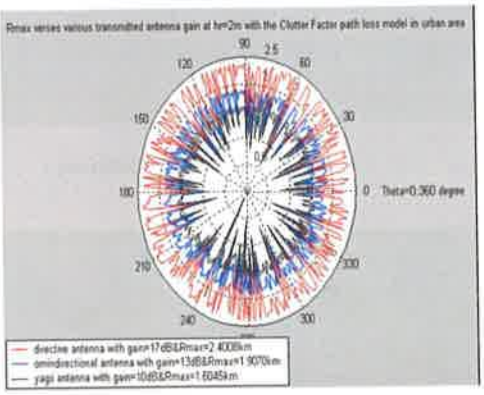

Fig.10: Cell Coverage with Clutter Factor Path Loss Model and Various Antenna Gain

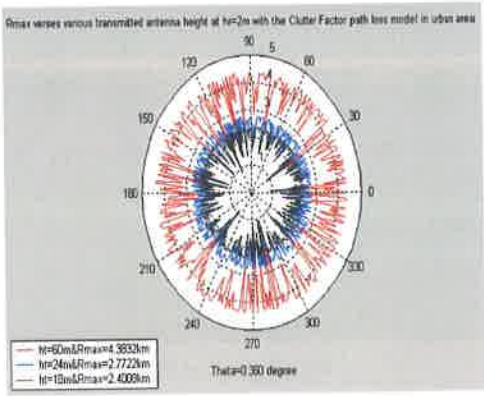

Fig.11: Cell Coverage with Clutter Factor Path Loss Model and Various antenna heights

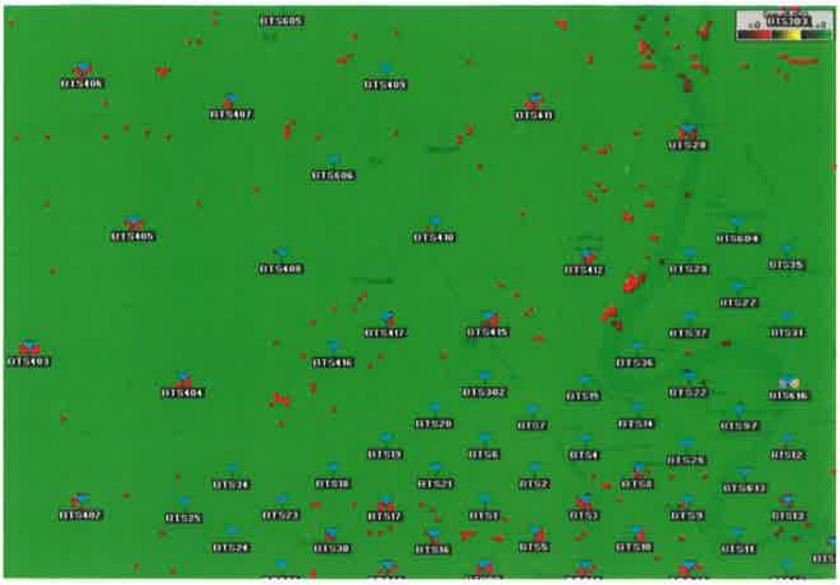

Fig.12: part 1 of Baghdad city

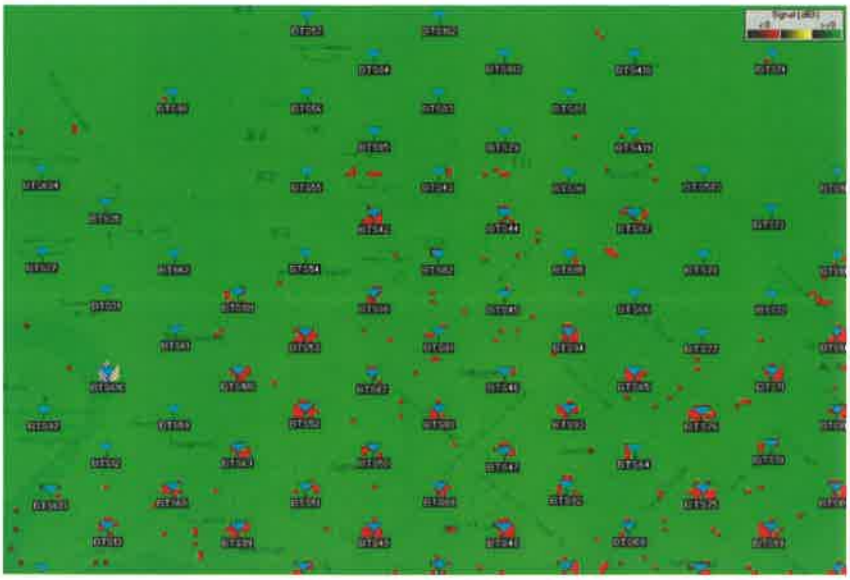

Fig.13: part 2 of Baghdad city

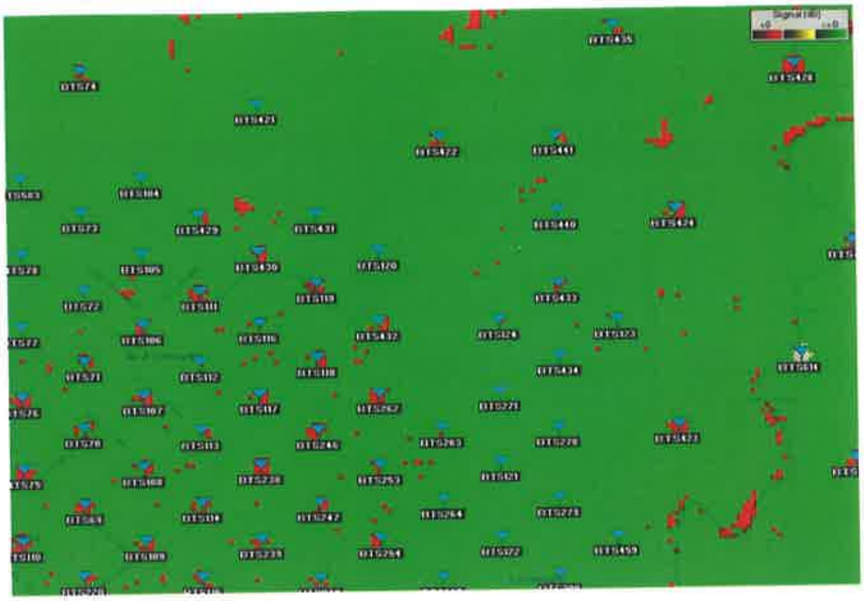

Fig.14: part 3 of Baghdad city

Fig.15: part 4 of Baghdad city

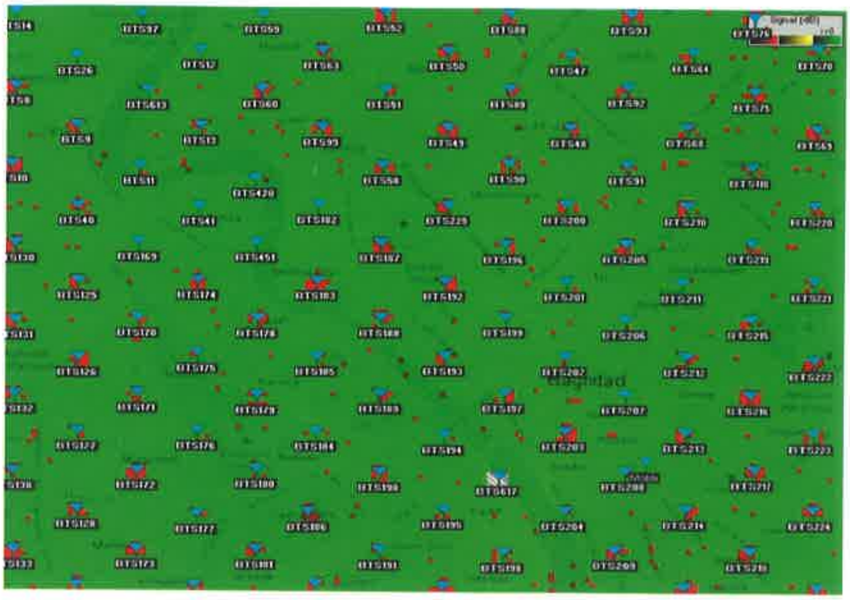

Fig.16: part 5 of Baghdad city

Fig.17: part 6 of Baghdad city

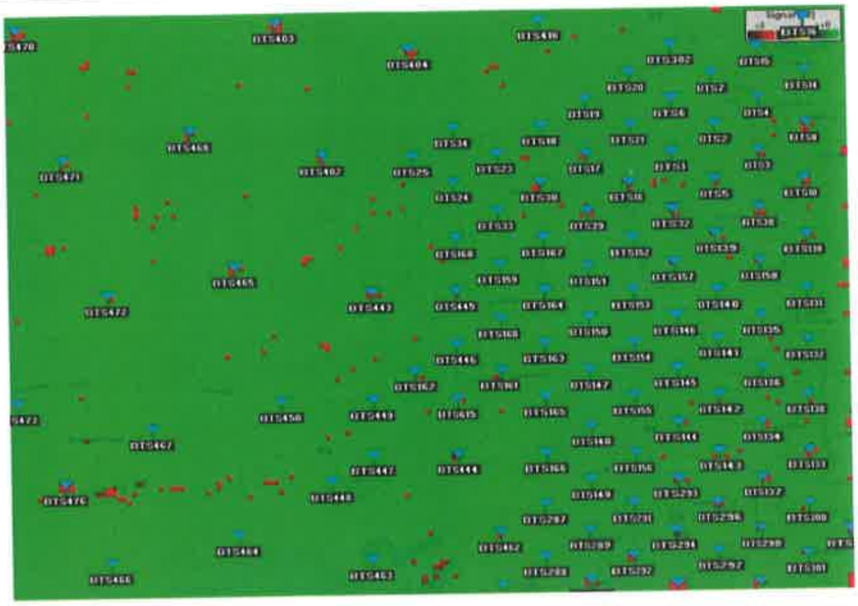

Fig.18: part 7 of Baghdad city

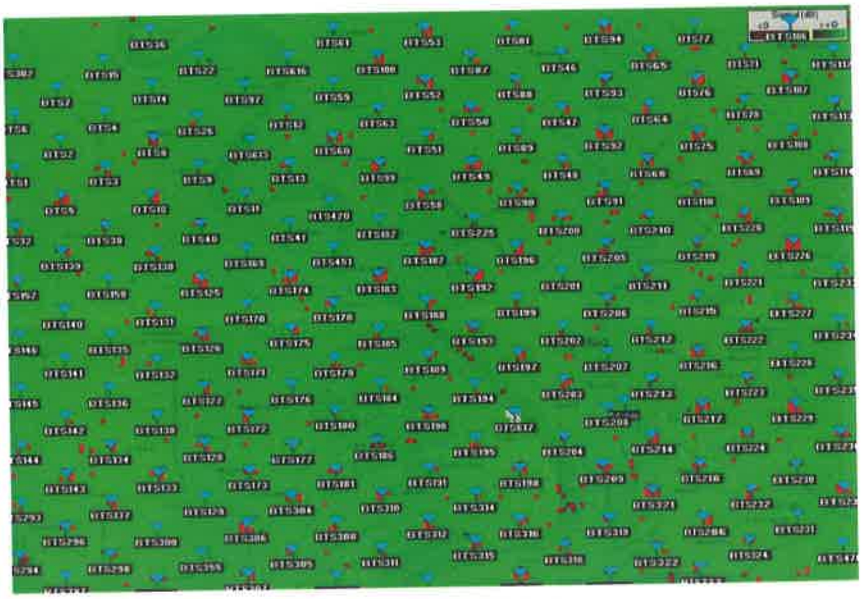

Fig.19: part 8 of Baghdad city

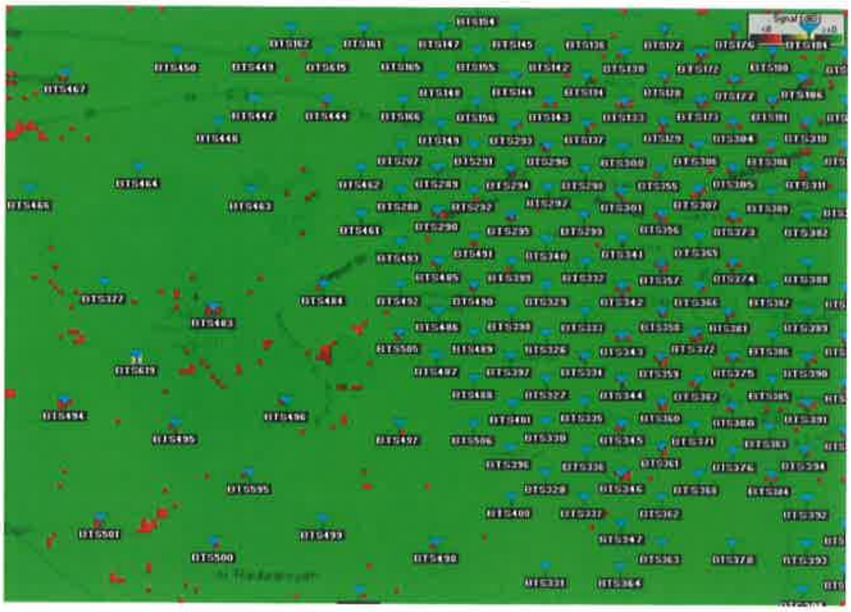

Fig.20: part 9 of Baghdad city

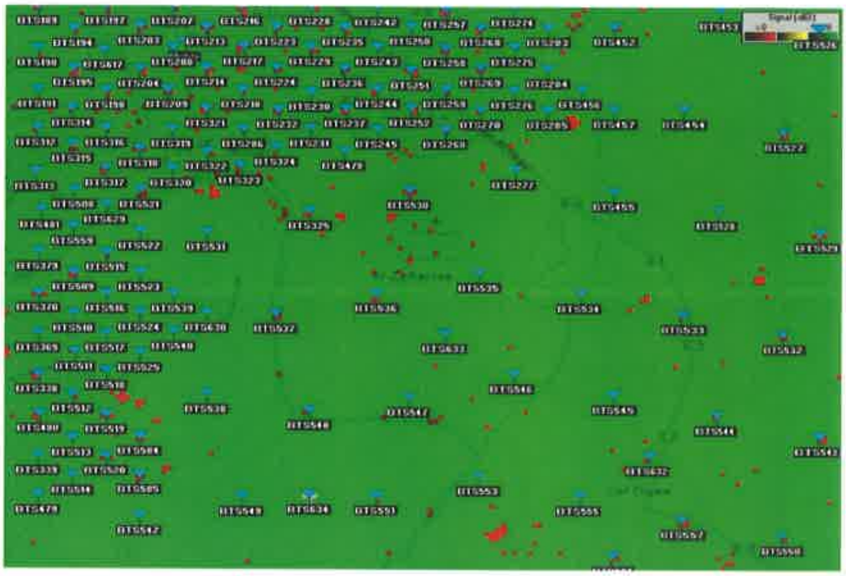

Fig.21: part 10 of Baghdad city

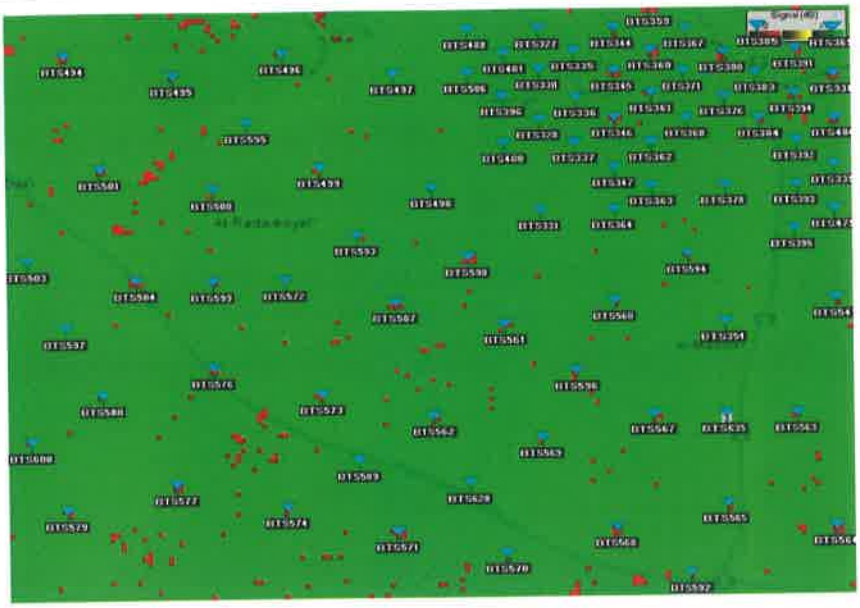

Fig.22: part 11 of Baghdad city