Optimization of UMTS network distribution using genetic algorithm

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Abstract— Since the radio network planning is a complicated task, methods are needed to optimize the radio network planning. Such that finding the optimal locations and configurations of the base stations in UMTS networks so as to maximize coverage and capacity and minimize the installation costs. In this paper random weighted multi-objective genetic algorithm is applied to various parameters of the radio network to maximize the coverage of the network and minimize the installation cost of the network and also to guarantee a good quality of signals received by the mobile users at different locations.

Index Terms— Planning, Optimization, UMTS, 3G Network,, Genetic Algorithm

1. Introduction

The universal mobile telecommunications system (UMTS) is a technical standard for a third generation (3G) telecommunication system. UMTS provides data rates more than three times higher than its second generation (2G) predecessors. The increased speed enables, for example, video calls, music downloads, or fast web surfing. The technology is already widely available. In 2007, a total of 166 commercial UMTS radio networks are operational in 66 countries covering all, and there are already more than 100 million UMTS subscribers.[1]

radio network planning is a complicated task due the number of conflicting parameters that effect the performance of the network (BTS location ,BTS configuration) .optimization algorithms such as genetic algorithm ,tabu search ,simulated annealing have been used to Facilitate this task [2] optimization of the Radio network is distinguished from radio network tuning, In the network tuning, the network configurations are changed in reaction to a performance deficiencies while the network is working (on-line). Radio Network optimization is supposed to be performed off-line and the optimization software is not considered as a part of the operation and maintenance system.[3]

this paper organized as fallows ,in section 2 optimization parameters are being discussed in detail ,in section 3 the proposed algorithm is being described in section 4 methodology and simulation results . in section 5 the conclusion.

2. Optimization Parameters

The optimization criteria that are associated to the network's performance can be divided into two groups: **mobile-based** criteria and **cell-based** criteria. Coverage is considered to be mobile-based criterion, since it is defined per user. Capacity is considered to be cell-based criteria, since the capacity calculations are performed based on the cell's capacities.

In this paper the mobile-based parameters are being optimized ,three parameters are discussed in this paper :site location , cost ,cover rate.[3]

2.1 Site location

In the classical site location (or site selection) problem formulation, a set of potential site candidates is given. A subset of these potential sites has to be selected. under quality constraints (e.g. a certain amount of coverage), or a certain budget (cost constraint)[4] .

Coverage is one of the most important optimization targets .Coverage optimization has been done by finding the optimal locations of the base stations thattook the maximum advantage of the coverage of these base stations[5]. the implementation cost of the network or the hardware cost is another optimization target. for this parameter the cost of the base stations is considered to be fixed and same for all base stations .so the cost minimized by minimizing the number of the base stations under quality constrain (coverage)[6] .Cover rate is optimize by adding service test points (STP) each point has certain traffic ,to the optimization area ,these points represent locations where signal power has been measured . a received signal at this points should be above a minimum threshold in order to ensure a good quality of service[7,2].

2.2 Measuring BTS coverage using propagation model

Cost-231 hata model is used [8].

$$Lp(d)=46.3+33.99\log10(f)-13.82\log10(hb)+(44.9-6.55\log10(hb))\log10d-a(hm)+clutter \quad (1)$$

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Where (f) the frequency in Mhz , (hb) is the height of base station in (m).
(hm) is the height of mobile statin in (m) , (d)distance from transmitter to the receiver in (Km) basically from (1-20 km).

a(hm)=(1.1 log10(f)-0.7)hm-(1.56 log10(f)-0.8)(2)

clutter is a clutter loss correction given by (clutter=0) dB for a medium sized city and suburban centers with moderate tree density ,(clutter =3) dB for metropolitan centers.

3. proposed methodology

After the coverage of one base station has been calculated a working area is designed assuming that

- 30*30 Km2 the total area. the area assumed to be free from obstacles and can place the BS in any point.
- 53 base stations with omnidirectional antennas has been distributed randomly in the area.
- All base stations have the same height (25 m).
- All base station have the same transmission power(20 W)

Base stations are coded inside the GA's chromosome as two vectors of real numbers each one representing one of the (x,y) coordinates .these coordinates represent the location of each base station in the optimization area such that

$bs1 = \{x1, y1\}$ this called the gene

$BS = \{bs1, bs2 \ldots\ldots bs_n\}$ where n number of BSs. This called a chromosome

3.1 Fitness function

The fitness function is used to evaluate each solution to find the best solution which either have the maximum fitness value or the minimum value.
The fitness function must include all the parameters that are related to the optimization problem . in this paper coverage and cost and the superposition area and the cover rate are included in the fitness function. Since there are many optimization parameters and each parameter has certain degree of importance weights are added to fitness parameters depending on the parameter importance.

$$Fit = w1 * fit1 + w2 * fit2 + w3 * fit3 + w4 * fit4 \quad (3)$$

(fit1) is the coverage fitness that is equal to :

Fit1=(covered area / total area)*100% (4)

The covered area is measured using pixels basis (dividing the area into small pixels and measure the number of covered pixels)
The second fitness for the superposition area use to prevent the aggregation of the cells in one area reducing the total coverage area.
the BSs are represented by circles with coverage radius (R) depending on the early mentioned assumptions ,the distance between two BSs are measured using the distance between two points law:

$$D = \sqrt[2]{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (5)$$

If D is equal to twice the radius the circles are contagious
If D is greater than twice the radius then there will be a gap between the cells
If D is less than twice the radius the circles are overlapped
The overlap area calculated by subtracting the distance D from (2*R) and added to the fitness function as percentage of the total area .
The third fitness is used to reduce the cost of the network ,this fitness is calculated by this equation :

$$C = \frac{tot - used}{tot} \quad (6)$$

Where tot are the total number of BSs and used are the used number of BSs in each solution.
The forth parameter represent the cover rate parameter .this parameter let the GA distribute the BSs depending on the user densities and it is calculated using this function

$$cover_{rate} = \frac{B}{A} * 100\% \quad (7)$$

Where B is the covered traffic and A is the total traffic ,the covered traffics are the STPs that receive power greater than minimum threshold .The benefit of this parameter is that the given area can be divided based on users densities in to rural and suburban and urban areas and place the BSs based on the area type.
The cost and the superposition area parameters are need to be minimized while the other parameters are maximized.

4. simulation results

TABLE 1

NETWORK SIMULATION PARAMETERS

Max BSs power	43 dBm
Max number of BSs	53
BS antenna	Omni/18 dBi
MSs antenna	Omni/0 dBi
BSs height	25m
MS height	2.5m
Total area	900 km^2
BS radius	3 km
Max number of STPs	250

Since this paper use weighted genetic algorithm so changing the weights will give different results ,at first the weight of the cover rate parameter is zero so the fitness consist of three parameters (coverage ,cost ,superposition) table.2 below give the result for different weights ,w1 represent coverage and w2 represent superposition w3 represent the cost and w4 represent the cover rate.

TABLE 2

THE RESULTS OF THE GENETIC ALGORITHM FOR DIFFERENT WEIGHTS

Weights	BSs no.	Coverage(%)	Overlap(%)	Gaps(%)	Fitness	Time(sec)
0.8:0.2:0	27	93.11	14.44	6.88	74.48	30
0.8:0.2:0	27	92.88	11.77	7.11	74.31	45
0.8:0.2:0	30	94.11	21.11	5.88	75.31	45
0.8:0:0.2	29	95.22	26.88	4.77	89.76	55
0.8:0.1:0.1	28	93.44	13.55	6.55	81.76	59
0.9:0.1:0	31	96	25.44	4	85.72	59
0.9:0:0.1	30	99.33	43.77	0.88	89.60	35
1:0:0	35	98.33	38.33	1.66	98.33	45
0.7:0.1:0.2	27	89.66	11.55	10.33	74.766	45

When the forth parameter is added and have weight the genetic algorithm distribute the BSs in high demand area fig(1) shows the distribution of the BSs and users .the red dots represent the BSs and the blue stars represent the users . If we assume that the area is divided in to urban and rural the GA will distribute the BSs only in the urban area, fig(2) shows the distribution of the BSs after the optimization .all the test pointshave been covered in this case .

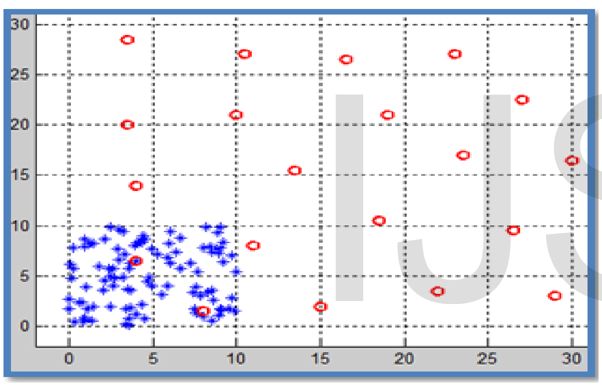

Fig. 1. the BS distribution before optimization

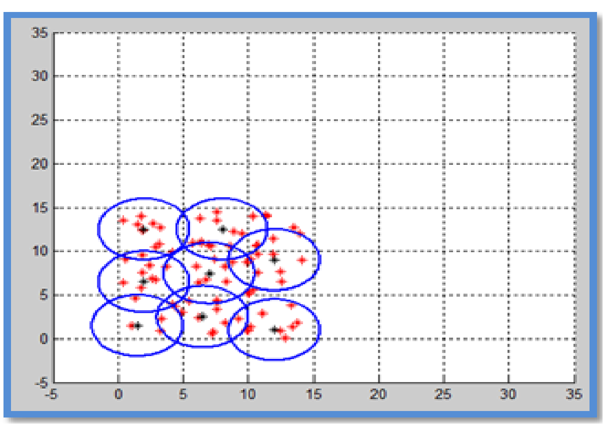

Fig. 1.the BSs distribution after optimization according to users density

5. conclusion

The GA was used to solve the BSs placement problem and the fallowing results were obtained :

Using three objectives fitness function (coverage , cost , superposition area) for optimizing the BSs deployment result in coverage maximization ,and reducing the superposition area and reducing the number of BSs which reduce the infrastructure cost .

Given area with different user densities the GA deployed the BSs depending on the users densities and not in the whole area. The execution time in this case was more than the previous one since the algorithm calculate link budget between the users and BSs with every iteration to find the cover rate parameter .

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