Optimizing the capacity of UMTS network using dynamic tilting of the sector antenna

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Abstract- Antenna tilting is one of the optimization parameters that affect the performance of the cellular networks by reducing the same and other cell interference and hence increasing the network capacity. In this paper the capacity of wide code division multiple access (WCDMA) system has been optimized using genetic algorithm (GA) by dynamically changing the shape and size of the sectors by changing the tilt of the antenna depending on the load of the users in each sector. The result of the optimization shows that the capacity of a network can be improved by dynamically changing the shape of each sector.

Index Terms— UMTS, mobile network, WCDMA, genetic algorithm, tilt angel

1 INTRODUCTION

Universal Mobile Communication System (UMTS) as a system is considers an evolutionary step for both voice and data calls of various transmission rates measured in kbps or Mbps. The main idea of UMTS is to be as dynamic as possible and to use system resources for different purposes; the capacity of WCDMA radio access is considers to be interference-limited since all mobile phones and neighbor base stations (BSs) interfere with each other in the both uplink and downlink directions [1]. Therefore, in a WCDMA radio network planning process, the main target is to plan the network in such a manner that other-cell interference is minimized in order to be able to maximize the system capacity [2]. The configuration of the base station antenna have a direct effect on the shape and size of the cell's coverage area and on the amount of interference radiated outside the cell coverage area. Hence, several requirements must be considered in the selection of the base station antenna. Finding the optimal configurations is a very complicated and time consuming task therefore optimization algorithms are needed to find the optimum configuration quickly and efficiently [3,4].

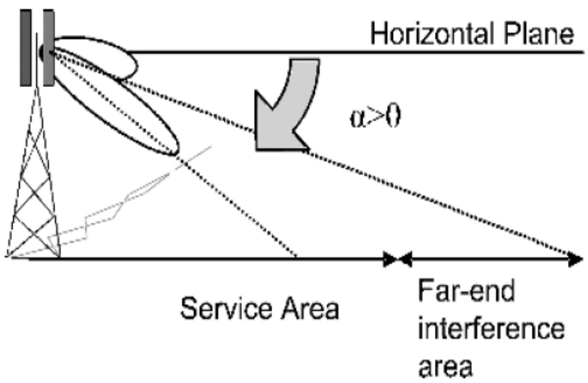
This paper organized as fallows; in section 2 the effect of antenna tilting angle is being discussed. In section 3 the number of users per BS is calculated. In section 4 the proposed methodology is being discussed, in section 5 the simulation result. In section 6 is the conclusion.

2 ANTENNA TILTING

The antenna tilt angel can be defined as the angle of the main beam of the antenna relative to the horizontal plane. The term down tilt is often used. [5] In the optimization of the antenna tilting the desired effect is to reduce the (i) ratio between the sectors.

$$i = \frac{i_{inter}}{i_{intra}} \quad (1)$$

Where (i_{inter}) is the other cell interference and the (i_{intra}) is the same cell interference.



3 SINGLE SITE CAPACITY

The number of users per BS can be calculated using load factor law; this law allows calculating WCDMA cell capacity without going to system level simulation, by Assuming that all users have the same traffic requirements [6].

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TABLE (1)

load factor parameters of WCDMA [7]

Parameter	Unit	Value
E_b/N_o	E_b/N_o requirement	5 dB
∝	Users Orthogonality	0.4
I	Other cell to own cell interference for six sectors	0.96
W	The chip rate	3.84 Mcps
Rj	Rate of user j	12.2 Kbps
V	Activity factor	0.67 for speech
η	Load factor	70%

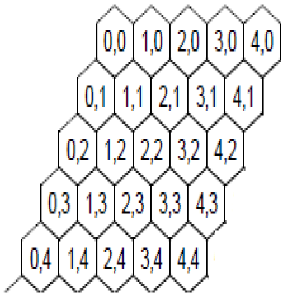

Fig (1) hexagon grid

4 PROPOSED METHODOLOGY

Before starting the optimization process a few assumptions have been made:

- Area with 25 cells, with radius 1 Km. each cell consist of six sector antenna (60°) for simplicity according to hexagonal characteristics.
- Shadowing and multipath fading in the radio channel have not been taken into account.
- The transmitting power is fixed.
- Without changing the tilt all the sector antennas have the same coverage area.
- Each base station has the same capacity and each user have the same traffic demand.
- Perfect uplink and downlink power control.

4.1 Cellular network model

Diamond-mesh grid network was created consist of 25 hexagons (5*5) fig(1) and fig(2) shows the geometry of hexagonal cells network .each hexagon is

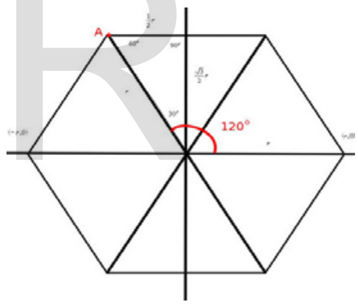

Fig (2) hexagonal geometry

Divided into six triangles each triangle represents one Sector the entire grid was bounded by circumference to prevent distributing the users outside the grid.

4.2. Users distribution

Users are distributed randomly within the cell sectors in the network since it's more realistic in real cellular network. each sector may contain more users than it can handles and other contain few users , the main target of the optimization in this case is to change both the shape and the size of the hexagons depending on the user distribution in order to maximize the number of served users. before optimization all sectors have the same shape when there is traffic congestion in certain sector and the opposite sector can provide service to number of unserved users ,the antenna of the first sector is tilted down to shrink the coverage and the antenna on the opposite side is tilted up to expand it coverage .Changing the shape of one cell can cause coverage gaps or overlapped areas so in order to avoid this with every change in one cell the opposite cell must change its shape also according to the change in the first cell. Since we are using GA for the optimization we are using the amount of shifting the radiation pattern as input to the algorithm in the initialization phase, values between (0%-60%) from the total radius are chosen randomly.

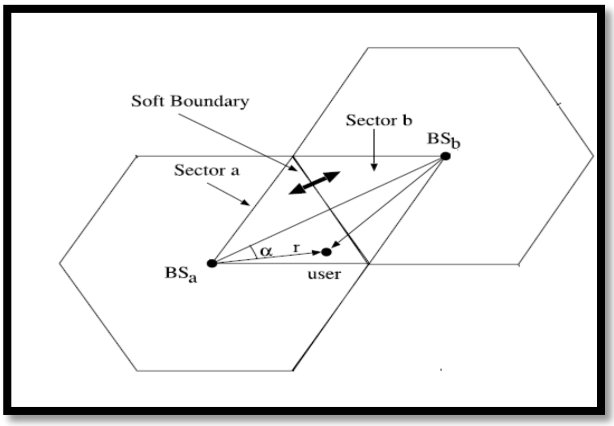

Fig (3) shows the boundaries between sectors before optimization.

4.3. Fitness function design

In this case the main goal of the optimization is to maximize the number of the served users by changing the shape of the hexagon so the main parameter of the fitness function is the number of served users .the algorithm gives the solution that give the highest number of the served users .each cell served the number of users calculated by the load factor if the number of users in this cell exceed this capacity then the distant users consider to be unserved .the summation of the powers of the BSs can be added as second objective to minimize the interference between cells but give a lower weight to it

$$\text{fitness} = \sum \text{served} - \text{users} \quad (2)$$

5. Simulation Result

TABLE (2)

RESULTS OF OPTIMIZATION WITH DIFFERENT MUTATION RATES.

Mutation probability	Total No. of users	Previous No. of served users	New No. of served users
0.01	1764	1670	1763
0.02	1764	1670	1756
0.03	1764	1670	1745
0.04	1764	1670	1746
0.05	1764	1670	1729

Table (2) shows the results of BSs antenna tilting optimization and how the number of served users was increased by changing the shape and size of the cells. The results also show that the lower the mutation probability the better the results are. The results show that the best mutation rate is 0.01 that give 1763 served users of a total 1764 with 120 iterations and 260 population size and 30 minutes execution time.

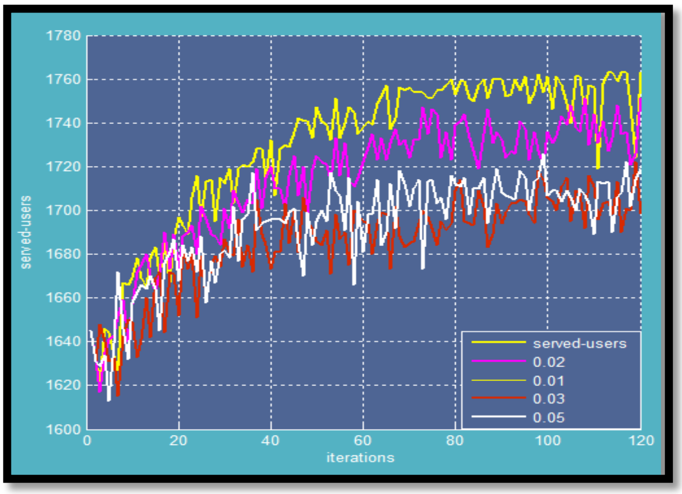

Fig (4) Fitness changing with different mutation probabilities.

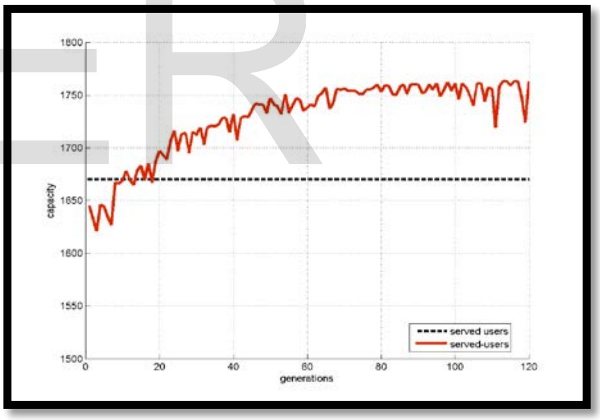

Fig (5) The number of served users before and after the optimization.

Fig (4) shows the change of the fitness with the iterations with different mutation rates, and it can be seen that 0.01 gives the highest fitness value. Fig (5) shows the system capacity before and after the optimization. Before changing the tilt, all sectors have the same configurations and the system capacity in term of served users reached to 1670. After the optimization the number of served users reached to 1763.

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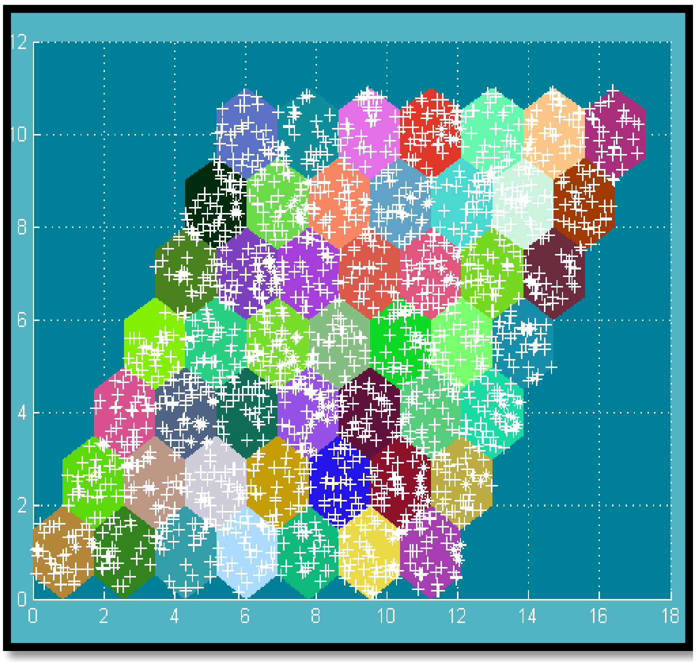

Fig (6) Cells geometry before the optimization.

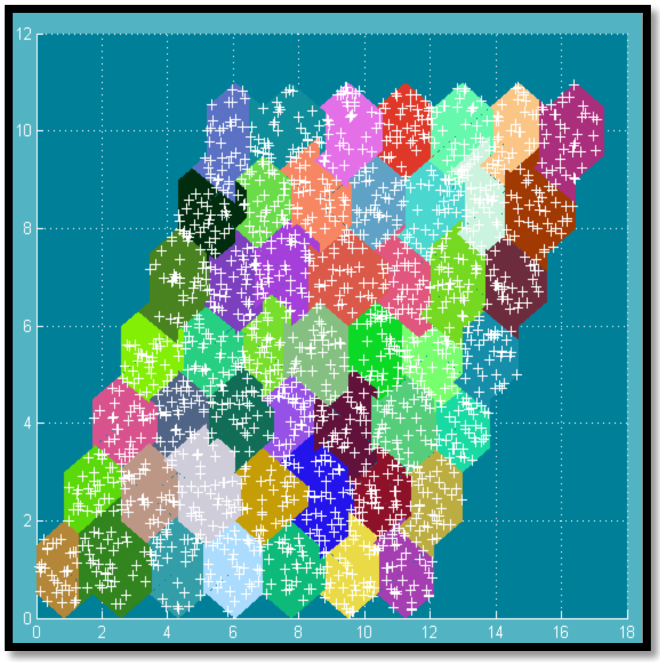

Fig (7) Cells geometry after the optimization.

Figure (6) and figure (7) shows the cells geometry before and after the optimization respectively. After the optimization the shape of the hexagons has been changed Changed. The small pluses represent the served users while the small stars represent the unserved users.

6. Conclusion

The GA was used to optimize the BS's antenna tilting to reduce the interference ratio (i) and to solve the problem of traffic congestion. With one objective fitness function (served users) the number of the served users increase to (1762) of a total (1764) by changing the shape of congested sectors.

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