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PLANNING AND OPTIMIZATION OF UMTS NETWORK RADIO LINK WITH LIMITED INTERFERENCE

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Abstract

Coverage and Capacity are significant issues in RF planning process for Universal Mobile Telecommunication System (UMTS). Radio link is interference limited and interference limited network is capacity limited. On the other hand, noise limited network are considered to be coverage limited. An important step towards mitigating this problem is to reduce interference by controlling channel power and re-configuring existing Base station(BS),so as to enhance Capacity and Coverage of a network. In this paper we propose an effective method for optimizing channel power along with maximizing the number of served users and minimizing the number of cell sites.

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Introduction

In cellular networks planning and optimization, parameters such as communication channel transmit power, level of interference, traffic type and distribution, soft capacity should be considered on priority. Optimizing the channel transmit power along with maximizing the number of several users and minimizing the number of cell sites [2].

The coverage problems in a network are defined by considering the signal level in each test point from all Base stations (BS) and our requirement is at least one level above a fixed threshold level. Network may be planned for signal quality rather than signal strength [1]. Selection of good Base station sites and channels will result in acceptable coverage performance at Base stations both in coverage area and in signal quality. Heuristic search method is to solve the maximal coverage location problem of transmitters. Maximizing coverage and minimizing transmitters may be archived by a Genetic Algorithm [10].

Capacity estimation is an important issue in performance analysis and call admission control and it is closely related to power control, strength based power control systems and signal to interference ratio (SIR) based power control system. The relationship between received power at a Base station (BS) and total other cell interference from users who are power controlled by other Base stations is derived for maximum capacity [11].

An economic design of network, a trade off between the cost of coverage and the benefit resulting from covering area is desired. This type of coverage model assumes a limited budget and includes this as a constant on the number .of facilities to be located. Thus, the optimization tries to place a fixed number of Base stations, so that the proportion of demand nodes covered by the cell within the permitted range is maximized. This may be explored using heuristic algorithm[12].

3G and 4G systems in addition to frequency planning involve various other parameters for making trade-off between coverage/capacity and service quality. These include communication power, interference level, traffic and soft capacity. An interference limited network is usually considered to be capacity limited. On the other hand, noise limited networks considered to be coverage limited [1, 13, 14].

Capacity and coverage calculation:

If there are N users in a cell and the signal is denoted by S then the interference can be calculated as I = (N - 1) S + η, where η is the back ground thermal noise. Hence the SNR is given by

$$SNR = \frac{S}{(N-1)S+\eta} = \frac{1}{(N-1)+\eta/S} \qquad (1)$$

Suppose the detector for each user can operate against the noise at an energy per bit-to noise power density level is given by E_b/N_0, whose numerator is obtained by dividing the desired signal power by the information bit rate, R, and dividing the noise (or interference) by the total bandwidth, W. This results in

$$E_b/N_o = \frac{W/R}{(N-1)+\eta/S} \qquad (2)$$

Where W/R is generally referred to as the "Processing gain" and the background noise determines the cell radius for a given transmitter power. The above equation can be written as the capacity in terms of number of users,

$$N = 1 + \frac{W/R}{E_b/N_o} - \frac{\eta}{S} \qquad (3)$$

That means, the number of users is reduced by the inverse of the per user signal-to-noise ratio (SNR) in the total system spread bandwidth, W. However, if the user is not speaking during part of the conversation, the output of the coder is lowered to prevent the power from being transmitted unnecessarily. This reduces the average signal power of all users and consequently the interference received by each user. The capacity is then increased proportional to this overall rate reduction. In order to attain an increase in capacity, the interference due to other users should be reduced. This can be done using antenna sectorization and monitoring of voice activity [13 , 14]. Thus with sectorization and voice activity monitoring factor α, the average E_b/N_0

$$E_b\big/N_o = \frac{W/R}{(N_S-1)\alpha+\eta/S} \qquad (4)$$

Where Ns, the number of users per sector and the interference to be that received by one sector's antenna. Now, consider interference from the jth user in neighboring cell k, then the ratio of other cell interference to the received signal strength at home base station is I/S [10]. Then equation (4) becomes

$$E_b\big/N_0 = \frac{W/R}{(N_S-1)\alpha+(I/S)\alpha+\eta/S} \qquad (5)$$

Where $(I/S) = (r_m/r_o)^m.(\xi_o-\xi_m)$, rm is the random distance to the corresponding home cell base station, ro is the distance to the neighboring cell, represent the shadowing parameter and m is the path loss exponent [14]. We can also write the above equation as

$$S = \frac{\eta}{\dfrac{W\big/R}{E_b\big/N_o} - (N_s-1)\alpha - (I/S)\alpha} \qquad (6)$$

Finally, the received power at the base station from the user1, is given by

$$S = S_1 - L_p - U \qquad (7)$$

Where S1 is the transmission power of the user, Lp is propagation path loss at distance d from the mobile station to base station and U is the shadow fading losses. From equations (6) and (7) we can build a relation among the received power, number of users and the coverage area.

Results and discussions:

A state-of-the-art planning is formulated by proposed solution method. System model incorporated here is considering a network with an area of m×n (km) which needs to be provided with coverage. Let us consider an Area, where the number of required sites (St) is made and the operators have a set of candidate sites; S= {S1, S2,..., St}. The cells need to provide coverage for a total number of Ut users in the area, according to the traffic model suggested in the dimensioning phase. Each cell operates at a power of P = {P1, P2,..., Pmax}.. We aim to minimize the cost associated with cell sites, by using the minimum number of cell-sites and maximize the revenue by increasing the number of served users. Hence, the objective function can be defined as:

$$\max\ F(f_1, f_2, f_3) = W_1 f_1 + W_2 f_2 + W_3 f_3 \quad (1)$$

Subject to:

$$W_1 + W_2 + W_3 = 1 \quad (2)$$

Where

$$f_1 = \frac{U_S}{U_t}, f_2 = \frac{P_t - P_u}{P_t}, f_3 = \frac{S_t - S_o}{S_t} \quad (3)$$

Here, Ut is the total number of users, Us is the number of served users, Pt represents total available power from all sites, Pu is total used power by all sites, St and So show the total number of sites and total number of "on" sites- in contrast to an "off" site, or a site that does not need to be deployed. W_1 to W_3 represent the weight associated with the parameter we would like to optimize. While Ut, Pt and St are fixed numbers in the system, we intend to find the sub-optimal values for U_s, P_u and S_o in a way that the objective function $F(f_1, f_2, f_3)$ is maximized.

Let us consider, for a rural area where each cell site is divided into three sectors, total area covered is 10X 10 km. Antenna height is 35 m and user height is 1.5 m and others data are:

U_t = 1000, U_s= 764, P_t = 3 db, P_u= 2.8 db, S_t=7 S_o=4

The simulated results are shown as:

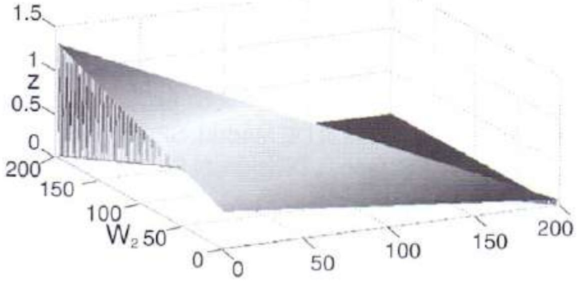
Let W_1 = 0 to 1;

W_2= 0 to (1-W1);

W_3= 1-(W1 +W2);

Then $Z = W_1 f_1 + W_2 f_2 + W_3 f_3$

$$Z = W_1(1.308) + W_2\ (0.066) + W_3(1 - \mathrm{W}_1 - \mathrm{W}_2)$$



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