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A QOS Aware Network Design for Future Wireless CDMA Networks

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Abstract: The aim of this study is to design a CDMA network that will increase the capacity of the entire network and decrease the amount of interference between the cells. The capacity of a single cell in a CDMA network depends on the number of simultaneous users that can be handled within that cell (intra cell interference), as well as on the interference of users in adjacent cells(intercell interference). Thus, the number of simultaneous users that can be handled within one cell depends on the number of simultaneous users in all the cells in the network. This interference limitation makes the cell placement in CDMA networks particularly difficult. The problem of placing cells in a region with a given user profile would require the calculation of the intercell interference which depends on the cell geometry, the transmit power levels of users and the number of users in the adjacent cells. This problem is not present in networks that use fixed channel assignment algorithms, wherein co channel interference is eliminated by using different frequency sets in adjacent cells, thereby separating the problem of cell placement and cell capacity, In such networks, the design rule of thumb is to place cells so that each will have a constant demand. Thus smaller cells are used in areas of high demand while larger cells are used in areas of low demand. In CDMA networks differing usage results in differing intercell interference, so a more efficient topology design is needed for CDMA networks.

Key words: CDMA networks, future wireless, QOS

INTRODUCTION

In[1-8] the authors shows that reverse-link capacity is increased considerably by soft handoff, but, at the same time, imperfect power control reduces it and compensates for the increase. On the other hand, forward-link capacity is decreased due to soft handoff and the reduction is shown to be more than the difference between reverse- and forward-link capacities. They believe that the overload in forward link limits the capacity of the system. From the above discussion, it is evident that among researchers, a consensus does not exist on whether the CDMA system capacity is reverse- or forward-link limited. However, the majority of the literature published on the subject is of the former view. In light of this, in this paper we consider the reverse-link capacity only.

In[9] they analyze both forward-and reverse-link capacity. They have shown that for an ideal power control and hard handoff case, reverse-link capacity limits the system capacity; however, the difference between forward and reverse-link capacities is not large. In[10] the performance of IS-95-based CDMA systems is studied in nonuniform and uniform traffic distribution with equal cell sizes. The elements that are investigated are the pilot channel chip energy to received signal power spectral density ratio, the forward link bit energy to noise power spectral density ratio and the reverse link bit energy to noise power spectral density ratio. Monte Carlo simulations are carried out under a hexagonal omnicell configuration to obtain statistics of capacity, handoff percentage and signal and interference levels.

PROPOSED WORK

The proposed works thus aims to design a CDMA network that has the maximum capacity and minimum interference between the cells. The proposed work aims to match cell design to user distribution for a given number of base stations based on the following factors such as

- CDMA network capacity calculation
- Reverse signal power and power control
- Pilot-signal power
- Base station location

The work describe a new network topology design technique for CDMA network that outperforms traditional

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techniques. In a CDMA network, the near-far problem necessitates power control, whereby the transmit power of mobiles is proportional to distance (from the base station) raised to the path-loss exponent. Typically, the power control scheme used in CDMA networks is signal level based, i.e., the power control equalizes the received power from the mobiles at the base station. Such a power control scheme is assumed this paper. In particular, SIR-based power control is not investigated.

When large cells are adjacent to small cells, users at the boundaries of large cells cause a lot of interference to users in small cells. This causes a significant reduction in the capacity of the small cells. To alleviate this problem, the nominal power of the mobiles in every cell is adjusted by a Power Compensation Factor (PCF) Since CDMA is interference limited, any decrease in the amount of interference translates into a capacity gain. Increasing the pilot-signal power of a base station increases the coverage region of that cell and thus increases the number of users and the intracell interference in that cell. However, it will decrease the number of users in the adjacent cells, thus decreasing the intercell interference on this base station.

In addition, changing the location of a base station changes the coverage region of that cell and the coverage regions of the adjacent cells. Thus, by controlling the transmitted pilot-signal power and adjusting the location of the base stations, the coverage region of each cell is controlled, which in turn controls the intracell and intercell interference. Given a fixed configuration of user distribution, we try to place a given number of cells in order to maximize capacity. The capacity of the entire network as a function of all the PCFs, the base-station locations and the transmitted pilot-signal powers was evaluated and present an optimization framework that allows us to maximize capacity.

Design rules are developed that can be applied to general user configurations (uniform or with hot spots). The design rules are validated by presenting comparative capacity results for networks that are designed by the proposed method versus those designed with traditional rules.

The proposed work firstly calculate the relative average intercell interference and then a network capacity is defined and sensitivity of capacity with respect to base station locations, pilot-signal powers and power compensation factors,then the optimization of capacity is performed. Thus a CDMA network with optimum capacity is designed that outperforms the traditional design rules.

CALCULATION OF INTERCELL AND INTRACELL INTERFERENCE

This part calculates the intercell interference of the mobile netwok. The calculation is done by using C language. Intercell and intracell interference is being calculated by considering two i an j cells and it assumes that each user is always communicating with and is power controlled by the base station that has the highest received power at the user. Let C_j denote the region where the received pilot-signal power from j base station is the highest among all base stations. A user located at coordinates (x,y) is at $r_j(x,y)$distance from base station j. Let n_j be number of users in cell j and A_j = Area(C_j), the area of cell j. The intercell interference is calculated by the following equation

$$I_{ji} = e^{(\gamma\sigma s)2} (n_j/A_j) \int\int (r_j(x,y)/r_i^{m}(x,y)) dA(x,y)$$

The above equation calculates the intercell interference at cell i caused by all users at cell j, for uniform user distribution. For non uniform user distribution ω (x,y),the relative average user density at (x,y) and thus the intercell interference at cell i caused by all users at cell j becomes

$$I_{ji} = e^{(\gamma\sigma s)2} (n_j/A_j) \int\int (r_j(x,y)/r_i^{m}(x,y) \omega(x,y)) dA(x,y)$$

CDMA NETWORK CAPACITY

Capacity of a network means the maximum number of users it can hold. This capacity is also done in C++ language. Initial capacity of the multicell CDMA network with spread signal bandwidth of W, information rate of R bits/s, voice activity factor of á and background noise spectral density of N_0 is considered. Assuming that the total number of M cells and also n_i users in cell i. The users in every cell must satisfy the following equation.

$$n_i + \Sigma n_j k_{ji} <= (W/R)/\alpha ((1/\Gamma) -(1/(E_b/N_0))) + 1 = c_{eff}$$
$$\text{for } i = 1,\ldots,M.$$

The energy to interference ratio denoted as E_b/N_0 .A set of users satisfying the above equations is said to be a feasible user configuration, i.e., one that satisfies the E_b/N_0 constraint.

For all cells equal capacity is defined as the requirement; each cell have an equal number of users i.e., n_i = n for all i. For the equal capacity case, the network capacity N is equal to M_n . The following equation is used to calculate the value of n .

$$n = \min [c_{eff}/(1 + \Sigma k_{ji})]$$

In general, for a given fixed configuration of user distribution, a feasible user configuration yields a network capacity N that is the solution to the following optimization problem subject to

$$\max \Sigma n_i$$
$$\text{subjected to } n_i + \Sigma n_j k_{ji} < c_{eff}$$
$$\text{for } I=1,\ldots,M.$$

The optimization problem is an Integer Programming (IP) problem. One technique to solve the IP problem is based on dividing the problem into a number of smaller problems in a method called branch and bound . Branch and bound is a systematic method for implicitly enumerating all possible combinations of the integer variables in a model.

SENSITIVITY ANALYSIS

Once the optimization problem is defined formulated the optimization problem that calculates network capacity, the effect of changing the transmission power of the mobiles, the pilot-signal powers and the locations of the base stations on this capacity will be investigated.

Sensitivity with respect to power compensation factors: Increasing the PCF of a cell increases the SIR of that cell, thereby increasing the capacity of that cell. On the other hand, it will also increase the interference into its adjacent cells, thereby reducing the capacity of those cells. Therefore, we wish to find the optimal values for the PCFs that will maximize the capacity of the entire network. The PCFs also provide flexibility in the allocation of capacity. By changing the PCFs, capacity can be exchanged between cells. In this work first we calculate the derivatives of the network capacity with respect to the PCFs and to use them in an optimization algorithm. These derivatives capture the effect of increases in the PCF of one cell on the capacity of the entire network. So optimum value of PCF will be found out.

If cell has a PCF β_j, its mobiles' signal powers have increased by a factor of β_j . And the interference becomes

$$I_{ji} = e^{(\gamma \sigma s)2} (n_j/A_j) \int\int \beta_j (r_j(x,y)/r_i^{m}(x,y)) dA(x,y)$$

The capacity of the network will be changing based on this interference

$$n = \min [\beta_i c_{eff}/(\beta_i + \Sigma \beta_j k_{ji})]$$

The derivative of new capacity with respect to PCF was be found out and it was used in the final capacity optimization.

Sensitivity with respect to transmitted pilot signal power: In a CDMA network, it is important to control the intercell interference. Increasing the pilot-signal power of a base station expands the coverage area of that cell, thereby increasing the number of users in that cell and thus the intracell interference. On the other hand, it will decrease the number of users in the adjacent cells, thus decreasing the intercell interference on this base station. The opposite effect takes place in the adjacent cells. The intercell interference into these cells increases and the intracell interference decreases. Therefore, we wish to find the optimal values of the transmitted pilot-signal powers that will maximize the capacity of the entire network.

Therefore, the optimal values of the transmitted pilot-signal powers that will maximize the capacity of the entire network is found out. Let the transmitted pilot signal power T_i. Here the derivative of interference with respect to T_m will be found out.

$$\delta c_i/\delta T_m = \Sigma (\delta c_i/\delta kk_i)/(\delta kk_i/\delta T_m)$$

It will be used for the final optimization of capacity.

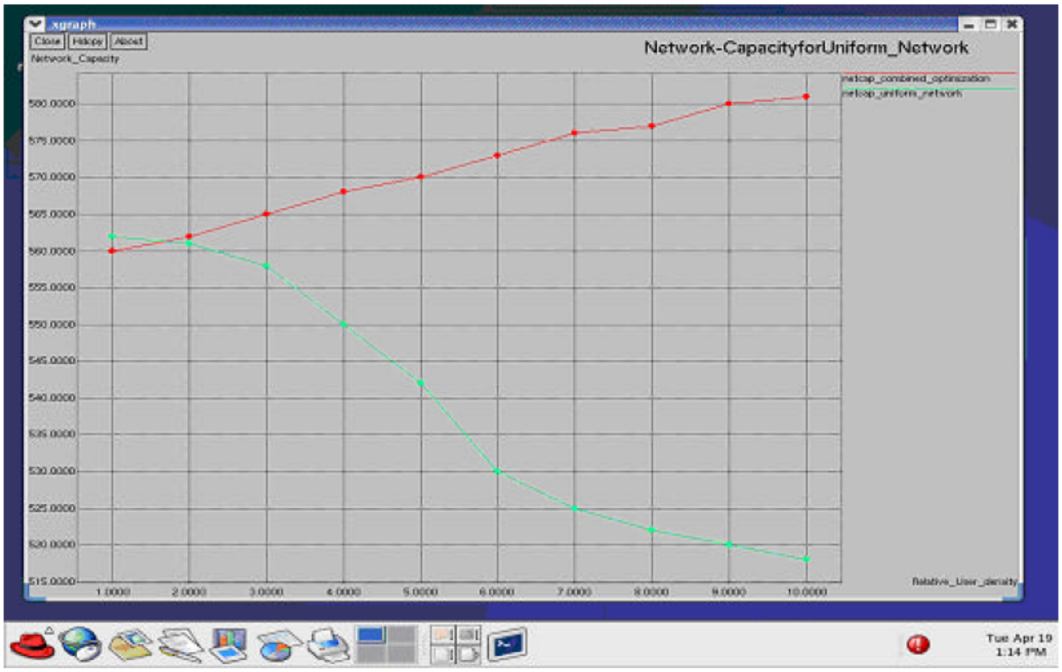
Sensitivity with respect to base station location: Another way we can control the intracell and the intercell interferences is by controlling the locations of the base stations. Changing the location of a base station changes the coverage region of that cell and the coverage regions of the adjacent cells. Thus, we wish to find the derivatives of the network capacity with respect to base-station location and use them in an optimization algorithm.Let the base station capacity be L_m. Here the derivative of capacity with respect to L_m will be found out.

$$\delta c_i/\delta L_m = \Sigma (\delta c_i/\delta kk_i)/(\delta kk_i/\delta L_m)$$

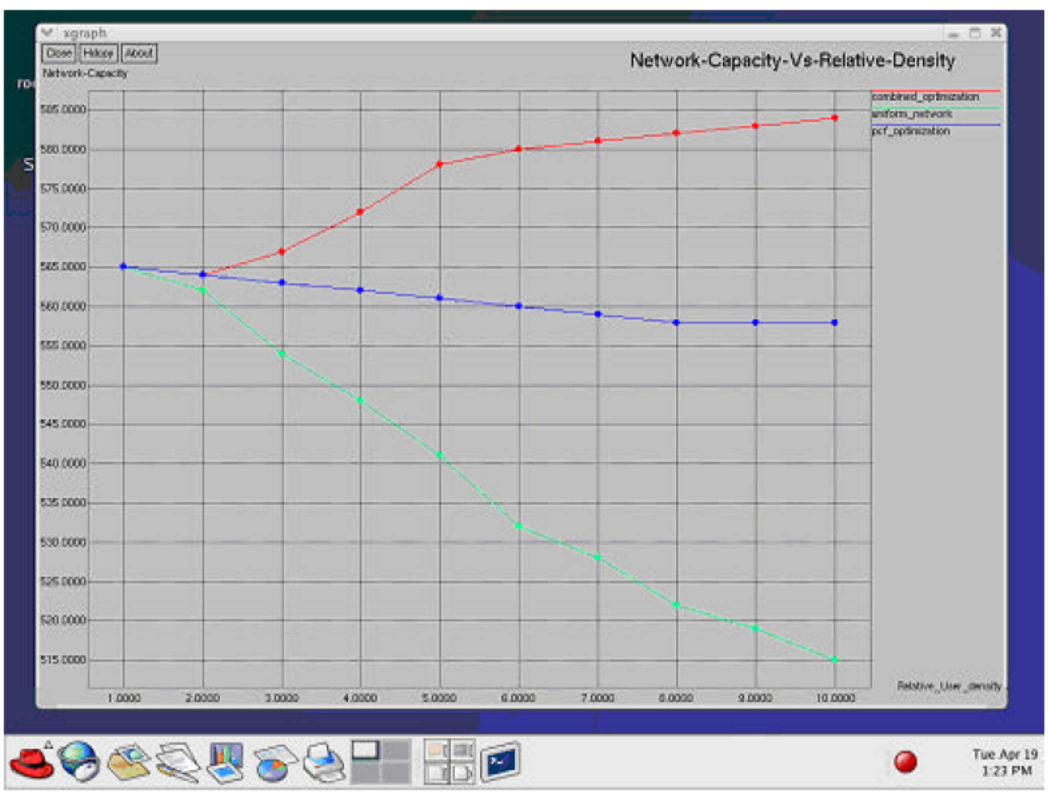
It was used in the final optimization problem.

RESULTS AND DISCUSSION

The calculation of CDMA network capacity is done after the calculation of intercell interference. For that the value of Γ (bit energy to interference ratio threshold) and W/R (bandwidth to information bit rate) are assigned to 9.2 dB and 21.1 dB respectively. The capacity should be always less that the number of effective channels. The Graphs 1 and 2 shows the results of this work. Finally the sensitivity analysis is done on this capacity based on the optimization algorithm which was developed considering the sensitivity of base station location , pilot signal power and transmission power of the mobiles.



Graph 1: Network capacity for uniform network



Graph 2: Network capacity versus relative density

CONCLUSION

This study shows that the capacity in a CDMA network can be increased by varying the transmission power of the mobiles, the pilot-signal powers and the base-station locations. The derivative of the network capacity with respect to pilot-signal powers, base-station locations and power compensation factor is calculated. These derivatives are then used in an optimization procedure to maximize the network capacity. The results confirm that for a uniform user distribution, a uniform network layout with equal-sized cells is optimal. For a nonuniform distribution, more cells need to be located inside the hot-spot cluster. If pilot-signal power is the only variable parameter, then an increase in pilot-signal powers of congested cells increases network capacity. Even though the intracell interference increases, a greater reduction in inter cell interference is achieved, which yields an increase in the overall capacity. A constrained optimization problem is constructed and solved, which guarantee a minimum capacity for every individual cell while maximizing the total network capacity. These results indicate that including a hard constraint on the minimum capacity of individual cells has little effect on network capacity given the flexibility of optimizing the transmission power of the mobiles, the pilot-signal powers and the location of the base stations. However, without such flexibility, the hard constraint on cell capacity imposes a significant penalty on network capacity. The network design technique introduced accommodates post deployment design changes in response to changes in demand, particularly by changing the PCFs and the pilot-signal powers.

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