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Design Characteristics of Soft Handoff in Uplink Two - Tier CDMA System

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***Abstract* — Wireless operators often encounter small region of dense user's traffic with a large coverage area (Macrocell).This paper studies a problem in smaller region coverage with high capacity (high density population) is little active. The Overlay is small cells tessellate almost all of the coverage area of the large (Umbrella), and the Hotspot smaller region coverage area with high traffic which needs low power and low cost units mounted on side of buildings. A large user capacity means that system supports a large of users per unit bandwidth which in turn implies higher revenues per unit cost (spectrum). In CDMA using uniquely code each user and frequency fixed using soft handoff in this system mean break old channel to call after transfer to new channel to new cell .Our simulation results demonstrate 40% increase user capacity compared to hard handoff.**

***Key Words*—Cellular System, CDMA, Microcell, Soft Handoff**

I. Introduction

Code Division Multiple Access (CDMA) is one of the multiple access methods employed by Cellular Systems in the world wide. It is therefore, an important multiple access scheme for which to understand the performance of the two – tier architectures. The alternative is to allow macrocell and microcell to share the same frequencies. Macrocell has problem in smaller coverage region with high density population (Ph). It needs high power and cost, microcell solve the problem of low power and low cost. Microcell is very active with smaller coverage area and embedded within macrocell. Both share the same frequency [1] – [5], [10], and [6]. We study the characteristics of soft handoff in two – tier CDMA system. Microcells are of two types; first type is Overlay small cells like tessellate that cover almost all the coverage area of the large (Umbrella). But it does handoff only within same tier. Second type is Hotspot embedded within macrocell which provide coverage area only to smaller regions where there are large number of users. Hotspot microcell base station can coordinate with macrocell base station to allow handoff between tiers [13], [11]. CDMA supports soft handover because of the use of constant frequency for all the network in this mobile will not need to change frequency with base station, but it only check whose pilot's signal is the strongest and select it by power constraints. [11], [13], [12]. The two –tier consists of Macrocell and Microcell.

- **Macrocell**: is Traditional system having radio cell anywhere between (1Km – 10 Km). The base stations are cost antenna and the height of towers antenna is greater than 30m.
- **Microcell**: is smaller embedded cell within macrocell having radio cell less than 1Km. The base stations are low cost antenna tower and the height of towers antenna is approximately 10m.

We show how to compute the hard handover and soft handover by Exact and Approximate 1&2 methods, for single macrocell /single microcell, and account for random user's locations. We have varied the distances, propagation effects path losses and SINR (signal to interference – plus noise – ratio) which is very important [7], [8], [9], [10]. The assumption describes the system geometry, propagation, processing assumptions, and then analysis and discussion on exact analysis method and approximate 1& 2 methods, [6], [7].

II. Assumptions

In this system, we have assumed a region of space R over which the distribution of user terminals are known. We have also assumed macrocell base station of antenna of height h_t.

$$G_M = 20log10\left(\frac{h_t}{200}\right) \quad 30 \le h_t \le 10 \qquad (1)$$

G_M is antenna gain for BS macrocell

$$G_\mu = 20log10\left(\frac{h_\mu}{3}\right) \quad 3 \le h_\mu \le 10m \qquad (2)$$

G_μ is antenna gain for BS microcell [7].

$$G_r = 10\ log1o\left(\frac{h_r}{3}\right) h_r \le 3 \qquad (3)$$

G_r is antenna gain for MS, and hr mobile station antenna is 1.5m [7]. We utilize Cartesian coordinate (x, y) to describe locations in this system. The macrocell BS is placed at origin point and the microcell BS is placed at distance D from macrocell, as shown in figure 1. We haveassumed that the coordinates are chosen such that microcell lies on axis at point (D, 0), by varying distances with different path losses. The system users desire rate R and use a processing gain of W/R, where W is the system bandwidth. We assume that the potential users are made of two types of populations: first, low density population [LD] user, distributed uniformly over the entire coverage region, secondly, high density population [HD] users distributed an over small square is s<<S where s is space of microcell and S is space of macrocell. We denote Ph[Probability Hotspot Density], that a randomly selected users from the HD population. The probability that a user is from the LD population is (1-P_h) =q, [1], [8], [9], [12].

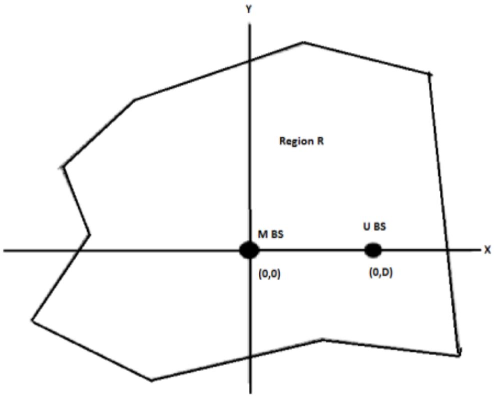

Fig.(1):- An example of the region R, with macrocell BS and microcell BS denote the macrocell BS and microcell BS respectively [9].

2.1 Propagation, Noise & Power Constraints

We have assumed that a signal transmitted at power Pt and transmission gain of the received power Pr (d) at the output of the RAKE receiver according to change in the distance.. The general formula for this is as given below by equation 4.

$$\Pr(d) = \begin{cases} H(\frac{b}{d})^2\gamma, & d \le b \\ H(\frac{b}{d})^4\gamma, & d > b \end{cases} (4)$$

Where Pr (d) is the received power, b is breakpoint distance for the macrocell and the microcell (b_M $=b_\mu$=b=100m). H is proportionally constant, that depends on wavelength, antenna heights and gain of antenna [8], [9], [13] that is-

$$H = G_\mu . G_r . \frac{\lambda}{4\pi b} (5)$$

Where $G_r$gain is for Mobile Station, G_r is gain antenna received λ wavelength for frequency= 900MHZ,γ is lognormal shadow fading $10^{\frac{x}{10}}$. The path loss depends on the distance between base stations and users' current position in the cell. If σ Standard deviation, γ for microcell path losses change in the range between(2.7 – 3.5) d B [7]. This is given as additive white Gaussian noise (AWGN) whose spectral power density noise bandwidth = 0.25 which is assumed to be the same for both bases that is microcell and macrocell [12]. $P_{min}$is minimum received power level P_{min}= -110.5 dBm, P_{out} =P_r (d) <P_{min}.[7].

$$P_{out} = 1 - Q\left(\frac{P_{min} - P_r(d)}{\sigma}\right) (6)$$

Where

$$\sigma = \sqrt{\sigma M^2 + \sigma\mu^2}\ (7)$$

Where P_{out} is outage probability under path loss and shadowing σM = 8 dB is standard deviation of macrocell and σU = 4 dB is standard deviation of microcell.P_h=$Q\left(\frac{P_{min} - P_r(d)}{\sigma}\right)$, P_h is Probability hotspot density, P_L= (1-P_h) is probability low density population .P_{inf} (N)=0.05 infeasible error (probability of error), N is number of users [7], [9], [13].

III. ANALYSIS AND RESULT

In the following section we have discussed on the mean interference (f) from adjacent cell in the case of hard and soft handoff. It has been shown that the effect of change in frequency and effects the change path loss.

3.1Hard Handoff in Two – tier CDMA System using mean interference value of f=2.38:-

The users transmit power with Pi which is of same capacity as we have used in exact method in uplink but with phase (0,2π) .The output streams at the macrocell and microcell bases are weighted by w_M and w_μ , respectively, and then summed after combining the overall output is signal interference noise ratio SINR of users [6],[7], [9],[3],[12].

$$\boldsymbol{SINR_i} = \frac{s_{i\frac{W}{R}}}{|WM_i|^2 IM_i' + |W\mu_i|^2 I\mu_\mu'} (8)$$

One method of estimating the capacity is to determine the probability that a CDMA channel doesn't have sufficient bandwidth to accommodate a mobile station for a given frame interval and still satisfy the interference constraints .This event is referred to as outage .During an outage of the reverse radio channel, the value of thermal noise bandwidth (η) which corresponds to range SINR between (6 d B and 10 d B), the equation shown below as used for calculation of average call ratio (λ) of entire system.

$$\frac{\lambda}{\mu} \cdot v \cdot (1 + f) = \Delta r \cdot F(B, \alpha_c) (9)$$

Where 1/μ is average call duration, v is voice activity factor v=0.4

$$B = \frac{Q^{-1}(Pout)^2}{\Delta r} (10)$$

and, $\Delta r' = \frac{Gp}{SINR}(1 - \eta)$

$$Gp = \frac{W}{R},\ RisDatabitrate$$

$$\boldsymbol{F(B, \alpha c)} = \frac{1}{\alpha c}\left[1 + \frac{\alpha_c{}^3 B}{2}\left(1 - \sqrt{1 + \frac{4}{\alpha_c{}^3 B}}\right)\right] (11)$$

Where α_c is Power control accuracy,

$$\alpha_c = e^{\frac{(\beta\sigma c)^2}{2}}, \beta = \frac{ln10}{10}$$

$\sigma_c$is standard deviation with lognormal distribution σ_c=2.5 dB [6]. CDMA transmissions in neighboring cells uses the same currier frequency .and therefore, causeinterference that accounts by introducing a mean interference factor. This reduces the number of users in a cell due to the other user mobile in the user's cell [6]. To calculate the numbers of users supported by this method have used equation (12) given below:

$$N = \frac{\lambda}{\mu} \cdot 3\ sectors \qquad (12)$$

The maximum number of users supported at the P_h =0.5. To take increasing to maximum between the values (0.4-0.6). As the SINR value is small so the capacity is higher for all values of Ph in Hard handoff as shown in curve 1 at the figure 2. Hard handover take more chance to dropping calls [6].

3.2 Soft Handoff in Two – tier CDMA System using mean interference value of f=0.77 Exact Method:-

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According this method, the mean interference (f) is of low value between neighboring cells. Traditionally soft handoff equations are developed when mean interference is of value f=0.77. From figure (2), it can be seen that curve 2 shows that when all values of Ph is at maximum P_h= 0.5, the capacity (i.e number of users) between the probability hotspot density range between 0.4 to 0.6 are higher, so the performance of the CDMA system is improved more than that of hard handoff as the chance of call drop is very less. Therefore through this method a 40% capacity improvement can be seen against hard handoff.

3.3 Soft Handoff in Two – tier CDMA System using mean interference value of f=0.57 Approximation 1 Method:-

This method of soft handover is better than the exact method. This can be analyzed when system the uses mean interference (f = 0.57) for neighboring cells, and standard deviation (σ_c = 2.5) to obtain power control accuracy (α_c = 0.6959). As observed from the curve 3 in figure (2), the number of user capacity is of maximum value at P_h=0.5 .This method increases the capacity by 40% as compared to hard handoff and 10% by exact method.

3.4 Soft Handoff in Two – tier CDMA System using mean interference value of f=0.57 Approximation 2 Method:-

This analysis method is developed by expressing the value of standard deviation equal to zero. Therefore thepower control accuracy (α_c)becomes one. Now equation (11) becomes-

$$F(B,\alpha_c) = [1 + \frac{B}{2}(1 - \sqrt{1 + \frac{4}{B}})\ ] \quad (13)$$

According to this method we obtain the maximum number of users at P_h =0.5 as shown curve 4 in figure (2). This method increases user capacity by 15% more as compare to soft handoff approximation 1method.

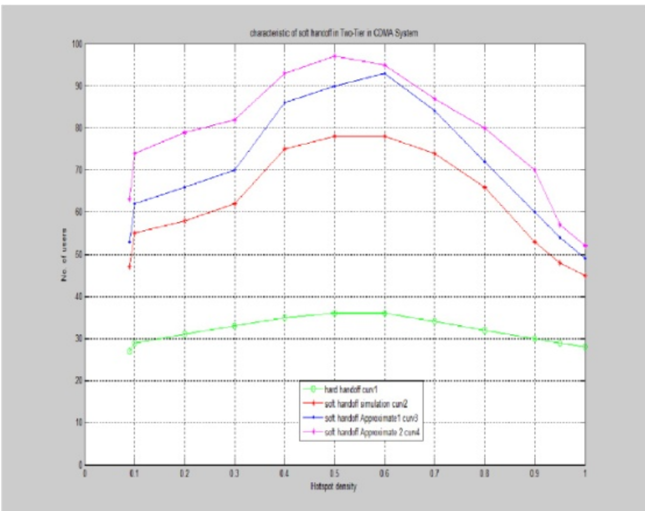

Figure (2) the result for simulation this system by MATLAB software

IV. CONCLUSION

The main objective of the work is to increase the capacity that is the number of users in Two – Tier CDMA system with fixed bandwidth (1.25MHZ) by multiple accesses. The focus was on the design characteristics of soft handoff in two – tier CDMA system by computing two analysis methods i.e Exact analysis method and Approximation analysis method. 40% improvement in result has been achieved by exact method compared to hard handoff in two – tier CDMA system. The Approximation 1 analysis method brought in the improvement by 10% against the exact analysis method when using power control accuracy (α_c = 0.6959). It was observed that the Approximation 2 analysis method is the best method giving improved result as compared to the Approximation 1 analysis method by 15% and the hard handoff by 55% .This method has brought maximum number of users with the probability hotspot density at (Ph=0.5) in soft handoff in two – tier CDMA system. The users can move between multiple base stations during the progress of their conversation in macrocell or microcell without dropping calls.

W/R	128		-	-
Γ_M	7dB		Γ_μ	7 dB
P_M	100m		P_μ	100m
H_M	$10H_\mu$		X0	300m
σ_M	8dB		σ_μ	4 dB
s	200m		S	1km

Table (1) Assumption for the system

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