International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May-2013 1524
ISSN 2229-5518

Coverage and Capacity Enhancement in CDMA systems using Antenna array over in Ricean Fading Channels

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Abstract— One of the most promising techniques for increasing capacity in CDMA system is through the use of antenna array. There are a lot of different ways to calculate capacity of CDMA system. Some of them are quite simple and has an explicit form. The paper introduces to the capacity and coverage in asynchronous Code Division Multiple Access CDMA 2000 based system. Different channel scenario is applied; for the AWGN we use 1 and 4 element antenna arrays to calculate the capacity against coverage assuming different path losses. While as for Ricean fading environment we use 1,4,9 and 16 - antenna elements to drive an expression for the signal to Interference plus Noise ratio (SINR) as a function of the number of users (K), number of antennas (Na) and signal to noise ratio levels (SNR). The analytical results will be verified by means of MATHCAD softwear package.

1 Introduction

THERE are various emerging technologies used to improve the capacity of CDMA systems like sectorization, voice activity services, antenna array and Interference cancellation. The latter two techniques are particularly suitable for enhanced uplink performance since the additional complexity they require is concentrated at the base station. Both antenna array and interference cancellation (IC) receivers can be deployed to enhance the cell capacity i.e. number of users in a cell. The capacity can be enhanced by using antenna array (structure of 2, 4 and 9) and by using IC receivers [1]. The CDMA system performance is limited by interference. The simple strategy of switching to the strongest signal to extracting maximum signal power from the antennas is not appropriate as it can lead to signal enhancement of an interferer rather than that of the desired user.

The analysis in this paper does not take diversity effects into consideration. The fading on the channels to each of the antennas is assumed to be completely correlated. In a real system, depending on how the antennas are configured and the propagation environment, there is usually some decorrelation between the channels of the different antennas. In the uplink, such decorrelation between receive channels gives additional uplink capacity and coverage beyond what is presented here.

A derivation of the system capacity- will be carried out and then applied to the case of a linear antenna array ranging from one to four array elements. The benefits of using antenna arrays to increase system capacity- will be exhibited [2,3].

The paper is divided into different sections. In section 2, a system model for CDMA system is presented which gives the basic capacity equation in terms of number of users. In section 3, Analytical System uplink capacity and coverage will be investigated; accordingly the modification of the basic capacity equation is presented; as well as the capacity calculations for single antenna element and multiple antenna element. In section 4, analytically determine the performance of the CDMA system using single and antenna array over Recian fading channel. Finally, the conclusion is presented in section 5.

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2 System Model

We consider the baseband equivalent model for asynchronous CMDA 2000 system with K users in the Uplink. It is employing normalized modulation wave forms $S_1(t)$ $S_2(t)$….. $S_k(t)$ The transmitted signal $S_k(t)$ of the k^{th} user and that the receiver is equipped with a Uniform Linear Array (ULA) antenna with inter element distance "d". The transmitted signal by the k^{th} is given by:

$$S_k(t) = W_m^k(t)a_I^k(t)\cos(\omega_c t) + W_m^k(t)a_Q^k(t)\sin(\omega_c t) \quad (1)$$

where $W_m^k(t)$ is the m^{th} QPSK Walsh Symbol (m =1, 2, . . ,M = 4) of the k^{th} user, $a_I^k(t) = a^k(t)a_I(t)$ and $a_Q^k(t) = a^k(t)a_Q(t)$ are the products of the user PN sequences and the I and Q channel PN codes, $a_I(t)$is the In-phase (I) channel spreading sequence, $a_Q(t)$ is the Quadrature (Q) channel spreading sequence , $a_k(t)$ is the k^{th} user long code sequence, $\omega_c = 2\pi f_c$ and f_c is the carrier frequency. The transmitted power of each user is assumed unity [5].

We consider a parameterized vector model to characterize the wireless channel; such channel is assumed to be Ricean

Channel Model between a single antenna at the mobile station (MS) and a ULA at the BS. We assume Line Of Sight (LOS) propagation between the MS and BS. In this paper, we do not consider temporal diversity, i.e. we assume that the number of multi paths is equal to one. The channel impulse response for k^{th} user at the n^{th} antenna, is given as

$$h^{k,n}(t) = \sqrt{\frac{K_R}{1+K_R}}\, h^{k,n}_{LOS}(t) + \sqrt{\frac{1}{1+K_R}}\, h^{k,n}_{NLOS}(t) \quad (2)$$

Where K_R is the Ricean factor which is defined as the ratio of the specular power to the diffused or scattered power, $h^{k,n}_{LOS}(t)$ and $h^{k,n}_{NLOS}(t)$ are the specular and scattered components respectively given by

$$h^{k,n}_{LOS}(t) = e^{[j(\phi^k_o + 2\pi . f_D . t . \cos\theta^k)]}\; e^{[-j.r.d.(n-1).\sin\theta^k]} \quad (3)$$

$$h^{k,n}_{NLOS}(t) = \frac{1}{\sqrt{S}} \sum_{s=1}^{S} e^{[j(\phi^k_S + 2\pi . f_D . t . \cos\psi^k_S)]}\; e^{[-j.r.d(n-1).\sin\theta^k]}$$

where k = 1, 2, . . . , K is the user index, n = 1, 2, . . . , N_a is the antenna index, S is the number of sub-paths for each resolvable path, r = $2\pi/\lambda$ is the wave number, f_D is the maximum Doppler frequency which is the ratio of the mobile velocity (v) and the wavelength(f_D=v/λ); ϕ^k_0 and ϕ^k_s are the random phases, assumed to be uniformly distributed over [0, 2π], θ^k is the mean angle of arrival (AOA) and ψ^k_s is the Angle of Departure (AOD) for each sub-path relative to the motion of the mobile, modeled by a uniform probability density function [4]. Rewriting Eq. (2), we have

$$h^{k,n}(t) = \beta^{k,n}(t) e^{-j\varphi^{k,n}(t)} \quad (4)$$

Where $\beta^{k,n}(t) = |h^{k,n}(t)|$ is the modulus of the complex Ricean channel amplitude, while as the parameter $\varphi^{k,n} = \arg\{h^{k,n}(t)\}$ is the phase of the carrier of the k^{th} user at the n^{th} antenna. This parameter includes the effects of fast fading, the difference in propagation delays (between antennas) and the phase difference (between the transmitter and the receiver carriers). In vector notation, the spatial signature or channel response vector for the k^{th} user can be expressed as $N \times 1$ vector as [11]:

$$h^k(t) = [h^{k,1} h^{k,2} \ldots h^{k,N}]^T \quad (5)$$

Where $(.)^T$ denotes transpose operation. The total received signal at the n^{th} antenna is given by:

$$x_n(t) = \sum_{k=1}^{K} [\beta^{k,n} W^k_m(t-\tau^k) a^k_I(t-\tau^k)\cos(\omega_c t + \varphi^{k,n}) + \beta^{k,n} W^k_m(t-\tau^k) a^k_Q(t-\tau^k)\sin(\omega_c t + \varphi^{k,n})] + \eta_n(t) \quad (6)$$

Where τ^k the path is delay, and $\eta_n(t)$is the noise which is assumed to be Additive White Gaussian Noise (AWGN).

3 Coverage and Capacity Analysis for Antenna Array

In this section we will introduce to the relation between coverage and number of antenna array assuming additive white Gaussian noise channel AWGN. The system used is An antennas array is used to enhance received signal-to-interference noise ratios (SINR) and may also be considered as forming beams for transmission. Likewise, switched beam systems use a number of fixed beams at an antenna site. The receiver selects the beam that provides the greatest signal enhancement and interference reduction.

A single antenna can also be constructed to have certain fixed preferential transmission and reception directions: today many conventional antenna systems split or "sectorize" cells. Sectorized antenna systems take a traditional cell area and subdivide it into "sectors" that are covered using multiple directional antennas sited at the BS location. Sectorized cells can improve channel reuse by confining the interference presented by the BS and its users to the rest of the CDMA systems. An antenna array will attempt to increase gain based on the user's signal as received at the various elements in the array.

3.1 Uplink Coverage Analysis

As a basis for the analysis of the effect of uplink capacity of coverage we can use the following formula for the received bit energy per power spectral density of the thermal noise plus interference, E_b/N_0 [3, 6]:

$$PG = \frac{[F.N_{th}.B + Va*(1+Ii).(K-1).Si](E_b/N_0)}{N_a * Si} \quad (7)$$

Where: PG : processing gain, E_b : bit energy, N_0 : power spectral density of thermal noise plus interference, F:is the noise figure of base station, N_{th} : power spectral density of the thermal noise, Si : received signal strength per antenna ,Va : voice activity factor, Ii : intercell interference factor, K : number of users in the cell, B : system bandwidth, Na : number of antennas. After some mathematical manipulation we can use equation (7) to express the capacity of the cell as:

$$K = 1 + \frac{N_a*PG}{Va*(1+Ii).SNR} - \frac{FN_{th}B}{Va*(1+Ii)Si} \quad (8)$$

Where SNR is the required (E_b/N_0). Assuming

$$N_{pole} = 1 + \frac{N_a*PG}{Va*(1+Ii).SNR} \quad (9)$$

Then we get: $K = N_{pole} - \frac{F.N_{th}.B}{Va.(1+Ii).Si}$

Where N_{pole} is the pole capacity, The pole capacity is the theoretical maximum capacity if the mobiles have infinite transmits power available. Note that the pole capacity is proportional to the number of antennas. The practical capacity is therefore typically a fraction of the pole capacity [3]. After some mathematical manipulation for equation (9); the required received signal energy per antenna "Si" can be expressed as:

$$Si = \frac{F.N_{th}.B}{N_{pole}.Va*(1+Ii).(1-K/N_{pole})} \quad (10)$$

Assuming that the user terminals have a limited power, Pt, and assuming path loss with a path loss exponent of "L" we can express the cell radius R as [7]:

$$R = r_0 * \left(\frac{P_t}{Si}\right)^{1/L} \quad (11)$$

Where r_0 is a constant, Given that the area (A= $R^2\pi$), of the cell is proportional to the cell radius squared and using equations (10) and (11) we can derive the relation :

$$A^{-L/2} = Z.\frac{1}{N_{pole}-K} \quad (12)$$

Where Z is a constant. If we approximate Npole as being proportional to Na (i.e. neglecting the "1" in equation (9)), assuming a nominal pole capacity of 1 when Na = 1 and absorbing the constant Z into a normalized coverage area, we can rewrite equation (12) as:

$$A^{-0.5L} = Z.\frac{1}{N_a - K} \quad (13)$$

We can now express the uplink normalized capacity K as a function of the normalized coverage area "A:, the number of antennas at the base station "Na", and the path loss exponent "L" as :

$$K = N_a - A^{0.5L} \quad (14)$$

For a given number of antennas and a given path loss exponent there is thus a trade-off between coverage and capacity. Figure 1 plots these trade-offs for one and four antennas (Na = 1, 4), with a path loss exponent of 2.7. The CDMA system is normally operated at a certain fraction of its maximum capacity (the pole capacity). To see how the coverage area increases we can divide equation (14) by Na, introduce the per antenna loading factor, $\mu = Na/K$ and rewrite it as:

$$A = (1-\mu)^{2/L}.N_a^{2/L} \quad (15)$$

Now, as μ remains constant, the coverage area gain for constant loading is given by:

Constant loading coverage area gain $=(N_a)^{2/L}$ (16)

4 BER Performance Analysis over Rican fading channel

To analytically determine the performance of the CDMA system, we follow the approximation procedure proposed in [5, 8]. The approximation proposes to adapt the single antenna performance bounds to array antenna systems by manipulating those terms in the error probability formulas for single antenna receivers that account for the noise and multiple access interference (MAI). The procedure divides the number of interferers into two categories − in-beam and out-of-beam- based on whether their direction of arrivals lie inside or outside the beam formed toward the desired user. The attenuation provided by the array antenna to each of the out-of-beam interferes is assumed to be constant. The in-beam interferers are counted as interference while the out-of-beam users increase the additive noise level for the evaluation of the error probability.

4.1 Performance Analysis-1D RAKE Receivers

Following [5], it can be shown that for a single antenna in Ricean fading environment, the noise terms N_I^K and N_Q^K can be modeled as mutually independent zero mean Gaussian random processes with variance: $\sigma_N^2 = N_0/2$; Similarly, the MAI terms M_I^K and M_Q^K can be modelled as a zero mean Gaussian random processes with variance:

$$\sigma_M^2 = {E_S}/{3N_c}\sum_{k=2}^{K} E\left[(\beta^k)^2\right] = \frac{E_s}{3N_c}(K-1)$$

where $E_s = E_b.\log_2(M)$ is the symbol energy, E_b is the bit energy, $N_c = 64$ is the spreading factor and the total path power for each user is normalized to unity. The total variance is a sum of squares of two Gaussian random variables, each with variance:

$$\sigma_T^2 = \sigma_N^2 + \sigma_M^2 = N_0/2 + (E_s/3N_c).(K-1)$$

The SINR can thus be written as:

$$\rho_{1D} = \frac{E_s}{2\,\sigma_T^2} = \frac{\gamma\,.N_0}{2(\frac{N_0}{2} + \frac{\gamma}{3}\frac{N_0}{N_c}.(K-1))} = \frac{\gamma}{1+\frac{2\gamma}{3\,N_c}(K-1)}$$

$$=(3\,\gamma\,N_c)\,/\,3\,N_c + 2\,\gamma\,(K-1) \quad (17)$$

Where $\gamma = E_s/N_0 = (E_b/N_0).\log_2(M)$

It can be shown that the mean bit error probability for a conventional 1D-RAKE receiver (i.e. single antenna) in Ricean fading is given by [6]:

$$P_b^{1D}(e) = \frac{M/2}{M-1}\sum_{q=1}^{M-1}\binom{M-1}{q}\frac{(-1)^{q+1}}{(1+q+q\delta_1)} \times \exp\left(\frac{-\delta_1}{(1+q+q\delta_2)}\right) \quad (18)$$

Where the variables δ_1 , δ_2 are given by:

$$\delta_1 = \rho.\left(\frac{1+K_R}{K_R}\right)^{-1} \quad ; \quad \delta_2 = \rho.(1+K_R)^{-1}$$

Where η is given by Eq. (17) for 1-D rake receiver, and K_R is Ricean factor (1,3 ,6) dB. The performance in Rayleigh fading (corresponding to $K_R = -\infty$ dB).

4.2 Performance Analysis-2D RAKE Receivers

Let the modified variances of the noise and MAI be denoted as $\overline{\sigma}_N^2$ and $\overline{\sigma}_M^2$ respectively. We know that the noise at the output of the antenna array is reduced by N times. Hence, $\overline{\sigma}_N^2 = (N_0/2)/N_a$; Let H denote the number of in-beam interferers. The number of out-of-beam interferers = K -H -1. Hence we have:

$$\overline{\sigma}_M^2 = \overbrace{\{\alpha_0(K-H-1).(E_s/3N_c)\}}^{out-of-beam} + \overbrace{\{f.H.(E_s/3N_c)\}}^{in-beam}$$

Where α_0 is the attenuation factor for out-of-beam interferers and (f =0.75) is a correction factor for in-beam interferers [11]. The modified SINR expression is thus given by $\rho = E_s/2\overline{\sigma}_T^2$; where $\overline{\sigma}_T^2 = \overline{\sigma}_N^2 + \overline{\sigma}_M^2$ is the total variance. Substituting the values and simplifying, we get:

$$\rho_{2D} = \frac{\gamma}{\left(\frac{1}{N_a}+\frac{2\gamma}{3N_c}H.f+\frac{2\gamma.\alpha_0}{3N_c}(K-H-1)\right)} = \frac{6.N_a.N_c\,.\gamma}{(6\,N_c+4\,.\gamma.N_a\,.H\,.f + 4\,\gamma\,N_a.\alpha_0(K-H-1))} \quad (19)$$

Using Eqs. (19) And (18) and assuming uniform distribution of interferers in the sector, we can obtain the average bit error probability of 2D-RAKE receiver as the probability of error of the CDMA system for Rican fading channel and N_a antennas becomes:

$$P_b^{2D}(e) = \sum_{H=0}^{K-1}\chi\eta^H\binom{K-1}{H}P_b^{1D} \quad (20)$$

$$P_b^{2D}(e) = \sum_{H=0}^{K-1}\chi\eta^H\binom{K-1}{H}\frac{M/2}{M-1}\sum_{q=1}^{M-1}\binom{M-1}{q}\frac{(-1)^{q+1}}{(1+q+q\delta_1)} \times \exp\left(\frac{-\delta_1}{(1+q+q\delta_2)}\right) \quad (20)$$

Where P_b^{1D} is given by Eq.(18) with ρ is given by Eq. (17), χ depend on the beam stretching of antenna array (1/ cos ϴ ; in

$\lambda(\theta)$) in practical (when $\Delta\theta < 60^0$ -70^0) it can approximated as $\chi = (1-\eta)^{(K-H-1)}$ [13],and the probability of an in-beam interferer η, are defined as [5] : $\eta = \frac{(2\theta_{BW})}{\Delta\theta}$; Where $\Delta\theta = 120^0$ is the total coverage angle of the sector and $2\theta_{BW}$ is the total beam width towards the desired user.

The optimization can be conveniently transformed in the wave numbers $w = \pi \sin(\theta)$ for $\theta_1 = 0$ as in this case the sin (.) stretching can be neglected:

$$\int_{-W_{Bw}}^{W_{Bw}} \left(\frac{\sin(wN_a/2)}{N_a \sin(w/2)}\right)^2 dw = 3W_{Bw}/2 \quad ;$$

$$2\int_{W_{Bw}}^{\Delta w/2} \left(\frac{\sin(wN_a/2)}{N_a \sin(w/2)}\right)^2 dw = \alpha_0(\Delta w - 2W_{Bw}) \qquad (A)$$

Where $W_{Bw} = \pi \sin(\theta_{BW})$ and $(\Delta w/2) = \pi \sin(\Delta\theta/2)$, shows the optimized values $((\theta_{BW}, \alpha_0)$ obtained numerically for varying the number of antennas N_a Once $(\bar{\theta}_{BW})$ has been optimized for a specified value of N_a the beam width can be rescaled to any value of according to the relation ship $\theta_{BW} = (\overline{N_a}/N_a)\bar{\theta}_{BW}$ as shown in the table 2. For small deviations from the broadside $(\theta_1 = 0)$, the beam width optimized for in (A) can be transformed into the beam width for any value θ_1 by stretching [13]; $\theta_{BW}(\theta_1) = \theta_{BW}/\cos(\theta_1)$ According to this model, the in-beam interferers can be easily evaluated for any DOA of interest θ_1 as those within the support $\theta(\theta_1)$.

4 Numerical Results:

In this section, we present several numerical examples to illustrate the impacts of the operating environment (i.e. the Rice factor, the delay spread and angular spread) on the BER performance improvement with 2D-RAKE receiver in Recian fading channels. Without loss of generality, the Base Station antenna array is assumed to be a Uniform linear array with identical spacing $d = \lambda/2$ between elements, broadside receiving $(\varphi = 0 - 2\pi)$, and each path arriving at antenna array with the same angular spread. For the system asynchronous CDMA 2000 with antenna array in Recian fading channels and AWGN channel. The summary of the used numerical values will be listed in the following tables:

TABLE 1
Main Analytical Parameters

System Model	CDMA 2000 – QPSK
Fading Model	Riciean fading -AWGN
SNR=Eb/N0	(-6 : 20)dB
No of path	1
Angular spread	10
No of user	1 : 20
No of antenna	1;2;4;9;16
Type of antenna	ULA
Chip rate	3.84Mchip /s
Processing gain	19.3dB
Path loss exponent	2.7: 3.5 For urban environment.
Carrier frequency	(1850 - 1990) Mhz
spreading factor Nc	64
total coverage Δθ	120°

TABLE 2
Equivalent Antenna Array Parameters

Number of antenna elements (Na)	2	4	8	12	16
Attenuation α_0 dB	-10	-12	-16	-17	-18.25
total beamwidth $(2\theta_{BW})^0$	40	30	15	5	4

By using a mathematical software package such as MathCAD to verify the previously analytical derived equations including equations (14), (15), (18), and (20).

In Fig (1): shows the Capacity vs Coverage area relationship as in equation (15) assuming number of user K, Na=1 and Na=4 for the Path loss exponent L = 2.7; Also illustrated are the points where the loading equals 56 % of maximum capacity (pole capacity). With the adaptive antenna, keeping the same relative loading, we simultaneously increase capacity by a factor of 4 and coverage by a factor of 2.2.
As mentioned above, a CDMA system is normally operated at a certain fraction of its maximum capacity (the pole capacity). Fig.1, illustrates how capacity and coverage increase when the fractional loading is held constant when going from a single- to multiple-antenna BS. With constant fractional loading and with the assumption that the pole capacity is proportional to the number of antennas, the increase in capacity is of course: Constant load capacity gain = Na

In Fig. (2): shows the Capacity (number of user K) and coverage area A trade-offs for one and four antennas. At Path loss exponent L= 2.7 and L = 3.5. It is found that the more the pass loss, the decrease the capacity and coverage.

In Fig. (3): shows the BER vs SNR for the case of single antenna, K =15 User with single path assuming Ricean fading Channels, Rice factor with value K_R=1,3 and ;6 dB respectively. The result shows that for as SNR=15 dB, it is found that BER=0.086 at rice factor K_R=1dB ; BER decrease to BER=0.052 at rice factor K_R =3dB; while BER decrease to BER=0.023 at rice factor with value K_R = 6dB, so for larger Ricean factors, there is a tremendous improvement in the BER depending on the power of the LOS component.

In Fig.(4): shows the BER vs SNR for the case of single antenna and antenna array (Na=1,4) respectively, K =15 User with single path assuming Ricean fading channels, Rice factor with value K_R= 4dB. The result shows that for as SNR=15 dB, it is found that BER= $4 * 10^{-2}$at single antenna; while BER decrease to BER=$9.049 * 10^{-3}$ at antenna array (Na=4); BER decrease so for increase number of antenna, there is a tremendous improvement in the BER depending on the increase number of antenna, at the same K and Ricean factor (KR).

In Fig. (5): Shows the BER vs. User K, for single antenna, SNR =10 dB with single path assuming Ricean fading with different Ricean factors with value K_R = 1, 3 and 6 dB respectively. The result shows that for as User K =10, it is found that BER=0.094 at rice factor K_R=1dB; BER decrease to BER=0.059 at rice factor K_R =3dB; while BER decrease to BER=0.028 at rice factor K_R = 6dB so for larger Ricean factors, there is a tremendous improvement in the BER depending on the power of the LOS component, at the same SNR and User K. The figure shows that as the number of user's increases, the performance of the system gradually deteriorates.

In Fig. (6): Shows the BER vs. Users K, for the case of single antenna and antenna array (Na=1,4) respectively, SNR =10 dB and rice factor (K_R = 4dB) with single path assuming Ricean fading channels. The result shows that for as K=4 user, it is found that BER= 0.024 at single antenna; while BER decrease to BER=1.975*10^{-3} at antenna array (Na=4); and shows that for as K=10 user, it is found that BER= 0.046 at single antenna; while BER decrease to BER=4.363*10^{-3} at antenna array (Na=4); BER decrease so for increase number of antenna, there is a tremendous improvement in the BER depending on the increase number of antenna, at the same SNR and Ricean factor (KR); the increase number of K user so for BER increase. There is a tremendous improvement in the BER; due to the performance of the system gradually deteriorates.
Figure (7): shows the BER vs. Users K, for (Na=1, 2, 4, 9, 16 at K_R=4dB) respectively; SNR = 10 dB, with single path assuming Ricean fading channels. The result shows that for as K=10 user, it is found that BER= 0.046 at single antenna; BER decrease to BER=8.708*10^{-3} at antenna array (Na=2); BER decrease to BER=3.275*10^{-3} at antenna array (Na=4); BER decrease to BER=1.308*10^{-3} at antenna array (Na=9); while BER decrease to BER=6.66*10^{-4} at antenna array (Na=16); and shows that for as K=20 user, it is found that BER= 0.086 at single antenna; BER decrease to BER=0.011 at antenna array (Na=2); BER decrease to BER=4.378*10^{-3} at antenna array (Na=4); BER decrease to BER=1.597*10^{-3} at antenna array (Na=9); while BER decrease to BER=7.966*10^{-3} at antenna array (Na=16); The figure shows that as the number of user's increases, the performance of the system gradually deteriorates. However for increase number of antenna, there is a tremendous improvement in the BER, the performance of the system gradually enhancement.

Figure (8): shows the BER vs. SNR , for Number of users K=15 , Na = 1,2,4,9,16 antennas respectively, with single path assuming Ricean fading channels (rice factor K_R=4dB). The result shows that for as SNR=9dB, it is found that BER= 0.076 at single antenna; BER decrease to BER=0.013 at antenna array (Na=2); BER decrease to BER=4.964*10^{-3} at antenna array (Na=4); BER decrease to BER=1.827*10^{-3} at antenna array (Na=9); while BER decrease to BER=8.703*10^{-4} at antenna array (Na=16); as compared to the case of Rician fading. However shows that with increasing Na reduces the required BER, which in turn, leads to an increase in the system performance so the system performance will get enhancement.

5 Conclusions:

In this paper, the performance enhancement of CDMA systems with AWGN and Rician fading
Channel using antenna arrays has been addressed. By taking advantage of the characteristics of CDMA 2000 system signals, and using uniformly distributed signal angles of arrival, the received signals at the elements were estimated. It can be concluded that the use of antenna arrays at the base station can significantly increase the capacity of the proposed system.

An analytical model for evaluating the mean BER of a DS-CDMA system with QPSK modulation, employing an array antenna and operating in Rician fading environments has been derived, a closed form expression for coverage, capacity, BER was derived and the analytical solution is verified using MathCAD to of and it is concluded that:-
The system performance is improved depending on the power of the LOS component. The proposed model has been shown to the performance of the complex antenna arrays in Rician fading under different conditions with reasonable degree of accuracy.
1- We can summarize the capacity and coverage of a CDMA system using antenna array as follows; If we increase the number of uplink antennas by a factor of Na, then the uplink capacity and coverage area increase by a factor of Na and $N_a^{2/\gamma}$, respectively. These gains are achieved simultaneously. So that the capacity improvement factors and coverage improvement factors are shown in relationship to each other.
2- From the point of view the BER vs SNR it is found that for different value of Ricean factors (K_R = 1,3,6) dB, the case of single antenna, K =15 User with single path assuming Ricean fading Channels so for larger Ricean factors, there is a tremendous improvement in the BER depending on the power of the LOS component.
3- From the point of view the BER vs SNR, it is found that for different value number of antenna (Na=1,4) respectively, K=15 User with single path assuming Ricean fading channels, Rice factor (K_R= 4dB). Then BER decrease so for increase number of antenna, there is a tremendous improvement in the BER depending on the increase number of antenna.
4- From the point of view the BER vs. Users K, it is found that for different value for the case of single antenna and antenna array (Na=1,4) respectively, SNR =10 dB and rice factor (K_R = 4dB) with single path assuming Ricean fading channels. Then BER decrease so for increase number of antenna, there is a tremendous improvement in the BER depending on the increase number of antenna.
5- From the point of view system shows that as the number of user's increases, the performance of the system gradually deteriorates. However for increase number of antenna, there is a tremendous improvement in the BER, the performance of the system gradually enhancement. The system performance is improved depending on the power of the LOS component. The proposed model has been shown to the performance of

the complex antenna arrays in Rician fading under different conditions with reasonable degree of accuracy.

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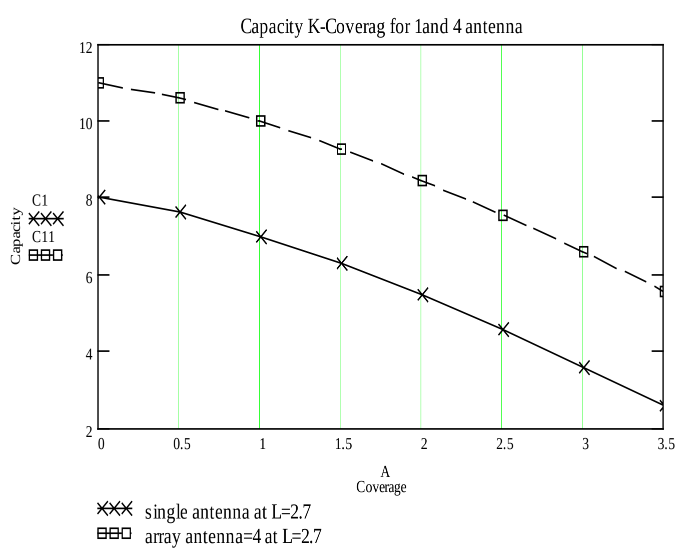

Figure 1: Capacity-coverage trade-offs for one and four antennas. At Path loss exponent L = 2.7

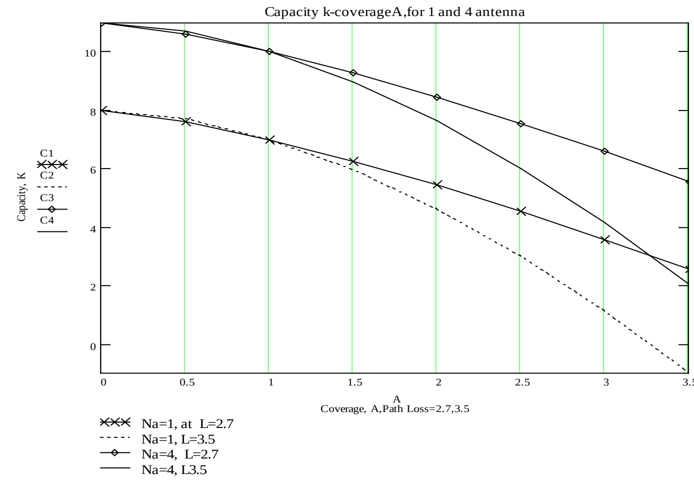

Figure 2: Capacity-coverage trade-offs for one and four antennas. At Path loss exponent L = 2.7-3.5

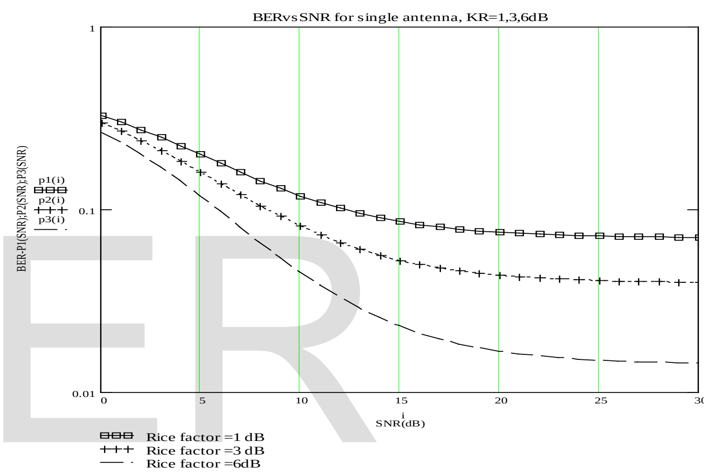

Fig 3. BER vs. SNR (dB) for single antennas, K =15 user with single path assuming Ricean fading Channels (K_R=1;3;6)dB respectively.

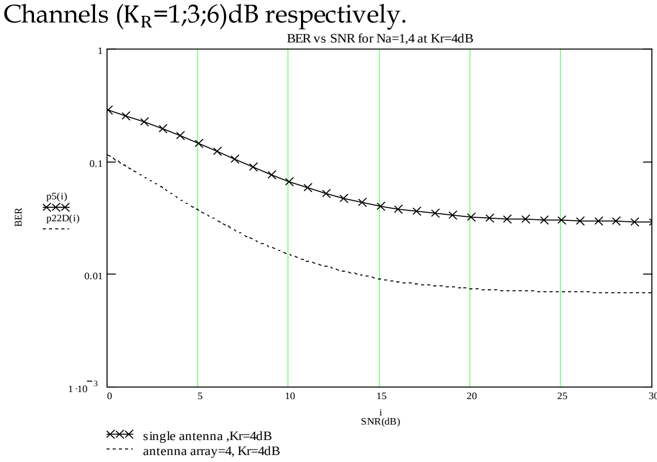

Fig.4. BER vs. SNR ; for Na = 1;4 antennas, Users K=15, assuming Ricean fading channels (K_R=4dB), respectively.

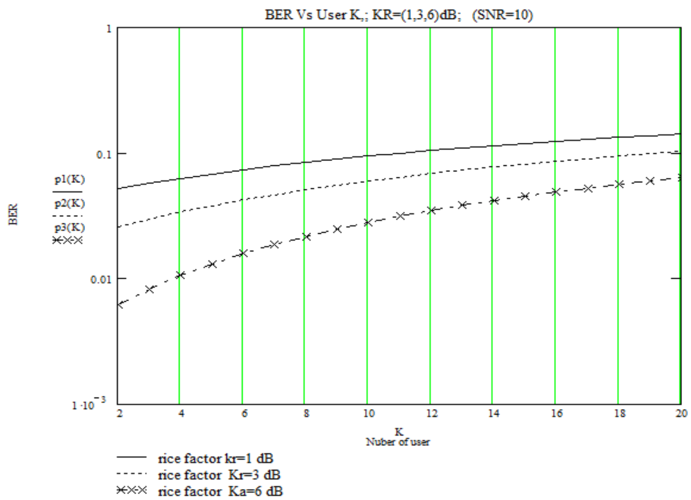

Fig5. BER vs. K User , for single antenna, SNR =10 user with path assuming Ricean fading Channels (K_R=1;3;6)dB respectively.

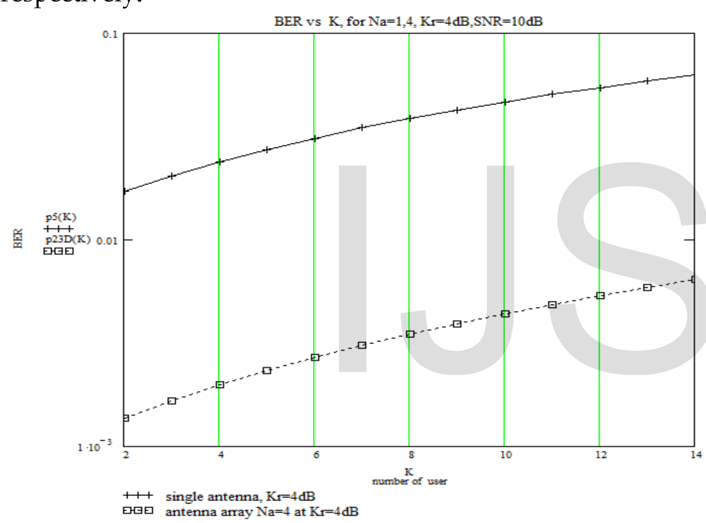

Fig.6. BER vs. Users K, for (single and antenna array Na= 1,4 at K_R=(4)dB, respectively SNR = 10 dB, assuming Ricean fading channels.

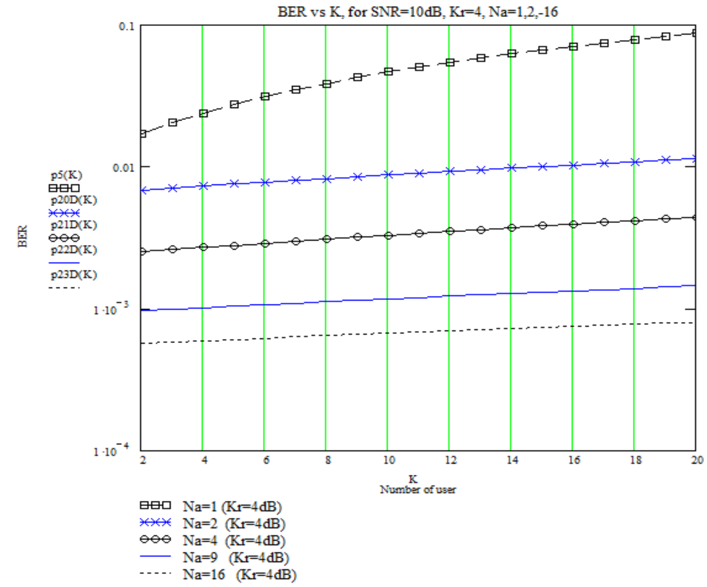

Fig. 7. BER vs. Users K, for (Na=1, 2, 4, 9, 16 at K_R=4dB) respectively; SNR = 10 dB, assuming Ricean fading channels.

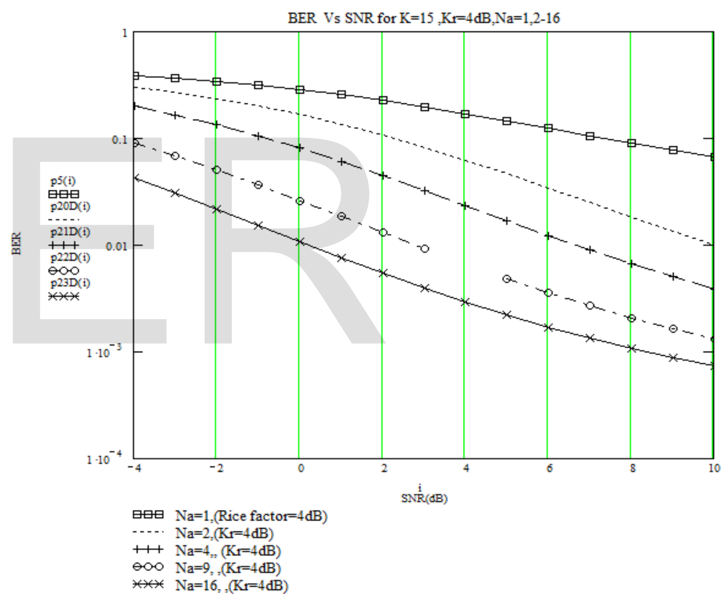

Fig.8. BER vs. SNR , for Number of users K=15 , Na = 1,2,4,9,16 antennas respectively, assuming Ricean fading channels (K_R=4) dB.