Performance and Capacity Enhancement Techniques of WCDMA Systems for Data Users

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Summary
One of the principle characteristics of CDMA and WCDMA systems is that its capacity is a function of total interference experienced by the network. The most common approaches investigated in this paper to enhance the system capacity are: Wideband CDMA, Power control accuracy, interference power, Frequency reuse, cell sectoring, power based call admission control, and etc. Since CDMA is interference limited system, the uplink signal-to-interference (SIR) is used in evaluating system capacity with each of the previous techniques under different environmental conditions, e.g., AWGN and Rayleigh fading using Perfect Power Control (PPC) and IPC. These techniques enhanced the WCDMA system capacity with high QoS. All other studies concerned with speech users but this study is concerned with data users. Data transmission use higher data rates than speech transmission so for the same bandwidth the total system capacity for data users will be less than it for speech users.
Keywords:
CDMA, WCDMA, Mobile communications, CDMA Uplink Capacity, Call Admission Control (CAC)

I. Introduction

One of the principle characteristics of CDMA system is that its capacity is a function of total interference experienced by the network, and is upper bounded by a cell experiencing the most interference. Thus, in CDMA based system it is important to calculate the total inter-cell and intra-cell interference to know the cell capacity [1]. All of the following techniques may be implemented to enhance the CDMA cellular system capacity: Using Orthogonal Spreading code schemes, Wideband CDMA, Power Control, Frequency Reuse, Cell Sectoring, power based Call Admission Control [2].

a1. Wideband CDMA

WCDMA is a DS-CDMA system which has larger total bandwidth than the old CDMA and so it has larger number of physical channels with channel bandwidth of 5, 10 and 15MHz compared with 1.25 MHz in old CDMA which allowed it to have higher bit rate and higher capacity than CDMA. This is why it is used in 3G systems to enhance total system capacity and QoS for both speech and data transmission [3].

a2. Power Control

Power control aims to reduce interference by minimizing the effects of the near-far problem (the received power at a BS from a mobile station (MS) near the cell boundary is less compared to a MS close to the BS), while keeping the received signal power, or the SIR, at the same level at the BS [4].

a3. Universal Frequency Reuse

CDMA cellular systems typically use universal frequency reuse (or a frequency reuse factor of 1), where the MSs and BSs use the whole bandwidth to transmit and receive information [2].

a4. Cell Sectoring

Cell Sectoring is a method that uses multiple directional antenna arrays to reduce the co-channel interference, resulting in increased cellular network capacity [3].

a5. Power Based Call Admission Control

WCDMA is an interference-limited system. When the system operates at nearly full capacity, admitting another user may affect the stability of the system. Therefore, proper Call Admission Control (CAC) should balance between Quality of Service (QoS) requirements for the new user and also for the existing users and at the same time keep the accepted traffic as high as possible. ***An ideal CAC mechanism*** should accept a call if and only if the power control algorithm is able to reach a new equilibrium with a guaranteed good quality of all connections. ***Interactive call admission scheme*** is very close to ideal CAC because it allows the new connection to transmit for a trial period during which it takes measurements to determine whether the connection can be tolerated. Unfortunately, these schemes are not practical due to long time. The best parameter that reflects the current load in

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the network. A ***simple received power-based admission control*** was proposed [2]. The measured interference includes both intra-cell and inter-cell interference and the measured values are compared with a threshold. The new attempt is only accepted if the threshold is not exceeded. Acceptance threshold must be carefully tuned to limit the dropping prob. [8].

II. Analysis and System Model

a. A study of Uplink WCDMA-FDD System Capacity enhancement techniques will be carried out in this section using mathematical analysis and simulation model.

a1. Single cell Capacity

The capacity of a CDMA cell depends on many different factors, such as Power control accuracy, interference power, sectoring, splitting, etc. [1]. In this part of the study, perfect power control is assumed. Since CDMA is interference limited system, the uplink signal-to-interference (SIR) is used in evaluating system capacity. If there are N users in a cell and the received signal power is denoted by S_r , then the cell BS process a composite received signals that contain the desired signal with power S_r and (N-1) interfering signals, each of power S Ignoring the background noise[6], the signal-to-interference (SIR) may be expressed.

$$SIR = \frac{S_r}{(N-1)S_r} = \frac{1}{(N-1)} \quad (1)$$

$$\frac{Eb}{N_o} = \left(\frac{W}{R_b}\right) SIR = \frac{P_G}{N-1} \quad (2)$$

$$P.G. = \frac{W}{R_b} = \frac{spreaded\ signal\ B.W.}{message\ \ B.W.} \quad (3)$$

The channel capacity may be expressed as :

$$C = N = 1 + \left(\frac{P_G}{\Gamma \frac{E_p}{N_o}}\right) = 1 + \left(\frac{P_G}{\Gamma}\right) \quad (4)$$

Where is the capacity including the back ground noise will be calculated as follows

$$N_p = \eta W_t$$

$$SIR = \frac{S_r}{N_p + (N-1)S_r} \quad (5)$$

$$\frac{Eb}{N_o} = \frac{S_r PG}{N_p + (N-1)S_r} = \Gamma = \frac{P_G}{(N-1) + \left(N_p / S_r\right)}$$

$$N = \left(1 + \frac{P_G}{\Gamma}\right) - \left(N_p / S_r\right) \quad (6)$$

In order to attain an increase in capacity, the interference due to other users should be reduced. This can be performed using antenna sectorization. Antenna sectorization means spatial isolation of users in a CDMA system by using directional antennas. This isolation reduces the interference and increase the capacity as a result [9]. Thus, with sectorization, the average E_b/N_o may be expressed as:

$$\frac{Eb}{N_o} = \frac{P_G}{(N_s - 1) + \left(N_p / S_r\right)}$$

Where, N_s is the number of users per sector.

With, $\frac{Eb}{N_o} = \Gamma$ and solving for N_s

$$N_s = 1 + \left(\left(\frac{P_G}{\Gamma}\right) - \left(N_p / S_r\right)\right)$$

The number of users per cell is approximately given by :

$$N = M.\, N_s$$

$$N = M.\left[1 + \left(\left(\frac{P_G}{\Gamma}\right) - \left(N_p / S_r\right)\right)\right] \quad (7)$$

The user density function which is a ratio between total numbers of users per cell to the total cell area can easily be estimated. It is an important function which gives information about the average number of users who make a call at the same time per unit area; this can be calculated as follows:

$$\rho = User\ density\ \ function = \frac{\text{total number of users per cell}}{\text{total cell area}}$$

For hexagonal cell shape we can calculate the cell area as follows:

$$cell\ area = \left[\left[\left(\frac{\sqrt{3}}{2}.R\right).(R).\left(\frac{1}{2}\right)\right].(6)\right] = \frac{3\sqrt{3}}{2}.R^2 \quad (8)$$

Then the user density function can be expressed as

$$\rho = \frac{N}{\frac{3\sqrt{3}}{2}.R^2} = \frac{M.N_s}{\frac{3\sqrt{3}}{2}.R^2} = \frac{2.M.N_s}{3\sqrt{3}.R^2} =$$

$$= \frac{2.M}{3\sqrt{3}.R^2}.\left[1+\left(\left(\frac{P_G}{\Gamma}\right)-\left(N_p/S_r\right)\right)\right] \quad (9)$$

The calculation of WCDMA single cell capacity, which was formulated in equation (7), assumes perfect power control between the MSs and BSs. However, transmitted signals between MSs and BSs are subject to multipath propagation conditions, which make the received($\frac{E_b}{N_o} = \Gamma$) signals vary according to a log-normal distribution with a standard deviation on the order of 1.5 to 2.5 dB .Therefore **imperfect power control** (IPC) will be produced. Thus, in the (IPC) case, the constant value of (E_b) in each cell needs to be replaced by the variable (E_b) = έ. (E_{bo}) which is log-normally distributed. Now define

$$\frac{E_b}{N_o} = \Gamma = \varepsilon.\frac{E_{bo}}{N_o} = \varepsilon.\Gamma_o \quad \text{And} \quad x = 10.\log(\varepsilon.\Gamma_o)$$

$$\varepsilon.\Gamma_o = 10^{x/10} = e^{Bx} \quad , \quad B = \ln(10)/10$$

According to [7], by evaluating the nth moment of έ using the fact that x is Gaussian function with mean τ and standard deviation σ , then taking the average value (the expected value), yields

$$E[10^{x/10}] = E[\varepsilon.\Gamma_o] = \Gamma_o.E[\varepsilon] = e^{B\tau}.e^{B^2.\sigma^2/2}$$

Γ_o can be chosen such that ($\Gamma_o = e^{B\tau} = 10^{\tau/10}$) which makes ($\Gamma_o = median[\Gamma]$)

Thus, the expected value becomes ($E[\varepsilon.\Gamma_o] = \Gamma.e^{B^2.\sigma^2/2}$), hence one can show that:

$$\Gamma_{IPC} = \Gamma_{PPC}.e^{B^2.\sigma^2/2} \quad (10)$$

Applying equation 10 into equation 7 , one can show that

$$N = M.N_s = M.\left[1+\left(\left(\frac{P_G}{\Gamma.e^{B^2.\sigma^2/2}}\right)-\left(N_p/S_r\right)\right)\right] \quad (11)$$

Equation (11) can be used as a general equation for single cell WCDMA system capacity, for perfect power control (PPC) the standard deviation (σ =0) but for the single cell capacity with Imperfect power control due to multipath the standard deviation is (1.5< σ < 2.5) dB.

a2. Multi-cell Capacity

For Multi-cell WCDMA system architecture, the system itself consisting of two or more cell sites operating at the same bandwidth. Therefore, the total interference at each cell site on the uplink direction is not only due to the users served by this cell (sector) but also from the active users in the other cell (sectors) [8]. Therefore E_b/N_o can be expressed as

$$\frac{E_b}{N_o} = SIR.\,p_G = \frac{S_r \cdot p_G}{N_p + \alpha.(N-1)S_r + \sum I(\text{from other cells})}$$

For two cells system model, assume that the average interference powers received from users in the neighbor cell are equal (for constant average distances between neighbor cell's users and the main cell base station) and assume that the average number of users in each cell is equal for uniform user distribution

$$\sum I(\text{from other cells}) = N.S_I$$

$$\frac{E_b}{N_o} = SIR.\,p_G = \frac{S_r \cdot p_G}{N_p + (N-1)S_r + N.S_I}$$

$$\frac{E_b}{N_o} = SIR.\,p_G = \frac{p_G}{\frac{N_p}{S_r} + (N-1) + N.\frac{S_I}{S_r}}$$

For simplified path loss model

$$P_r = P_t.(\frac{\lambda}{4\pi d_o})^2.(\frac{d_o}{d})^{\gamma}.G_b.G_m \quad , \quad P_r \alpha (\frac{1}{d})^{\gamma} \quad , \quad \frac{P_{r1}}{P_{r2}} = (\frac{d_2}{d_1})^{\gamma}$$

$$for: \; P_{r1} = S_r \text{ and } P_{r2} = S_i$$

Assume that the distance between each MS and BS in the neighbor cells is neglected compared with the distance between the two base stations which equal to $\sqrt{3}R$ $so: \; d_1 = R$ and $d_2 = \sqrt{3}R$

$$\frac{S_I}{S_r} = (\frac{R}{\sqrt{3}R})^{\gamma} = (\frac{1}{\sqrt{3}})^{\gamma} : \text{for minimum received power}$$

$$\frac{E_b}{N_o} = \frac{p_G}{\frac{1}{SNR} + (N-1) + N.(\frac{1}{\sqrt{3}})^{\gamma}}$$

$$\frac{1}{SNR} + N\left[1 + (\frac{1}{\sqrt{3}})^{\gamma}\right] - 1 = \frac{p_G}{\Gamma}$$

$$N = \frac{\left[\frac{p_G}{\Gamma} - \frac{1}{SNR} + 1\right]}{\left[1 + (\frac{1}{\sqrt{3}})^{\gamma}\right]}$$

The total number of users per cell can be expressed as:

$$N = M.N_s = M.\left[\frac{p_G}{\Gamma} - \frac{1}{SNR} + 1\right].\frac{1}{\left[1 + (\frac{1}{\sqrt{3}})^{\gamma}\right]}$$

The pervious equation was calculated assuming (PPC) but for (IPC) the cell capacity will be as follows

$$N = M.N_s = M.\left[\frac{p_G}{\Gamma.e^{B^2.\sigma^2/2}} - \frac{1}{SNR} + 1\right].\frac{1}{\left[1 + (\frac{1}{\sqrt{3}})^{\gamma}\right]}$$

For k-cells system assuming (PPC) and neglecting all except the first tier interference the general equation for the cell capacity will be as follows

$$N = M.N_s = M.\left[\frac{p_G}{\Gamma} - \frac{1}{SNR} + 1\right].\frac{1}{\left[1 + (k-1)(\frac{1}{\sqrt{3}})^{\gamma}\right]}$$

i.e. the cell capacity for 7-cells WCDMA cellular system will be

$$N = M.N_s = M.\left[\frac{p_G}{\Gamma} - \frac{1}{SNR} + 1\right].\frac{1}{\left[1 + (7-1)(\frac{1}{\sqrt{3}})^{\gamma}\right]} \quad (12)$$

And for IPC capacity will be given as

$$N = M.N_s = K.M.\left[\frac{p_G}{\Gamma.e^{B^2.\sigma^2/2}} - \frac{1}{SNR} + 1\right].\frac{1}{\left[1 + (k-1)(\frac{1}{\sqrt{3}})^{\gamma}\right]} \quad (13)$$

a3. Power Based Call Admission Control

In this part WCDMA multi-cell system capacity for data users is analyzed in the uplink direction using power-based Multi-Cell Admission Control (MC-AC) algorithm. From [10]; the total received power at the base station can be calculated using the following equation:

$$P_{tot} = N_p + P_{own} + I_{oth}$$

Where P_{tot} is the total received power at base-station, Np is the noise power, P_{own} is the received power from UEs in the serving cell, and I_{oth} is the received interference power from UEs in neighbor cells. Assuming that the received power from all of the mobile stations that belong to the same class (bit rate) are equal and denoted (S_r). This assumption comes from the fact that closed loop power control is more faster than admission control decision so perfect power control could be Assumed. Therefore one can find that:

$$P_{own} = N.P_t.H = N.S_r$$

Where N is the number of UEs in the cell, P_t is the transmitted power from each UE, Sr is the received power from each user, and H is the path gain. The SIR can be expressed as:

$$\gamma_k = \frac{(E_b/N_o)_k}{(W/R_k)} = \frac{\Gamma}{PG} = SIR = \frac{S_r}{(N-1)S_r} = \frac{S_r}{N.S_r - S_r} \approx \frac{S_r}{P_{own} - S_r} \quad (14)$$

Load Factor and Noise Rise

The admission control algorithm estimates the increase in the total received power due to a new user and decides to accept or reject this user according to the current system state. Load increment due to a new arriving user can be estimated as follows: Solving for S_r in Equation (14) gives:

$$S_r = \frac{\gamma}{\gamma+1}.P_{own} = P_{own}.\Delta\tau$$

$$\Delta\tau = \frac{S_r}{P_{own}} = \frac{\gamma}{\gamma+1} \quad (15)$$

Where $\Delta\tau$ is the fraction of the system load that is generated by a user. Another way of expressing the total received power is to describe it as a rise over thermal noise. It is defined as the ratio between the total received power at the base-station and thermal noise:

$$noise\ rise \equiv \Lambda = \frac{P_{tot}}{N_p} = \frac{N_p + P_{own} + I_{oth}}{N_p} \quad (16)$$

$$\text{total load factor} = \eta_c = \frac{P_{own} + I_{oth}}{N_p + P_{own} + I_{oth}} \quad (17)$$

$$\text{Therefore: } \left(\Lambda = \frac{1}{1-\eta_c}\right) or \left(\eta_c = 1 - \frac{1}{\Lambda}\right) \quad (18)$$

Noise rise is the best indicator of the load level at the base station because it has a direct relation with the total power received at the BS, so it is usually taken as an admission decision parameter [10]. A new user is admitted if the following condition is achieved: $\Lambda < \Lambda_{th}$ Where, Λ is the noise rise at the own cell after the new user has been admitted and Λ_{th} is the noise rise threshold. Since it is impossible to exactly predict the noise rise increase before admitting the new user [10], then the pervious condition can be modified to: $\Lambda_{est} < \Lambda_{th} - \Lambda_{hr} = \Lambda_{target}$ Where Λ_{est} is the estimation of Λ, Λ_{hr} is a head room

parameter set as a safety margin to compensate for the estimation errors.
From (equation17) the total load factor can be calculated as follows:

$$\eta_c = \frac{P_{tot}}{N_p} = \frac{N.S_r + I_{oth}}{N_p + N.S_r + I_{oth}}$$

Substituting

$$\eta_c.N.S_r + \eta_c.(N_p + I_{oth}) = N.S_r + I_{oth}$$

$$N.S_r.(\eta_c - 1) = I_{oth} - \eta_c.(N_p + I_{oth})$$

$$S_r = \frac{I_{oth} - \eta_c.(N_p + I_{oth})}{N.(\eta_c - 1)} = \frac{I_{oth} - \eta_c.N_p - \eta_c.I_{oth}}{N.(\eta_c - 1)}$$

Therefore the capacity is expressed as

$$N = \frac{I_{oth}(1 - \eta_c) - \eta_c.N_p}{S_r.(\eta_c - 1)}$$

Assuming that the cell radius is R then the distance between two base stations is $\sqrt{3}R$ hence:

$$S_I = S_r.\left(\frac{R}{\sqrt{3}R}\right)^{\gamma=3} = S_r.\left(\frac{1}{\sqrt{3}}\right)^3$$

$$I_{oth} = (k-1).N.S_I = (k-1).N.S_r.\left(\frac{1}{\sqrt{3}}\right)^3$$

For 3 sectors

$$N = 3.N_s = 3.\left(\frac{(k-1).N.S_r.\left(\frac{1}{\sqrt{3}}\right)^3.(1-\eta_c) - \eta_c.N_p}{S_r.(\eta_c - 1)}\right)$$

Assume 7-cell interference model for multi-cell WCDMA communication system with PPC, then

$$N = \left(\frac{18.N.S_r.\left(\frac{1}{\sqrt{3}}\right)^3.(1-\eta_c) - 3.\eta_c.N_p}{S_r.(\eta_c - 1)}\right)$$

$$N = \frac{3.\eta_c.\frac{1}{SNR}}{18.\left(\frac{1}{\sqrt{3}}\right)^3.(1-\eta_c) - (\eta_c - 1)}$$

Therefore the total number of active users per cell using CAC and PPC for multi-cell WCDMA communication system assuming 7-cell system (1'st tier model) can be expressed as:

$$N = \frac{3.(\Lambda - 1).\left(\frac{PG}{\Gamma}\right)}{18.\left(\frac{1}{\sqrt{3}}\right)^3 + 1} \quad (19)$$

In simulation, the WCDMA system parameters are assumed as shown in table (1) using different values of bandwidth and bit rates with chip rate 3.84Mcps.

Table (1): WCDMA system parameters for data users

Bandwidth	Received Signal power	$\eta = \frac{N_p}{W_s}$	SNR	Bit rate for data	P.G.
5 MHz	7.9433*10^-11 w = -101 dB	10^{-16}	0.158866= -7.99 dB	144kbps	34.7
				384kbps	13
10 MHz	7.9433*10^-11 w = -101 dB	10^{-16}	0.079433= -11 dB	144kbps	69.4
				384kbps	26
20 MHz	7.9433*10^-11 w = -101 dB	10^{-16}	0.0397165= -14 dB	144kbps	138.8
				384kbps	52

III. Simulation Results

a. Capacity Performance of WCDMA Network

The Number of data users per cell as a function of signal to interference ratio (SIR) is illustrated in figure 1

a1. WCDMA Single Cell Capacity with PPC and IPC

Comparison between WCDMA Cell Capacity for data users with different environmental conditions is shown in figure 2 with PG=34.7, B.W. =5MHz, chip rate 3.84Mcps, and data rate=144kbps. WCDMA Cell Capacity with AWGN and different values of bandwidth and PG is shown in Figure 3 with bit rate 384kbps and in Figure 4 with bit rate 144 kbps. Figure 5 discuss the effect of sectoring on single cell capacity for data users with AWGN channel and different sectoring modes as 3-sectors per cell (120 degree sectoring) and 6-sectors per cell (60 degree sectoring) using processing gain 34.7 , bandwidth 5MHz , data rate = 144kbps , chip rate 3.84Mcps with perfect power control (PPC). So from all of pervious results it is found that the optimum capacity with minimum interference and with accepted (E_b/N_o =2dB) for good QoS will follow the parameters used in figure 6 and the user density will be as shown in Figure 7. And Table (2) shows the Numerical results for WCDMA single cell Capacity for data users.

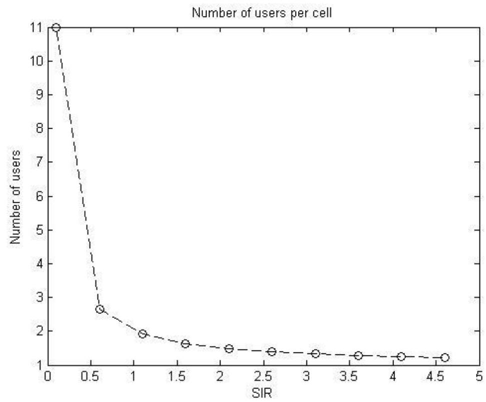

Figure 1

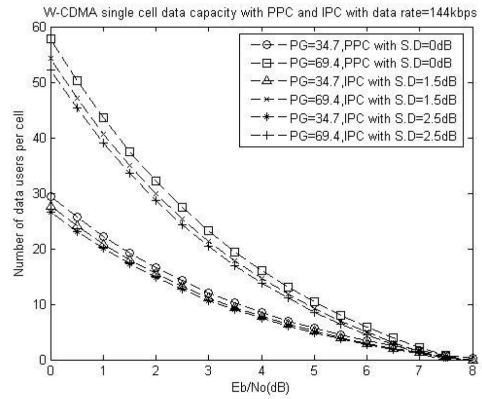

Figure 4

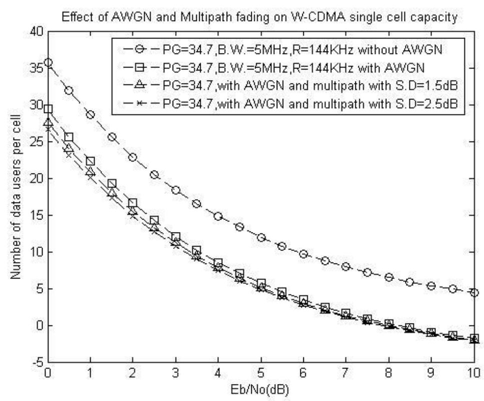

Figure 2

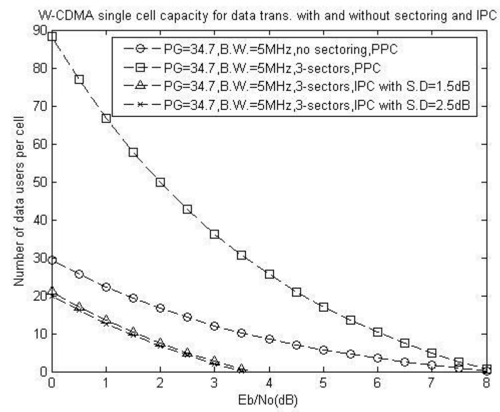

Figure 5

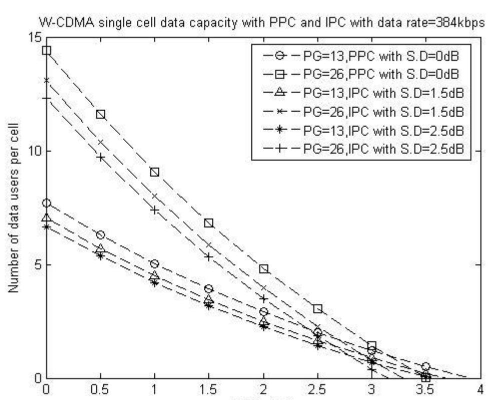

Figure 3

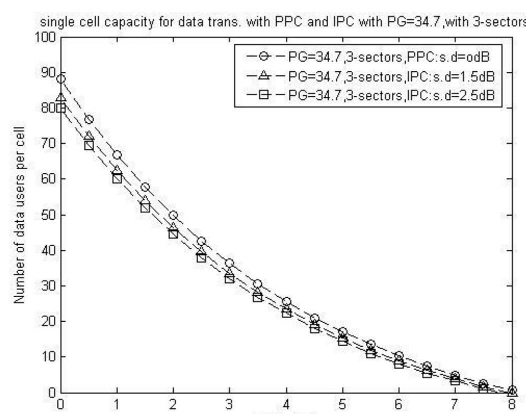

Figure 6

Table (2)

Cell capacity With PPC	The Optimum	52	3-sectors per cell ,PG=34.7, data rate = 144kbps,and total BW=5MHz				
	3-sectors per cell	52	11	95	21	188	38
	simple	18	4	32	7	63	13
Cell capacity With no AWGN		23	10	45	20	89	38
	P.G.	34.7	13	69.4	26	138.8	52
Eb/No		2dB	1.5dB	2dB	1.5dB	2dB	1.5dB
Bit rate		144 Kbps	384 Kbps	144 Kbps	384 Kbps	144 Kbps	384 Kbps
SNR		0.158866= -7.99 dB		0.079433= -11 dB		0.0397165= -14 dB	
$\eta = \frac{N_o}{W_i}$		10^{-16}		10^{-16}		10^{-16}	
Received Signal power		$7.9433*10^{-11}$ w = -101 dB		$7.9433*10^{-11}$ w = -101 dB		$7.9433*10^{-11}$ w = -101 dB	
B.W.		5 MHz		10 MHz		15 MHz	

Single cell WCDMA interference model for data users

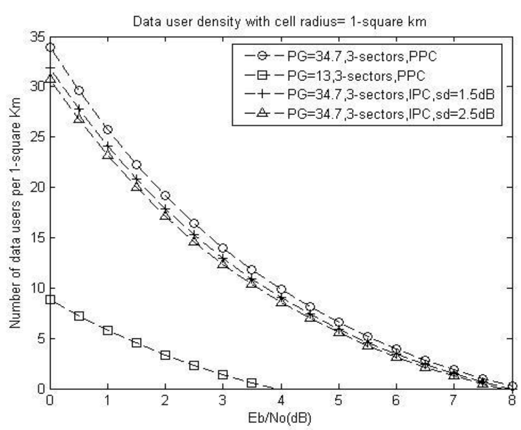

Figure 7

a2. WCDMA Multi-cell capacity for data users with (PPC) and (IPC)

Assume that γ=3 and the average distances between in-cell users and base station are equal =R assuming there is a power control where the average distances between neighbor-cells users and base station are equal to $\sqrt{3}R$ neglecting the distance between these data users and their base stations, with system parameters as shown in table (1).Figure 8 shows the effect of AWGN and multipath on the cell capacity in multi-cell WCDMA communication system using 7-cell interference model, with data rate=34.7 or 69.4 kbps and WCDMA cell capacity is shown in figure 9 with PPC and IPC with σ=1.5 or 2.5 dB with B.R=13 or 26 kbps for 7-cell interference model, Figure 10 shows the effect of sectoring on increasing the WCDMA Multi- cell capacity for data users. Figure 11 compares between PPC and IPC for the optimum WCDMA multi-cell capacity for data users. The user density with PPC and IPC is shown in figure 12. Table (3) shows the Numerical results for WCDMA Multi-cell Capacity for data users.

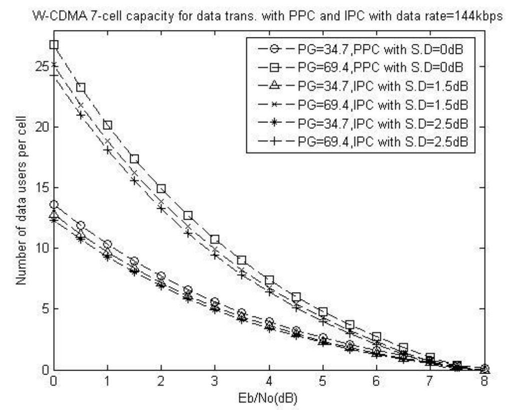

Figure 8

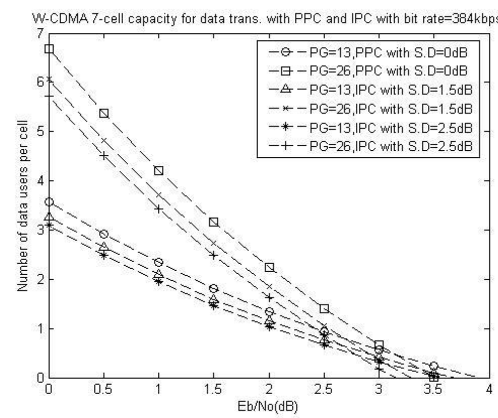

Figure 9

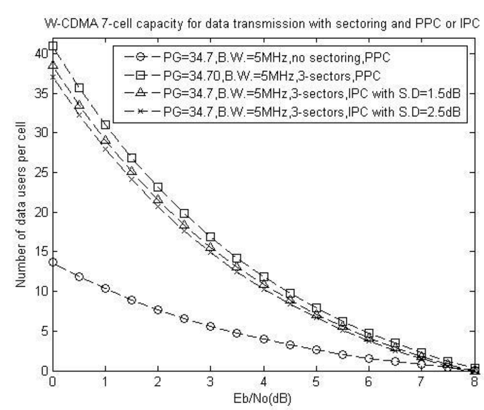

Figure 10

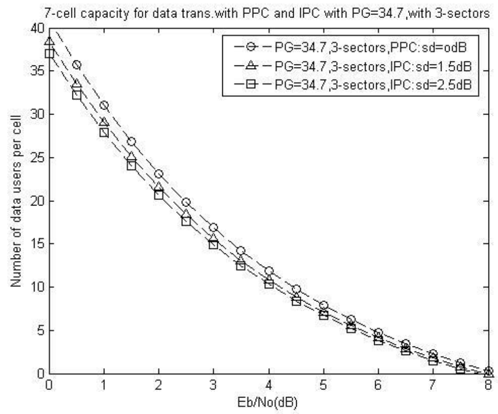

Figure 11

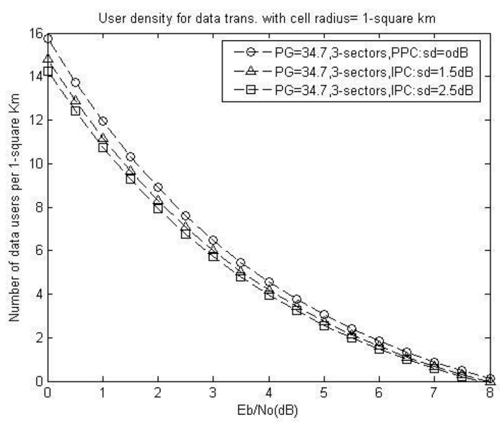

Figure 12

Table (3): Numerical results for WCDMA Capacity

The Optimum	IPC (σ=2.5dB)	17	3-sectors per cell , PG=34.7, data rate = 144kbps,and total BW=5MHz but with itra-cell and inter-cell interference				
	IPC (σ=1.5dB)	18					
	PPC (σ=0dB)	23					
3-sectors per cell sectoring	IPC (σ=2.5dB)	17	3	39	6	78	9
	IPC (σ=1.5dB)	18	3	42	6	81	9
	PPC (σ=0dB)	23	6	45	9	88	12
simple	IPC (σ=2.5dB)	6	1	13	2	26	3
	IPC (σ=1.5dB)	6	1	14	2	27	3
	PPC (σ=0dB)	7	2	15	3	29	4
Cell capacity With no AWGN		10	4	21	8	41	16
P.G.		34.7	13	69.4	26	138.8	52
Eb/No		2dB	1.5dB	2dB	1.5dB	2dB	1.5dB
Bit rate		144 Kbps	384 Kbps	144 Kbps	384 Kbps	144 Kbps	384 Kbps
SNR		-7.99 dB		-11 dB		-14 dB	
$\eta = \frac{N_s}{W_c}$		10^{-16}		10^{-16}		10^{-16}	
Received Signal power		-101 dB		-101 dB		-101 dB	
B.W.		5 MHz		10 MHz		15 MHz	

a3. WCDMA Capacity for data users with call admission control (CAC)

Figure 13 shows the effect of Call Admission Control (CAC) with Different values of Noise Rise on increasing the WCDMA Multi-cell capacity with PPC. The data user density is shown in figure 14. Figure 15 shows the effect of (CAC) with Different values of PG and Noise Rise on the WCDMA Multi-cell capacity for data users, and Table (4) shows the effect of CAC on WCDMA capacity

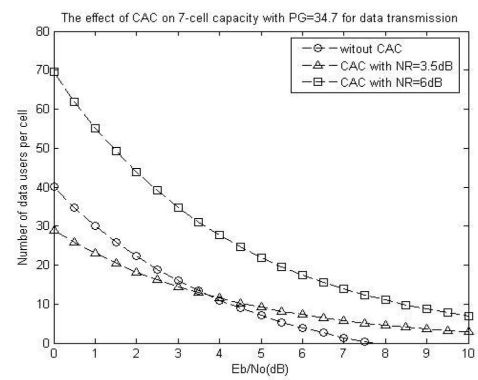

Figure 13

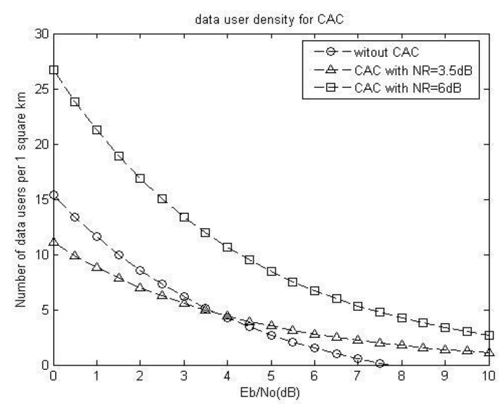

Figure 14

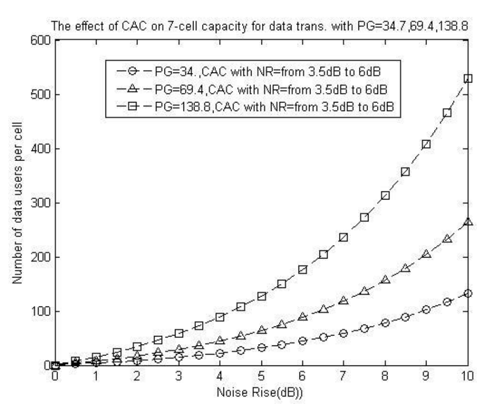

Figure 15

Table (4): The effect of CAC on data users Capacity

WCDMA Multi-cell Capacity for data users using 7-cell interference model with E_b/N_o = 2dB and PPC			
PG=34.7	PG=69.4	PG=138.8	Cell capacity
23	45	88	Without CAC
17	36	73	CAC with Noise rise = 3.5 dB
23	47	93	CAC with Noise rise = 4.1 dB
44	88	176	CAC with Noise rise = 6 dB
N= 44 users per cell			Optimum Capacity
3-sectors per cell, PG=34.7, data rate = 144kbps,and total BW=5MHz with call admission control (CAC) using NR= 6 dB			conditions

From table 4 It is found that the system capacity when CAC is used with Noise rise = 4.1 dB is equal to the capacity with no CAC, Therefore Noise rise must be more than 4.1 dB to enhance WCDMA network Capacity using CAC.

IV. Conclusion

Performance analysis for WCDMA is carried out in this paper. Numerical results are obtained from the mathematical expressions showed improvement in system capacity in terms of maximum number of data users accessing the same channel bandwidth. The most efficient parameters used to enhance Network capacity in the present work are: Sectoring, increasing processing gain, the use of perfect power control, and Multi-cell Call Admission Control (CAC). For data rate 144kbps the spectral utilization is found to be increased from 18 to 52 users at fixed value of Eb/No=2 dB at perfect power control using single cell interference model .It is found to be increased from 7 to 23 users at fixed value of Eb/No=2dB at perfect power control using in multi-cell WCDMA system using 7-cell interference model ,and it is found to be increased from 6 to 18 users at fixed value of Eb/No=2dB at imperfect power control with σ=1.5 dB and from 6 to 17 with σ=2.5 dB used in multi-cell WCDMA system with 7-cell interference model. When Multi-cell Admission Control (CAC) is used, it is found that the system capacity be enhanced from 17 to 44 for Noise rise = 6 dB and PG=34.7.It is found also that the system capacity when CAC is used with Noise rise = 4.1 dB is equal to the capacity with no CAC, Therefore Noise rise must be more than 4.1 dB to enhance WCDMA network Capacity using CAC. Increasing data rate for data transmission to 384 kbps will produce less capacity and Eb/No will be not more than 1.5dB so Qos will be not good as before.

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