

# Enhanced Spectral Utilization of WCDMA FDD System at 5 MHz

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## ABSTRACT

Multiuser detection technique has been applied for capacity enhancement in the presence of loading, voice activity, sectorization, inter & intra interference in multicell scenario of third 3G WCDMA system. In CDMA based system, each user transmits a data sequences spreaded by a code. This code is Unique to the mobile station (MS) and base station (BS) on both uplink and downlink. The present paper deals with capacity in term of number of user in single and multicell environment in the presence of capacity influencing factor at a constant power of the base station in a CDMA based system operating in downlink FDD mode at 5 MHz bandwidth

**Keywords:** Capacity Model, WCDMA, Loading, Sectorization, voice activity, Multi-User Detection.

## 1 INTRODUCTION

The rapidly increasing demand for bandwidth in wireless services has directed the research towards the development of highly flexible radio interfaces. WCDMA has emerged as a promising technique for providing services with different signaling rate and with efficient statistical multiplexing of the active users [1]. The information is spreaded over a band of 5, 10, 20 MHz. The objective of this access technique is to maximize the spectrum utilization .i.e. to provide service to more users with the same amount of spectrum. Support of high data rate transmission: 12.2 kbps, 64 kbps, 144 kbps, 384 kbps with wide area coverage, 2 Mbps with local coverage. High service flexibility: support of multiple parallel variable rate services on each connection [2].

[3] Shows comparison between capacity of CDMA to that of conventional time division multiple access (TDMA) and frequency division multiple access FDMA for satellite applications and suggested a reasonable edge in capacity over FDMA & TDMA system. This edge was further explained in [4] after recognizing, CDMA capacity is only interference limited unlike FDMA and TDMA capacities, which are primarily bandwidth limited. Any reduction in interference converts directly and linearly into an increase in capacity. [5] Presented the capacity / coverage of the uplink/downlink of a CDMA system in different realistic radio signal propagation environments such as free space, rural, suburban and urban areas. However, despite its advantages, there are challenges in the design of

WCDMA receivers due to complexities associated with the detection and degradation of performance due to the Multiple Access Interference (MAI), which limits the capacity of the system. Multiple user detection (MUD) techniques have been proposed to mitigate MAI [13].

## 2 SYSTEM MODEL FOR CAPACITY

Capacity is defined as the total Number of users that can support the system simultaneously with in a cell of WCDMA. In order to derive an expression for the WCDMA system capacity in perfect power control, the energy per chip of all users is the same and equal to  $E_c$ . Ignoring the contribution of thermal Noise power spectral density to the effective noise power spectral density [6]. The Bit Energy to effective noise ratio ( $E_b/N_o$ ) is given by

$$\frac{E_b}{N_o} = \frac{E_b}{(K-1)E_c}$$
$$\frac{E_b}{N_o} = \frac{GpE_c}{(K-1)E_c} = \frac{Gp}{K-1}$$

If we take into account the background thermal noise (N) with the variance  $\sigma_n^2, E_b / N_o$  becomes.

$$\frac{E_b}{N_o} = \frac{Gp}{(K-1) + N / E_c}$$
$$\frac{E_b}{N_o} = \frac{Gp}{(k-1) + \sigma_n^2 / S}$$

Where (S) is the signal power and (N) is the one

sided noise power spectral density.  $G_p$  is referred to as the processing gain,  $E_b/N_o$  is the value required for adequate performance of the receiver. The number of users is reduced by the inverse of the signal to noise ratio (SNR) in the total system bandwidth  $W$ .

$$K \leq 1 + \frac{G_p}{E_b / N_o} - \frac{\sigma_n^2}{S} \quad (1)$$

### 3. IMPACT OF DIFFERENT PARAMETERS ON CAPACITY MODEL

The analysis takes into account a number of capacities influencing factor such as loading factor, sectorization, power factor, effect of intra & inter interference and voice activity factor. This paper does not explicitly address modulation techniques and their performance. Rather, assuming an efficient modulation and forward error correcting code for the given channels, established the conditions under which the receiver will achieve an acceptable level of performance, particularly in terms of the maximum number of users supportable per cell.

#### 3.1 Loading

The Eq (1) is effectively a model that describes the number of users in a single WCDMA cell can support and surrounded by the many cells in a cellular system [7]. Then the particular cell is said to be loaded by users from other cells. The effect of loading is shown mathematically in Eq (2).  $\eta$  is the loading factor and the inverse of the factor  $(1+\eta)$  known as frequency reuse factor  $F$ . The effect of loading on the performance of the system is shown in fig 1.

#### 3.2 Antenna Sectorization

Particular Cell can be sectorized to three sectors so that each sector is only receiving signals over 120 degrees. In effect, a sectorized rejects interference from users that are not within its antenna pattern. This arrangement decreases the effect of loading in a particular cell [9].

#### 3.3 Voice Activity

CDMA systems use speech coding, reducing the rate of the speech coder with voice activity detection along with variable rate data transmission could decrease the multiple access interference. By employing a variable rate vocoding, the system reduces the total interference power by this voice activity factor. According to [10], the voice activity factor for human speech averages about 42%. Thus Eq. (1) is modified to account for the effect of the entire three factors in eqn (2),

$$K = \left[ 1 + \frac{G_p}{E_b / N_o} \left( \frac{1}{1 + \eta} \right) \lambda \left( \frac{1}{\nu} \right) \right] \quad (2)$$

#### 3.4 Intra, Inter- Cell Interference

A very important issue in FDD Downlink is the orthogonality of the interference from the own cell. The intra-cell interference ( $I_{intra}$ ) caused due to own cell. The inter-cell interference ( $I_{inter}$ ), interference caused by neighboring cells. But in present study we consider the time dispersive, than the intra cell interference will spill over into the desired signal. The attained Signal to interference plus noise ratio Value is given in Eq (3) where  $S$  is the received signal strength,  $G_p$  is the processing gain and  $N$  is the thermal noise [2,10].

$$\frac{E_b}{I + N_o} = \frac{S.G_p}{I_{intra} + I_{inter} + N} \quad (3)$$

The fraction of the intra-cell interference caused by the users operating in the same cell to the total interference experienced by the desired user is given in Eq (4).

$$F = \frac{I_{intra}}{I_{intra} + I_{inter}} \quad (4)$$

$$\frac{E_b}{N_o} = \frac{G_p}{(K / F) - 1} \quad (5)$$

$$K = F \cdot \left[ 1 + G_p \left( \frac{E_b}{N_o} \right)^{-1} \right]$$

$K$  is the number of users that are associated with the cell receiving signals from the base station situated at the centre of the cell. By considering only those user which are in single cell but influenced by the inter cell interference [11]. The combine effect on multicell capacity is given by Eq (6).

$$K = F \left[ 1 + G_p \left( \frac{E_b}{N_o} \right)^{-1} \cdot \frac{1}{1 + \eta} \cdot \lambda \cdot \frac{1}{\nu} \right] \quad (6)$$

#### 3.5 Multi-user Detection (MUD)

A major technological difficulty of CDMA system is near far problem and Multiple Access Interference. The optimum multi-user detector for asynchronous multiple access Gaussian channels was obtained in [12,13], where it was shown that the near far problem suffered by the conventional CDMA receiver is overcome by a more sophisticated receiver, which accounts for the presence of other interference in the channel.

$$\frac{E_b}{N_o} = \frac{S.G_p}{(1 - \beta)I_{intra} + I_{inter} + N_o} \quad (7)$$

From Eq (4), Intercell interference can be calculated by

$$I_{inter} = \frac{1-F}{F} \cdot I_{intra} \quad (8)$$

$$\frac{Eb}{N_o} = \frac{S \cdot G_p}{(1-\beta)I_{intra} + \left(\frac{1-F}{F}\right)I_{intra} + N_0}$$

For K number of user in cell with all the capacity influencing parameter is shown in Eq (9).

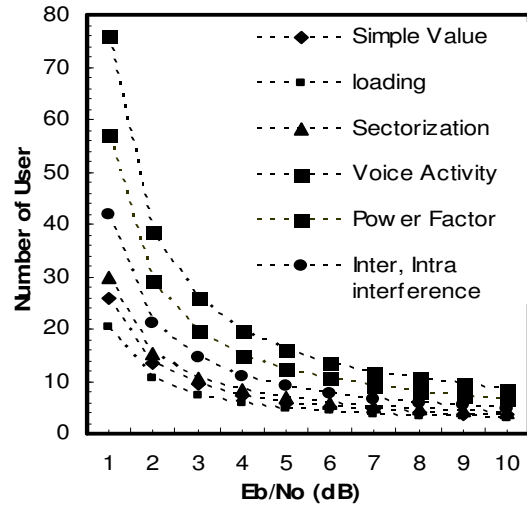
$$K = 1 + \frac{G_p \left(\frac{E_b}{N_o}\right)^{-1} \left(\frac{1}{1+\eta}\right) \lambda \cdot \alpha \cdot \frac{1}{v}}{\left[ (1-\beta) + \left(\frac{1-F}{F}\right) \right]} \quad (9)$$

#### 4 PERFORMANCE EVALUATION

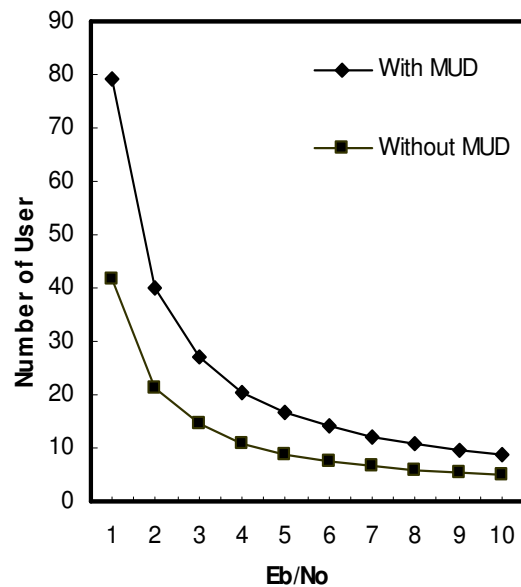
Fig 1 shows the variation in number of user as Eb/No is changed from 1 to 10 in the presence of loading factor 30%, Sectorization (1.5), Constant power control 75% to all the user, voice activity (3/8), fraction of Intracell Interference to total interference 73% when the chip rate is 3.84 Mcps & data rate is 12.2 kbps for voice service.

When the system contain processing gain and signal to noise ratio only than it support only 6 user at Eb/No 5 dB for voice application shown in fig 1 without any performance effecting parameter. As represented by simple value in the above said graph. Due to the loading factor on desired user by the neighboring cell, it degrade the capacity up to 5 user after that induced capacity enhancement parameter such as sectorization and voice activity. Due to this it supports 7 and 15 users with all the parameters.

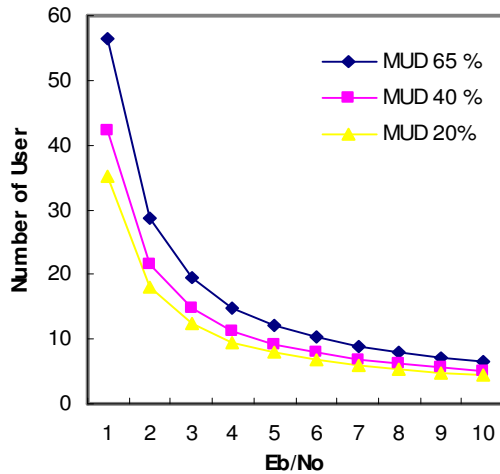
In multicell environment the effect of intra and inter interference directly affect the system capacity and reduces the number of user to 9 at fixed value of signal to noise ratio is 5 dB. Fig 2 shows the capacity enhancement in term of number of user with multiuser detection. The comparison between the combined effects of the different parameter with the capacity enhancement multiuser detection technique ( $\beta$ ) in multicell environment is shown in fig 2. It minimizes the multiple access interference and increases the performance upto 16 user per cell at all the same parameter taken in the fig 2. To study the impact of the different operation scenario, different multiuser detection factor assumed to represent different multipath propagation condition. The effect is shown in fig 3. The result shows that MUD is increased; the more users can access simultaneously same channel bandwidth.



**Figure 1** Effect of Variable factor on Capacity in term number of User at varying condition of signal to noise ratio (Eb/No)



**Figure 2** Effect of MUD on the system capacity at varying condition of Signal to noise ratio for Voice application



**Figure 3** Comparison of different value of MUD factor at voice application on Number of User with varying condition of Eb/No

## 5 CONCLUSION

CDMA based third generation (WCDMA) mobile networks need efficient network planning. The network planning process will allow the maximum number of users with adequate signal strength in a CDMA cell. The expression derived in this present work in cooperating the performance enhance parameters provides the improved the system performance in term of maximum number of user access the same channel bandwidth. The spectral utilization is found to be increased from 9 to 16 users at fixed value of Eb/No 5 dB at perfect power. Further it was found to decrease as the Eb/No is increased beyond five. The work is in progress for enhancement in the spectral efficiency beyond 5 dB value of Eb/No as well as different power constraints.

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## 6 REFERENCES

[1] Suyeb.A.Khan ,Jasvir Singh, M.Mian, Performance of Different Spreading Factor in WCDMA Downlink FDD Mode, International

Journal of Lateral Computing (Special Issue ), Vol 3, No.1 ISSN 0973-208X, PP 236-252 (2006).

[2] Prasad Ramjee, Tero ojenpera, Wideband CDMA for third generation Mobile Communication, Artech House, Boston London, (2001).

[3] Lee.W.C.Y, Overview of Cellular CDMA, IEEE Transaction on vehicular Technology, VOL. 40, PP-291-302, (1991).

[4] A.J Viterbi, When not to spread spectrum –A sequel, IEEE Communications Mag. Vol. 23, PP 12-17, (1985).

[5] Zreikat A.I, et al, A Comparative Capacity / Coverage Analysis for CDMA Cell in different Propagation Environment, Wireless Personal Communications, Vol. 28, PP 205-231,(2004).

[6] K.S Gilhousen et al, On the capacity of a Cellular CDMA System, IEEE Trans. On Veh. Tech. Vol 40. No 2, (1991).

[7] Prasad, Ramjee, CDMA for Wireless Personal Communication, Artech House, New York, USA (1998).

[8] Joseph C. Liberti, jr. etal, Analytical Result for the capacity improvements in CDMA, IEEE Transaction on vehicular technology , vol. 43, No. 3, PP 680-690, (1994).

[9] Ernestina Cianca, “Spread spectrum technique and their Applications to Wireless Communications”, IETE Journal of Research, Vol 15, No. 1 Jan-Feb 2005, PP-5-18.

[10] Suyeb Ahmed Khan, Jasvir Singh, M.Mian Capacity Analysis of WCDMA in forward Link FDD Mode System, 3<sup>rd</sup> IEE Mobility Conference 06,” Organized by Rangsit University, Bangkok, Thailand, 25 - 27 (2006). (Presented).

[11] H. Fu and J.S. Thompson. Downlink capacity analysis in 3GPP WCDMA networks system. 3G Mobile Commun. Technol., PP 534–538, (2002).

[12] S.H. Jeong and J.A, Copeland. Cell loss ratio and multiplexing gain of an ATM multiplexer for VBR voice sources. Local Computer Networks, PP 384–389,(1998).

[13] Multiuser Detection. Cambridge, U.K.: Cambridge Univ. Press, (1998).