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BOUNDING PERFORMANCE AND ANALYZING INTERCARRIER INTERFERENCE IN WIRELESS MOBILE CDMA

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Abstract

While rapid variations of the fading channel cause intercarrier interference (ICI) in code division multiplexing access (CDMA), thereby degrading its performance considerably,they also introduce temporal diversity, which can be exploited to improve the performance. In this paper,we first evaluate the Inter channel Interference which include the Signal to Interference Ratio (SIR) and Inter Carrier Interference (ICI) in a MC DS CDMA wireless system. . However, existing ICI cancellation methods do not cancel ICI entirely and the BER performance after ICI cancellation is still much worse than the BER performance of original system without ICI. Moreover, popular ICI cancellation methods like ICI self-cancellation reduce ICI at the price of lowering the transmission rate and reducing the bandwidth efficiency. Other frequency-domain coding methods do not reduce the data rate, but produce less reduction in ICI as well.

Keywords: ICI,CDMA,MC DS CDMA,BER,OFDM

I. INTRODUCTION

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Wireless communication is the transfer of information over a distance without the use of electrical conductors or "wires". The distances involved may be short (a few meters as in television remote control) or long (thousands or millions of kilometers for radio communications. Multiple access schemes based on a combination of code division and OFDM techniques have already proven to be strong candidates for future 4G systems[11]. Several techniques have been proposed. The three most popular proposals are multicarrier (MC-) CDMA, multicarrier modulation with direct sequence (DS-) CDMA, and multitone(MT-) CDMA . In this thesis, I concentrate on MC-CDMA, a novel digital modulation and multi access scheme and a very promising technique for 4th generation cellular mobile radio systems. MC-CDMA allows high-capacity networks and robustness in frequency selective channels. MC-CDMA is a combination of OFDM and code division techniques. Hence, we will study the current state-of-the art trends for implementation of OFDM and CDMA using Field Programmable Gate Array (FPGA) devices. The implementation of OFDM and CDMA have been categorized according to modulation/demodulation, detection, channel estimation, synchronization, interference suppression, frequency offset estimation, timing recovery, and equalization.

II. RELATED TECHNIQUES

A.Code Division Multiple Access (CDMA)

Code division multiple access (CDMA) is a channel access method utilized by various radio communication technologies. It should not be confused with the mobile phone standards called CDMA One and CDMA2000 (which are often referred to as simply "CDMA"), which use CDMA as an underlying channel access method.

One of the basic concepts in data communication is the idea of allowing several transmitters to send information simultaneously over a single communication channel.CDMA is a form of

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spectrum "signaling, since the modulated coded signal has a much higher data bandwidth than the data being communicated.

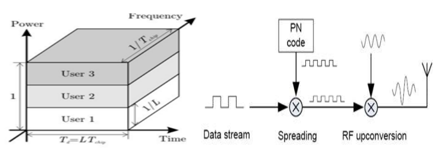

Fig 1 and 2 Code Division Multiple Accesses (CDMA)

An analogy to the problem of multiple access is a room (channel) in which people wish to communicate with each other. To avoid confusion, people could take turns speaking (time division), speak at different pitches (frequency division), or speak in different languages (code division). CDMA is analogous to the last example where people speaking the same language can understand each other, but not other people. Similarly, in radio CDMA, each group of users is given a shared code. Many codes occupy the same channel, but only users associated with a particular code can understand each other.

B. Direct Sequence Code Division Multiple Access (DS-CDMA)

In Direct Sequence spread spectrum transmission, the user data signal is multiplied by a code sequence. Mostly, binary sequences are used. The duration of an element in the code is called the "chip time". The ratio between the user symbol time and the chip time is called the spread factor.The transmit signal occupies a bandwidth that equals the spread factor times the bandwidth of the user data.

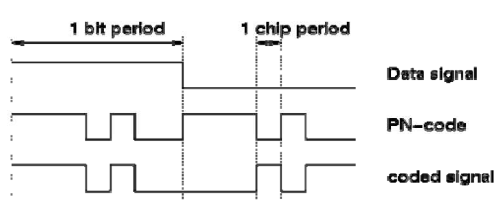

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Fig 3. A DS-CDMA signal is generated by multiplication of a user data signal by a code sequence

C. Multi Carrier Direct Sequence Code Division Multiple Access (MC DS CDMA)

The multicarrier DS-CDMA transmitter spreads the S/P converter data streams using a given spreading code in the time domain so that the resulting spectrum of each sub carrier can satisfy the orthogonality condition with the minimum frequency separation. This scheme is orthogonally proposed for a uplink communication channel, because the introduction of OFDM signaling into DS-CDMA scheme is effective for the establishment of a quasi-synchronous channel.

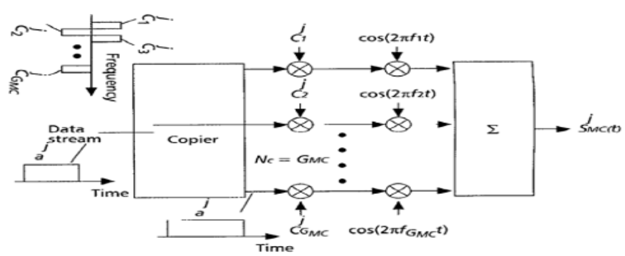

Fig 4. MC DS-CDMA scheme transmitter

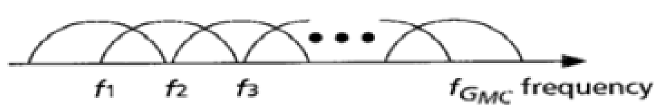

Fig 5 MC DS-CDMA power spectrum of transmitted signal

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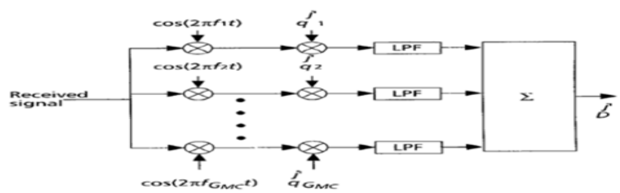

Fig 6 MC DS-CDMA receiver

The block diagram of a MC-DS CDMA transmitter is shown in Figure 4. The incoming data stream is first converted to a parallel stream and then spread in time using spreading codes. This ensures that the resulting spectrum has orthogonal subcarriers. The spreading code is represented as *C(t)* and the processing gain is *N*. The receiver block is shown in Figure 6. The despreading is done in time after the FFT followed by a low pass filter and demodulation. In the figure show the MC DS-CDMA transmitted signal, respectively, where G_{MC} denotes the processing gain, N the number of sub carriers, and Cj(t). The spreading code of the j-th user. In a MC DS-CDMA scheme with a larger sub carrier separation is proposed in order to yield both frequency diversity improvement and narrow band interference suppression. In addition, a MC DS-CDMA scheme, which transmits the same data using several sub carriers, is proposed.

III. Evaluation of Interchannel Interference

A. Gaussian Approximation

This method used to evaluate the effect of interchannel interference on the receiver performance is the Gaussian Approximation. To use the Gaussian Approximation the first and second derivatives of the MGF have to be calculated in order to obtain the mean and standard deviation.

Thus, we have:

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$$M'_{ON}(s) = n_1\lambda_1(1+\lambda_1 s)^{n_1-1}(1+\lambda_2 s)^{n_2} + n_2\lambda_2(1+\lambda_2 s)^{n_2-1}(1+\lambda_1 s)^{n_1} \tag{1}$$

and

$$M''_{ON}(s) = n_1(n_1-1)\lambda_1^2(1+\lambda_1 s)^{n_1-2}(1+\lambda_2 s)+n_2(n_2-1)\lambda_2^2(1+\lambda_2 s)^{n_2-2}(1+\lambda_1 s)+ \\ + 2n_1n_2\lambda_1\lambda_2(1+\lambda_1 s)^{n_1-1}(1+\lambda_2 s)^{n_2-1} \tag{2}$$

As the mean is given by *M*□*ON*□(0) we have

$$\mu_{ON} = n_1\lambda_1 + n_2\lambda_2 \tag{3}$$

The variance which is given by (4) is

$$\sigma_{ON}^2 = -n_1\lambda_1^2 - n_2\lambda_2^2 \tag{4}$$

By replacing n_1 , n_2 ,□□□, and □□□with their definitions the following equations for the mean and standard deviation are obtained for the ON-case:

$$\mu_{ON} - 4mk^2\left(\frac{2}{x}+1\right)+4m(1-k)^2\left(\frac{1}{x}+1\right) \tag{5}$$

and

$$\sigma_{ON} = \sqrt{8mk^3\left(\frac{2}{x}+1\right)^2 + 8m(1-k)^3\left(\frac{1}{x}+1\right)^2} \tag{6}$$

By taking a similar approach in the OFF-case, the mean and standard deviation are obtained as

$$\mu_{OFF} = 4mk^2\left(\frac{1}{x}+1\right)+4m(1-k)^2 \tag{7}$$

And

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$$\sigma_{OFF} = \sqrt{8mk^3\left(\frac{1}{x}+1\right)^2 + 8m(1-k)^3}$$

(8)

With the use of the parameters calculated above, the BER can be calculated. To analyze the receiver performance the BER was fixed at 10^{-6} and 10^{-9}. The optimum values of *m* and the receiver sensitivity *p N* were calculated for different values of the channel overlap *k*.

For the double-sided interference case the procedure is the same. However, equations (5) to (8) have to be changed to include the effects of two interfering signals and not just one. The equivalent equations are given by

$$\mu_{ON} = 4mk^2\left(\frac{3}{x}+1\right) + 4m(1-k)^2\left(\frac{1}{x}+1\right)$$

(9)

$$\sigma_{ON} = \sqrt{8mk^3\left(\frac{3}{x}+1\right)^2 + 8m(1-k)^3\left(\frac{1}{x}+1\right)^2} \qquad (10)$$

$$\mu_{OFF} = 4mk^2\left(\frac{2}{x}+1\right) + 4m(1-k)^2 \qquad (11)$$

$$\sigma_{OFF} = \sqrt{8mk^3\left(\frac{2}{x}+1\right)^2 + 8m(1-k)^3}$$

B. Chi-Square Approximation

The second method used to evaluate the effect of the interchannel interference on the receiver performance is the chi-square approximation. The mean and variances, which were

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obtained in the previous section for the Gaussian Approximation, were fitted into the MGF of a random variable with chi-square distribution.

For the ON-case, the MGF is of the following form

$$M_{ON}(s) = \left[1 - 2\sigma_{ON}^{2} s\right]^{-2m_1}$$

(12)

Where $$m_1 = \frac{\mu_{ON}^2}{2\sigma_{ON}^2}$$

□□□□ and □ □ON□□are given by (5) and (6) respectively.

For the OFF-case, the MGF is of the form

$$M_{OFF}(s) = \left[1 - 2\sigma_{OFF}^{2} s\right]^{-2m_0}$$

(13)

Where

$$m_0 = \frac{\mu_{OFF}^2}{2\sigma_{OFF}^2}$$

and □□□FF and □ OFF□ □are given be equations (10) and (11) respectively.

The procedure described above is valid for both the single and double-sided interference cases. The only difference is the use of the different values of □□□□ , □ ON□□□□□□□FF and □ OFF□ for each case.

IV. Simulation Results

A. Numbers of user (j) with the signal to interference ratio (SIR)

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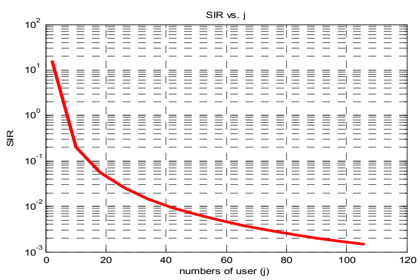

Fig 7. SIR vs. j

Here we can see the plot between the numbers of user (j) vs. the signal to interference ratio (SIR). If we increase the numbers of user (j), the signal to interference ratio will decrease. The signal to interference ratio depends on signal power (Ps). Here Ps=1mw and the curve is for the number of sub-carrier (Nc) = 4.

B. Number of user with signal to interference ratio (Nc = 4, 10, 18, 30)

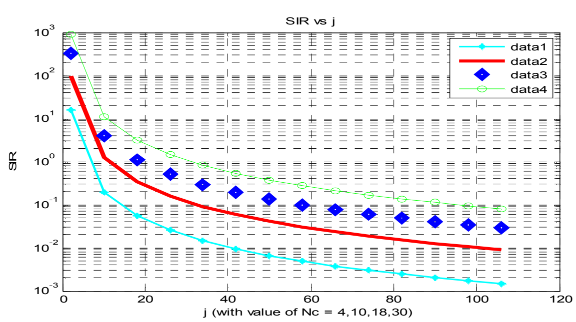

Fig 8. SIR vs. j (with value of Nc)

This figure is modified version of previous one. Here we can see that the plot is in between the number of user vs. signal to interference ratio. Here the signal power is 1mw and we

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vary the number of sub-carrier (Nc) such as Nc = 4, 10, 18, 30. If we increase the number of user (j) then the signal to interference ratio will be decrease.

C. The number of user (j) with Inter Carrier Interference (ICI)

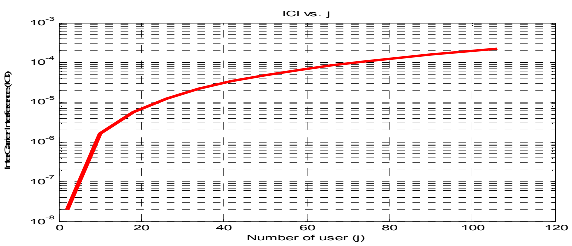

Fig 9. ICI vs. j

Here we can see that the plot is about the number of user (j) vs. Inter Carrier Interference (ICI). If we increase the number of user (j) then the inter carrier interference (ICI) will be increase. Here the number of user is 14 times, signal power is 1mw and the we have used the ICI equation and the curve is for the value of alpha = 0.2

D. The numbers of user (j) with inter-carrier interference (ICI) (with value alpha)

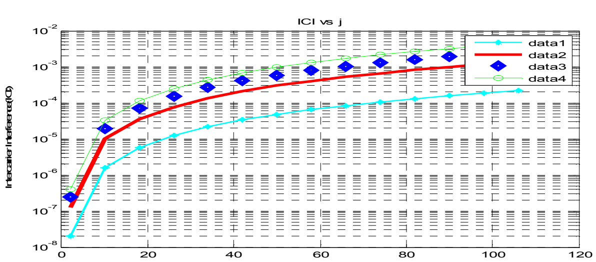

Fig 10. ICI vs. j (with value alpha)

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Here we can see the modified version of the plot between the numbers of user (j) vs. inter-carrier interference (ICI). We have plotted these curves for different values of alpha such as alpha = 0.2, 0.5, 0.7, 0.9. The signal power is also Ps = 1mw and the number of user is 14.

VI. Conclusion

1. On comparing Numbers of user (j) with the signal to interference ratio (SIR): If we increase the numbers of user (j), the signal to interference ratio will decrease. The signal to interference ratio depends on signal power (Ps).
2. On comparing Numbers of user (j) with the signal to interference ratio (SIR) with different value of Nc = 4, 10, 18, 30: If we increase the number of user (j) then the signal to interference ratio will be decrease.
3. On comparing the numbers of user (j) with inter-carrier interference (ICI) as we increase the number of user (j) then the inter carrier interference (ICI) will be increase.
4. On comparing the numbers of user (j) with inter-carrier interference (ICI) (with value alpha): If we increase the number of user (j) then the inter carrier interference (ICI) will be increase. We have plotted these curves for different values of alpha such as alpha = 0.2, 0.5, 0.7, 0.9.

References

[1] Xue Li, Ruolin Zhou, Steven Hong, and Zhiqiang Wu , “Total Inter-Carrier Interference Cancellation for MC-CDMA System in Mobile Environment” , IEEE Communications Society subject matter experts for publication in the IEEE Globecom 2010 proceedings.

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http://www.ijccr.com
VOLUME 2 ISSUE 1 JANUARY 2012

[2] V.Jagan naveen, K.Murali Krishna, K.RajaRajeswari "Performance Analysis Of MC-CDMA And OFDM In Wireless Rayleigh Channel" International Journal of Advanced Science and TechnologInternational Technology Vol. 25, December, 2010
[3] Tao LUO, Gang WU, and Shaoqian LI, Yong Liang GUAN, Choi Look LAW, "DS-CDMA and MC-CDMA with Per-User MMSE Frequency Domain Equalization", International journal of hybrid information technology, vol 1.1,No. 3, july2008
[4] V.Nagarajan and P.Dananjayan, "Performance Enhancement Of MC-DS/CDMA System Using Chaotic Spreading Sequence" , Journal of Theoretical and Applied Information Technology, 2005 - 2008 JATIT.
[5] Arvind Kumar, and Rajoo Pandey "An Improved ICI Self-Cancellation Scheme for Multi-Carrier Communication Systems" World Academy of Science, Engineering and Technology 32 2007
[6] Salih M. Salih, N. Uzunoglu, A. A. Ali and Waleed A. Mahmud "A Proposed Improvement Model of MC-CDMA Based FFT in AWGN Channel" Pg.517-520, IEEE 2007.
[7] Hen-Geul Yeh, Yuan-Kwei Chang, and Babak Hassibi "A Scheme for Cancelling Intercarrier Interference using Conjugate Transmission in Multicarrier Communication Systems" IEEE Transactions On Wireless Communications,VOL6.
[8] Mohd. Hasan, Tughrul Arslan, and John S. Thompson, "Low-Power-Adaptive MC-CDMA Receiver Architecture" , ETRI Journal, Volume 29, Number 1, February 2007
[9] Ranjith Padmasiri Takeo Fujii Yukihiro Kamiya Yasuo Suzuki , "Variable Spreading Method for MC/DS-CDMA Road to Vehicle Communication System" , 2006 IEEE Ninth International Symposium on Spread Spectrum Techniques and Applications
[10] Vasu Chakravarthy, Abel S. Nunez, And James P. Stephens, "TDCS, OFDM, AND MC-CDMA: A Brief Tutorial", IEEE Radio Communications, September 2005
[11] Xiaodong Cai , Georgios B. Giannakis, "Bounding Performance and Suppressing Intercarrier Interference in Wireless Mobile OFDM" IEEE Transactions On Communications, VOL. 51, NO. 12, December 2003

[12] A. C. Mccormick and E.A. Al-susa, “Multicarrier CDMA for Future generation mobile communication” , Electronics & Communication Engineering Journal, april 2002