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Ant Colony Optimization Algorithm For PAPR Reduction In Multicarrier Code Division Multiple Access System

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ABSTRACT
MC CDMA is a rising candidate for future generation broadband wireless communication and gained great attention from researchers. It provides benefits of both OFDM and CDMA. Main challenging problem of MC CDMA is high PAPR. It occurs in HPA and reduces system efficiency. There are many PAPR reduction techniques for MC CDMA. In this paper we proposed Ant colony optimization algorithm to reduce PAPR with different number of user using BPSK and QPSK modulation. ACO is a metaheuristic technique and based on the foraging behavior of real ants. It provides solution to many complex problems. Simulation result proves that ACO using BPSK modulation is effective for reducing PAPR in MC CDMA.

***Keywords* –** Ant colony optimization, Complementary Cumulative Distribution Function (CCDF), MC CDMA, OFDM, PAPR

I. INTRODUCTION

Mobile radio communication systems are needed to give high-quality multimedia services to mobile users. Combination of OFDM and CDMA has gained interest from researchers as multiple access method for future wireless communication. One of best combination is MC CDMA (multicarrier code division multiple access) [1]. MC CDMA is an emerging technique for future generation multi-carrier broadband wireless transmission and mobile communications because high bit rate is required for these communication. MC CDMA is a fusion of CDMA and OFDM and keeps the benefit of both techniques.

In MC-CDMA, First all user in system are divided into many small groups. Then all user are spread by spreading codes to obtain frequency diversity gain and signals are converted into parallel streams [2]. This provides non selective fading in every subcarrier. The OFDM part of MC CDMA is high speed wireless data transmission system. It allows good spectral efficiency, high data rate, robustness against multipath fading. OFDM provides solution for the selectivity of the channel. This makes transmission of high data rate in fading environment. Other part i.e. CDMA provides multiple access capability by parallel transmission of multiple users [3]. Therefore MC CDMA has accomplished protection versus both time dispersion channel and frequency selective fading and also offers multiple access strategy.

OFDM and MC CDMA gives following advantages: (1) racy to inter- symbol interference, co-channel interference and impulsive parasitic noise; (2) lower implementation complication compared with the single carrier solution; and (3) high spectral efficiency [4]. Despite the advantages of MC CDMA, it has many disadvantages such as sensivity to frequency offset, problem in subcarrier synchronization and high peak to average power ratio. The challenging problem is high PAPR. PAPR occur in HPA used at transmitter and produce distortion in signal. It occurs because transmitted signal is sum of many large independent signals. PAPR increases with increased number of sub carrier which produces in band distortion, spectrum regrowth, damage in detection efficiency, excess battery consumption. High PAPR increases complexity of ADC and DAC. Thus reduction of PAPR is an important research topic for wireless system [5].

There are many PAPR reduction techniques given in literature. These techniques are grouped into three categories: signal distortion techniques, signal scrambling techniques and coding techniques. Clipping, peak windowing, peak cancellation and companding comes under signal distortion schemes. Selected Mapping (SLM)[6], Partial Transmit Sequence (PTS)[7] comes under scrambling scheme. Golay complementary sequences, Shopire-Rudin sequences, and barker codes come under Coding techniques which are used for signal scrambling. In spite of these techniques, there are many optimization algorithm to reduce high PAPR of MC CDMA, like swarm optimization, chip optimization, artificial ant colony optimization, genetic algorithm, artificial bee colony algorithm etc. Swarm optimization is basic of all other algorithms [8].

In this paper we proposed ant colony optimization technique to reduce PAPR of MC

CDMA signal. ACO is a new metaheuristic approach for solving hard combinatorial optimization problems. ACO is based on the foraging behavior of real ants. ACO has autocatalytic behavior means it has positive feedback. The source of ACO is the pheromone laying and following conduct of ants which apply pheromones as a communicating medium. ACO is based on choosing a city, updating pheromone trails and pheromone trail decay. PAPR value is calculated after complete tour of ants.

This paper is organized as follow: In first section 2, MC CDMA system model, PAPR and CCDF is described. In section 3, ant colony optimization algorithm is explained. In section 4, simulation result of MATLAB and result is given. In section 5, conclusion and in section 6, conclusion is given.

II. SYSTEM DESCRIPTION

2.1 System model

The basic transmitter structure is similar to OFDM. In OFDM different symbols are transmitted on the subcarriers, but same symbol on several subcarriers are transmitted in MC CDMA [9].

The MC CDMA transmitter configuration of the pth user for downlink is shown in Fig 1. There are p active users. It transmits P user's data symbol simultaneously on several sub channels. After modulation, user data is send to the spreader and mapped in the frequency domain using Inverse Fast Fourier Transform (IFFT). At the spreader pth user's spreading sequence is used to spread the p user data in the time domain, then give to Quadrature Amplitude Modulation (QAM) mapper followed by serial to parallel (S/P) converter. IFFT is used to divide the bandwidth into orthogonal overlapping Kc subcarriers and modulated by a single chip. This data is converted into serial data and then cyclic prefix or guard interval is inserted to scrap ISI. Finally for transmission the signal is send to Digital to Analog converter through Rayleigh fading channel with Additive White Gaussian Noise (AWGN) followed by HPA [10]. Transmitted signal is represented as:

$$x(t) = \frac{1}{\sqrt{P}} \sum_{m=1}^{M} \sum_{j=1}^{J} \sum_{k=1}^{P} d_m^{(p)} c_j^{(p)} e^{j2\Pi\{M(j-1)+(m-1)\}t/T_s} \quad (1)$$

Where
T_s is symbol period of signal, in which $0 \le t \le T_s$.

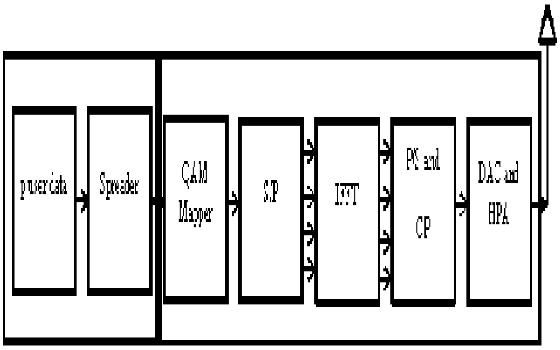

Fig 1: block diagram of MC CDMA transmitter [10]

2.2 Peak to Average Power Ratio

PAPR is a criterion to measure the level of peak power. PAPR is evaluated per symbol. PAPR can be stated as relation of maximum power of transmit symbol divided by average power of that symbol [11]. In MC CDMA, signal is sum of narrowband signals. The peak power of these added subcarrier signal becomes N times larger than average power [12].High PAPR decrease efficiency and increase the cost of RF power amplifier which is costly component in radio. In simple words PAPR is defined as the ratio of peak power to the average power of multicarrier signal. Mathematically it is represented as:

$$PAPR = \frac{p_{peak}}{p_{average}} = 10\log_{10} \frac{\max\left[|x(t)|^2\right]}{E\left[|x(t)|^2\right]} \quad (2)$$

Where p_{peak} is output peak power and $p_{average}$ is output average power.

2.3 Cumulative Distribution Function

The parameter Cumulative Distribution Function (CDF) is used to measure the performance of any PAPR technique. Complementary CDF curve defines how much time signal spends at or above a given power level. The CCDF of PAPR provides probability that the PAPR of MC CDMA symbol exceeds a given threshold PAPR0. The CCDF of PAPR can be written as:

$$CCDF(PAPR0) = (PAPR > PAPR0) \quad (3)$$

The power level is represented in dB relative to the average power. A CCDF curve is fundamentally a plot of relative power levels versus probability. The CCDF is the Complement of CDF and is given as:

$$CCDF = 1 - CDF \quad (4)$$

III. ANT COLONY OPTIMIZATION

Ant colony optimization algorithm is proposed by Marco Dorigo in 1991 in his PhD thesis. ACO is inspired from the foraging behavior of real ants. Solution for complex problems is determined whether it is good or bad using ACO.

When ants find the food source they return to their colony leaving behind a chemical known as pheromone trail. Other ants comprehend pheromone and choose the path on which concentration of pheromone is high. Intensity of pheromone determines which city is visited to be next. ACO algorithm has positive feedback. PAPR is determined on the basis of intensity of trail. PAPR is determined after the one complete tour. Every city is visited only once in one tour. This record is kept is taboo list. Taboo list memorizes the cities which have visited in tour and intensity of pheromone. Compute the length of path. Pheromone is updated continuously and path is determined again. Record the shortest path. The cycle is repeated continuously until best solution i.e. minimum PAPR is determined [13].

Probability that ant goes from city l to city m is given by:

$$p_{l,m} = \frac{\tau_{l,m}^{a}\eta_{l,m}^{b}}{\sum_{c=1}^{g}\tau_{l,m}^{a}\eta_{l,m}^{b}} \quad (5)$$

Where

$\tau_{l,m}$ is amount of pheromone

$\eta_{l,m}$ is desirability of transition

a and b are parameters to control trail versus visibility

Pheromone intensity after updating is given by:

$$\tau_{l,m}(f+1) = q\tau_{l,m}(f) + \Delta\tau_{l,m} \quad (6)$$

Where

q is pheromone evaporation coefficient

$\Delta\tau_{l,m}$ Is intensity increment and is given by:

$$\Delta\tau_{l,m} = \sum_{k=1}^{m}\Delta\tau_{l.m}^{k} \quad (7)$$

Where

If city (l, m) is used by ant, then $\Delta\tau_{l,m}^{k} = q$ otherwise $\Delta\tau_{l,m}^{k} = 0$.

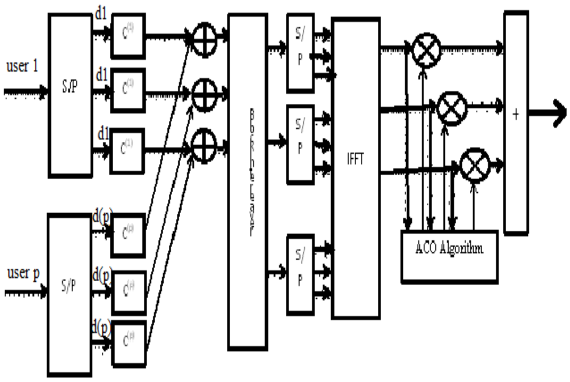

Fig 2: block diagram of ACO

Fig 2 shows the transmitter model of MC CDMA with ACO. After performing IFFT of signal, ant colony optimization is applied on it. Output of ACO and IFFT are multiplied and signal is transmitted on AWGN channel using Rayleigh fading. Then signal are summed up and value of PAPR is calculated. Minimum value of PAPR is taken as final output.

IV. SIMULATION AND RESULT

In this section, performance of MC CDMA is evaluated using ant colony optimization. Table 1 shows the simulation parameters used.

Table 1: Simulation Parameters

Spreading Codes	Walsh Hadamard
Modulation Process	BPSK,QPSK
Processing Gain	16
Number of data symbols per MC CDMA symbol	8
Number of sub carrier	128
Number of user,k	8,16
Oversampling factor	4

In our simulation, the MC CDMA system employed using active user 8 and 16, sub carrier are 128, a walsh hadamard spreading code of length 16and BPSK and QPSK modulation. The oversampling factor is 4 of the system. CCDF of PAPR of transmitted continuous time signal is used for evaluating PAPR reduction. CCDF curves are represented for 1000 input symbol.

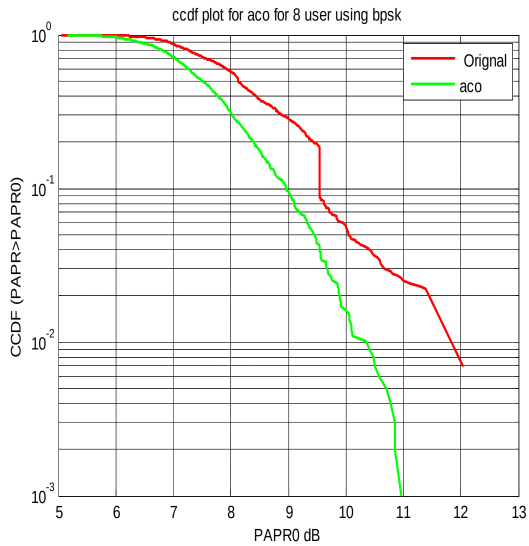

Fig 3: CCDF of PAPR of BPSK modulated MC CDMA using ACO with k=8

Fig 3 shows CCDF of PAPR of BPSK modulated MC CDMA using ACO with 8 number of user. The value of PAPR is reduced by 1 dB for ACO when compared to original MC CDMA signal at CCDF=10^{-3}.

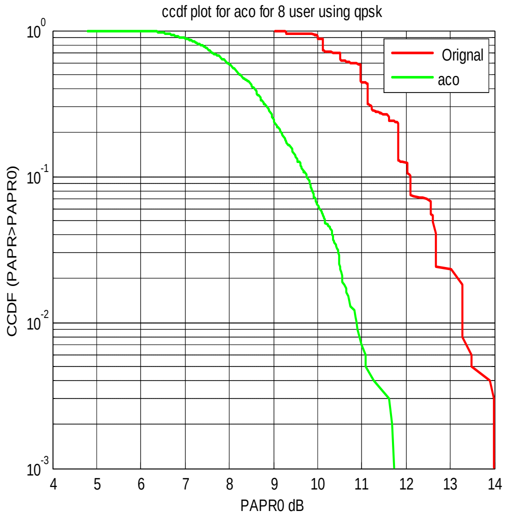

Fig 4: CCDF of PAPR of QPSK modulated MC CDMA using ACO with k=8

Fig 4 shows CCDF of PAPR of QPSK modulated MC CDMA using ACO with 8 number of user. The value of PAPR is reduced by 2.2 dB for ACO when compared to original MC CDMA signal at CCDF=10^{-3}.

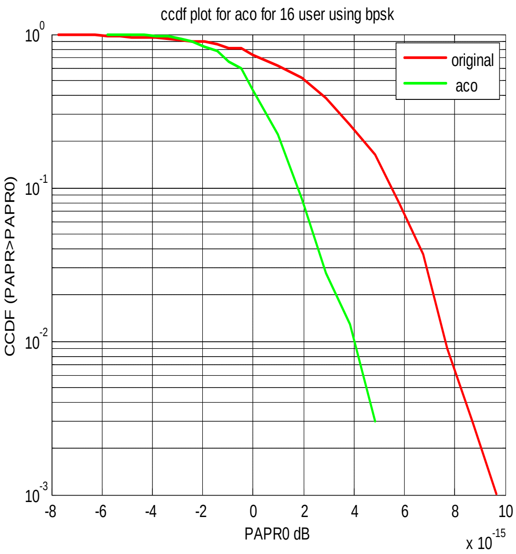

Fig 5: CCDF of PAPR of BPSK modulated MC CDMA using ACO with k=16

Fig 5 shows CCDF of PAPR of BPSK modulated MC CDMA using ACO with 16 number of user. The value of PAPR is reduced by 4 dB for ACO when compared to original MC CDMA signal at CCDF=10^{-3}.

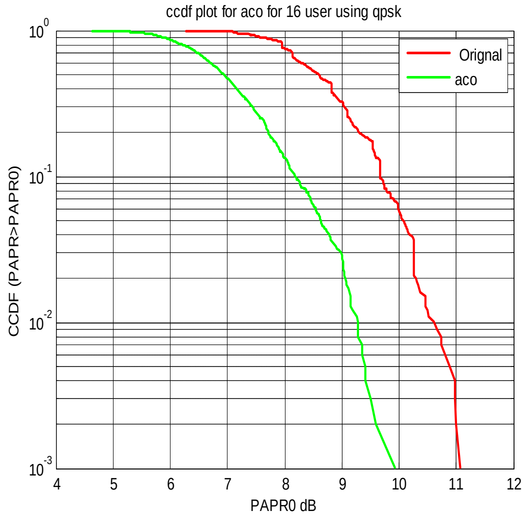

Fig 6: CCDF of PAPR of QPSK modulated MC CDMA using ACO with k=16

Fig 6 shows CCDF of PAPR of QPSK modulated MC CDMA using ACO with 16 number of user. The value of PAPR is reduced by 0.8 dB for ACO when compared to original MC CDMA signal at CCDF=10^{-3}.

V. CONCLUSION

The challenging problem of MC CDMA is high PAPR. In this paper, we have proposed ant colony optimization algorithm for PAPR reduction of MC CDMA. ACO is swarm intelligence based algorithm and is inspired from behavior of real ants. We calculated PAPR for different number of users using BPSK and QPSK modulation. From MATLAB simulation it is concluded that BPSK modulation is best for PAPR reduction in MC CDMA. PAPR reduction increases as we increase number of user.

VI. ACKNOWLEDGEMENT

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REFERENCES

[1] M. Tabulo, D. Laurenson, S. McLaughlin and E. Al-Susa, *A Linear Programming Algorithm for a Grouped MC-CDMA System, IEEE,* 2003.
[2] Y. Zhang, Q. Ni, H. Chen, Y. Song, *AnIntelligent Genetic Algorithm for PAPR Reduction in a Multi-Carrier CDMA Wireless System,* , *IEEE*, August, 2009.
[3] S. Jitapunkul, K. Wutthipompong, J. Songthanasak and S. Kunaruttanapruk, *Peak to Average Power Ratio Reduction in MC-*

CDMA using Partial Transmit Sequences, *IEEE*, 2004.

[4] R. Manjith, S. C. Ramesh and M. M. I. Majeed, *Papr Reduction In Ofdm & Mc-Cdma Systemusing Nonlinear Companding Techniques*, *Irkutsk Listvyanka, Russia,* July 2010, 11 – 15.

[5] N. T. Pınar, D. Karabog, M. Yıldırım and B. Akay,] *Partial Transmit Sequences Based On Artificial Bee Colony Algorithm For Peak-To-Average Power Ratio Reduction In Multicarrier Code Division Multiple Access Systems*, *IET Commun., 5(8),* 2011, 1155–1162.

[6] B. uml, R.W., Fisher, R.F.H., Huber, J.B., *Reducing The Peak-To average Power Ratio Of Multicarrier Modulation By Selected Mapping*, *Electron. Lett., 32(22),* 1996, 2056–2057.

[7] Mu¨ller, S.H., Huber, J.B., *OFDM with reduced peak-to-average power ratio by optimum combining of partial transmit sequences*, *Electron. Lett.*, *33(5)*, 1997, 368–369.

[8] K. Singla, R. Kaur, G. Kaur, *An Overview of PAPR Reduction Optimization Algorithm for MC CDMA System*, *International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622, National Conference on Advances in Engineering and Technology (AET- 29th March 2014).*

[9] Z. Fedra and V. Sebesta, *The new PAPR reduction approach in MC-CDMA*, *IEEE,* 2006.

[10] B. Sarala1 and D. S. Venkateswarulu, B. N. Bhandari, *Overview Of MC CDMA PAPR Reduction Techniques*, *International Journal of Distributed and Parallel Systems (IJDPS), 3(2),* March 2012.

[11] S. Singla and V. Tiwana, *PAPR Reduction in OFDM System Using Ant Colony Optimization*, *International Journal of Advanced Research in Computer and Communication Engineering, 2(8),* August 2013.

[12] G. Kaur and R. Kaur, *An Overview of PAPR Reduction Techniques for an MC-CDMA System*, *International Journal of Advanced Research in Computer Engineering & Technology, 1(4),* June 2012.

[13] Y. Pei, W. Wang, S. Zhang, *Basic Ant Colony Optimization*, *International Conference on Computer Science and Electronics Engineering,* 2012.