ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 2, Issue 2, February 2013

Concert augmentation in Cognitive Radio System with OFDM and Beamforming technique for Data communication

A. Suban, K.Mangayarkarasi

Abstract— **Cognitive radio is an proficiency that enables the cognitive users (secondary users) to stumble on white space (unused spectrum) in the primary user's spectrum band and allowing them to make exploit of the detected spectrum of data transmission. As soon as the white space has been recognized, it will be worn by a number of secondary users. When the number of users exists it is alike as Multiple Input Multiple Output (MIMO). Provision a large number of users bring into play the detected spectrum for data transmission, this will forge mutual interference among them. The MIMO characteristics are improved by using Orthogonal Frequency Division Multiplexing (OFDM) using its orthogonal subcarriers. OFDM has an added advantage of producing less BER yet for the negative SNR. But high Peak to Average Power Ratio (PAPR) is a crucial drawback for such multicarrier technique. This aspect is also analyzed with Partial Transmit Sequence (PTS). Further the performance of the users is increased by using Beamforming technique. In this paper we showed the performance graph of MIMO-OFDM for different dimensions of MIMO antennas, PTS to reduce PAPR, and Beamforming for enhanced performance**

Index Terms—**Cognitive radio, MIMO, OFDM, PAPR, PTS, Beamforming**

I. INTRODUCTION

Highlight Cognitive radio is emerging as a technology, used for the future radio networks [1,2] for identification of the unused spectrum of the primary users at that time. After detecting the spectrum hole, it is used for the efficient transmission of data between the secondary users, so that the spectrum will be shared without any interference between them. In general, ideal spectrum sensing cannot be done in practice and thus mutual interference can occur between the primary and secondary (cognitive) users, this leads to the QoS constraint of the secondary user [3]. In order to have a consistent cognitive radio system with high data rates, it requires most efficient way of spectrum sensing and data transmission methods. For the dynamic spectrum detection and data transmission, the cooperative relay technology is considered. The cooperative sensing of spectrum will be done in two phases: the phase of signal detected by the cognitive users, and the phase of initial detection results in reporting to the fusion center, these phases in general are referred to as detection and reporting phase.

The report on the signal detection of the channel to the fusion center will be done using the dedicated channel [4] and [5]. This usage of dedicated channel for reporting phase is done in order to avoid interference with the primary user. However, this approach of using a dedicated channel requires extra spectrum resources and it involves complex signaling issues due to dedicated channel resource management. In [6,7], the concept of selective relay based cooperative sensing (SRCS) was introduced in order to avoid the usage of orthogonal channel for reporting phase.
The consistent cognitive radio system with high data rate will be achieved by the cooperative relays for both the spectrum sensing and data transmission [8, 9]. Here, the spectrum sensing and data transmission will be done cooperatively, and it cannot be optimized separated. If the time for spectrum sensing is increased then the time intended for secondary transmission will be condensed [10].

II. PROPOSED SYSTEM MODEL

A. *Cognitive Radio System as MIMO*

MIMO techniques are one of the promising concepts in wireless communications Multiple-Input Multiple-Output (MIMO) is effectively a radio antenna technology as it uses multiple antennas at the transmitter and receiver to enable a variety of signal paths to carry the data. Accordingly MIMO wireless systems can be viewed as a logical extension to the smart antennas that have been used for many years to improve wireless communication link. A channel may be affected by fading and this will impact the signal to noise ratio. In turn this will blow the error rate, presumptuous that a digital data is being transmitted. The standard of spatial diversity is to provide the receiver with multiple versions of the same signal. If these signals are affected in different ways by the signal path, the probability that all these signals will be affected at the same time is considerably reduced. It provides improvements in the signal to noise ratio and they are characterized by improving the reliability of the system with respect to the various forms of fading.

The multiple paths only served to introduce interference.

Manuscript received Sep 15, 2012.
A.Suban *is Assistant Professor in the Department of Electronics and Communication Engineering, Velammal College of Engineering and Technology, Madurai-625009, Tamil Nadu, India.*
K.Mangayarkarasi *is M.E final year with the Department of Electronics and Communication Engineering (Communication Systems), Velammal College of Engineering and Technology, Madurai-625009, Tamil Nadu, India.*

By using MIMO, these supplementary paths can be used as an advantage. They can provide additional robustness to the radio link. This in turn acts as a powerful feature for increasing channel capacity at higher Signal to Noise Ratio (SNR). Thus the probability of occurrence of error is reduced by the use of MIMO system that too with optimal use of bandwidth. It makes use of multipath to increase the chance of correctly decoding the received signal-thus lowering the bit error rate.

The general outline of Cognitive radio as MIMO is shown in Fig.1

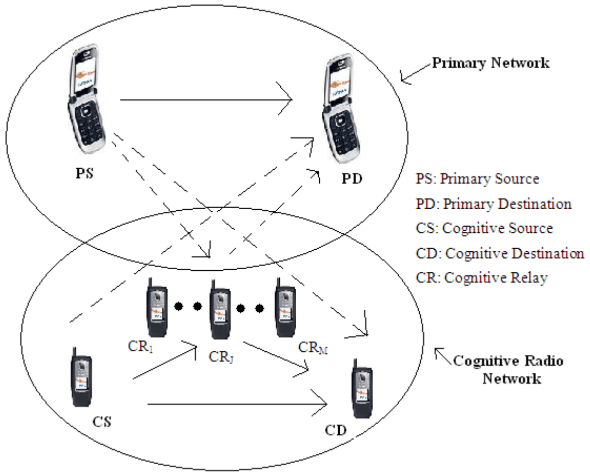

Fig.1 A cognitive radio as MIMO

B. Cognitive Radio System with OFDM

OFDM is Orthogonal Frequency Division Multiplexing. It is used to trim down the interference among the number of users. In this the single broadband frequency is divided into a large number of parallel narrow band of frequencies. By this we can transmit the information with less bandwidth. This makes the channel to be frequency flat and also it eliminates reverberation. The block diagram is shown in Fig 2.

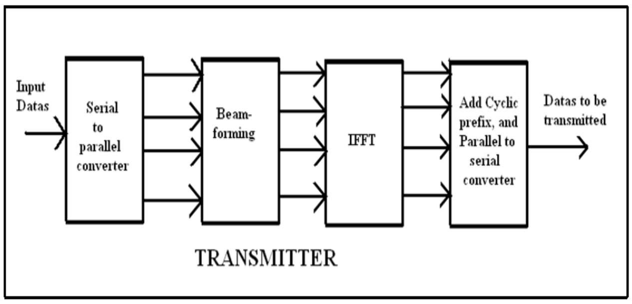

Fig.2 Cognitive radio transmitter with OFDM

Thus from this block diagram we can infer that the OFDM intrinsic scheme produces orthogonal carriers by using the Inverse Fast Fourier Transform (IFFT).

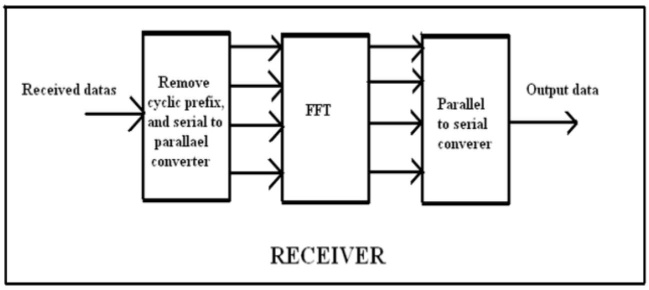

Fig.3 Cognitive radio receiver with OFDM

In addition to that IFFT is also used to lift up the frequency used in the baseband to that of transmittable high frequency. Thus this mitigates the interference between the carriers of nearer frequencies. Moreover the cyclic prefix addition makes us to reduce the most significant problem of the digital communication that is the Inter Symbol Interference (ISI). By using the frequency response of sub-carrier used for transmission, the amount of information for each sub-band can be altered. On the other hand these narrow bands have a smaller amount frequency selective fading. So the OFDM also conserves the bandwidth along with improved data rate to the highest degree which is the main intention. These traits made OFDM to be more suitable for MIMO. In addition to that the OFDM technique provides very less BER even for negative SNR that makes the system to be more consistent.

C. Peak to Average Power Ratio (PAPR)

The system which incorporates MIMO-OFDM techniques has a factor to be painstaking which is a Peak to Average Power Ratio of the transmitting signal. PAPR is the ratio between the maximum power and the average power of the signal in general. It is vital to consider this feature while integrating. In fact PAPR is one of the most negative issues as it mortifies the efficiency of the system. If the peak transmit power is restricted by either regulatory or application constraints, the effect is to reduce the average power allowed under multicarrier transmission comparable to that under constant power modulation techniques. This in roll reduces the range of multicarrier transmission. The Cumulative Distribution Function (CDF) of PAPR is one the most generally used performance evaluates for PAPR reduction. The CDF is used here for scrutiny of PAPR which symbolizes the probability that the PAPR of a data block exceeds a given threshold. The CCDF of PAPR takes into account only the peak value of the output signal, whereas the deprivation is caused by all signal samples falling in the nonlinear region. It is consequently more momentous to analyze the CDF of the instantaneous normalized signal power (INP). It gives a much more precise approximation of the gain that can be achieved using a peak power reduction technique. A number of techniques to reduce this PAPR are offered which can be attached to the proposed system for an augmentation in the result obtained.

ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
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D. Cognitive Radio System with PTS

In PTS technique, an input data block of N symbols is divided into dislodge sub-blocks. The subcarriers in each sub block are weighted by a phase factor for that sub-block. The phase factor is favored such that the Peak to Average Power Ratio (PAPR) of the collective signal is diminished. By putting into practice PTS technique, PAPR will be reduced by subdividing the blocks into disjoint sub-blocks. The block diagram of the PTS is shown in Fig 4.

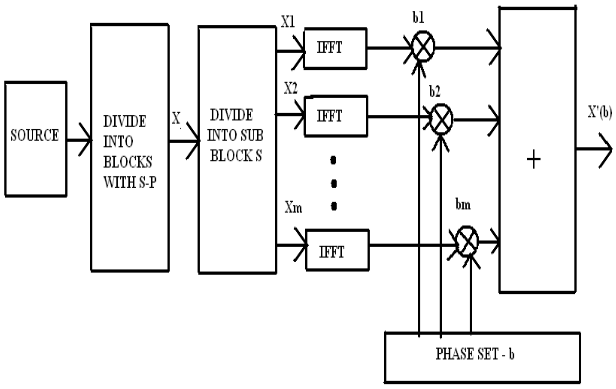

Fig.4 Block Diagram of PTS

E. Cognitive radio system with Beamforming

Based on the estimated channel stipulation, Beamforming cognitive transmitter is premeditated and is shown to be capable of directing Cognitive Users (CU's) transmit signals through the channel and thus removing the interference. When the PUs channel is free, it will be owed among the number of secondary users. If there are a number of users in cognitive radio system, the interference among the CUs will enhance. These interferences among the CUs will be reduced by Beamforming technique. Beamforming is a technique that is done for the transmission or reception of data. This technique is done by concentrating a particular user at an instance. The Beamforming will be done during the transmission of data on the transmission side of the CUs.

III. RESULTS AND DISCUSSION

The performance analysis of the channel is enhanced by using Beamforming technique that was revealed in this work. The noise added by the channel is also reputed to be Gaussian random noise. The objective of our scrutiny is to draw attention to the concert of this system by comparing them with various interconnected systems. For an analysis of the efficiency of this system a performance measure is made between the SNR (in dB) and BER.

The cognitive radio is considered as a multiple user system and then the channel is made orthogonal to each other, the peak to average power ratio is reduced by Partial Transmit Sequence and Beamforming applies to the multi users. The performance of the system is being examined by considering different number of users and different subcarriers.

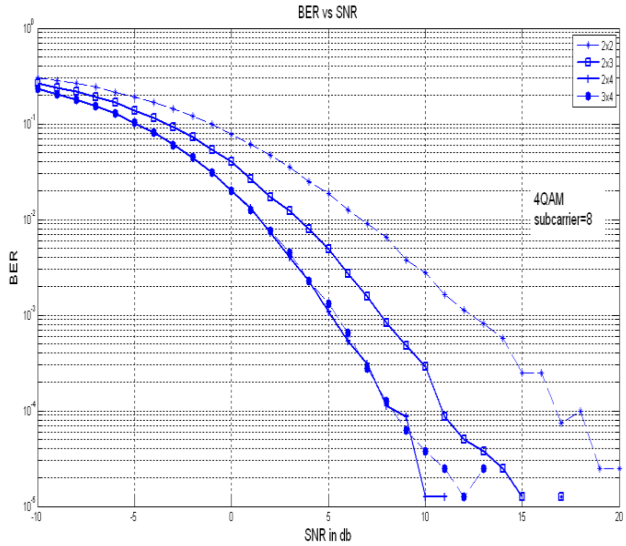

Fig.5 BER vs. SNR for 4-QAM for various dimensions of MIMO

The Fig 5 the performance analysis of a MIMO-OFDM system with 4-QAM modulation with a subcarrier of 8 for diverse dimensions of MIMO systems i.e. for 2×2,2×3,2×4,3×4. It is experiential that the probability of error is low down in the MIMO dimension of 2×4 and 3×4 due to receiver's diversity. The consequences are simulated only with MIMO's particular features of spatial diversity where identical information is transmitted in all the transmitting antennas for improved feature. This makes available good adaptation of the signal all the way through one or more paths, thus tumbling the probability of error as the cordial faded signals can be left alone.

If the number of subcarriers enlarges, then the amount of the error decreases. This makes OFDM more appropriate for MIMO systems. The orthogonal carriers cause a reduced amount of interference in a MIMO antenna that is narrowly positioned. MIMO-OFDM gives supplementary capacity than the conventional MIMO in existence of multipath as shown in Fig 6.

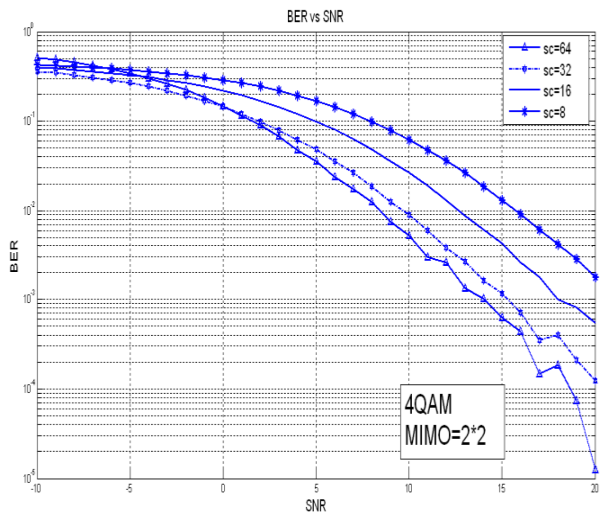

Fig.6 BER vs. SNR for 4-QAM for various subcarrier with dimensions of MIMO as 2×2

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Table I

SUMMARY OF QAM IN MIMO-OFDM FOR DIVERSE SUBCARRIERS

SNR (dB)	NO. OF SUBCARRIERS	PROBABILITY OF ERROR
5	8	0.1688
	16	0.0988
	32	0.0479
	64	0.0349
10	8	0.0618
	16	0.02615
	32	0.00879
	64	0.00522
15	8	0.0128
	16	0.00422
	32	0.00118
	64	0.00062

The implication of Fig 6 is given in the Table I. It is inferred that when the number of subcarriers increases, the probability of error decreases.

In the above proposed system including the MIMO-OFDM proposal we find PAPR to be a cause that need to be measured. So the porch of this system for a better performance will be probable by reducing this PAPR to the minimal value promising by an apt technique. Analysis can be made on the system based CDF. The preliminary analysis here is done for an untutored system concerning different subcarriers without any technique to condense PAPR.

The fig 7 is the estimation of PAPR for the system with different subcarriers.

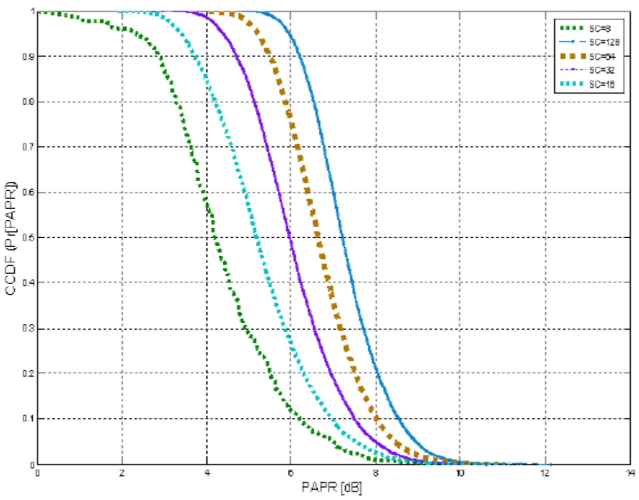

Fig.7 Effect of PAPR for different subcarriers using PAPR vs CDF

PAPR is dissimilar for different subcarriers. So an insignificant PAPR reduction technique well-matched with the proposed system will be better alluring. Figure 7 shows the comparison of PAPR with PTS and without PTS technique

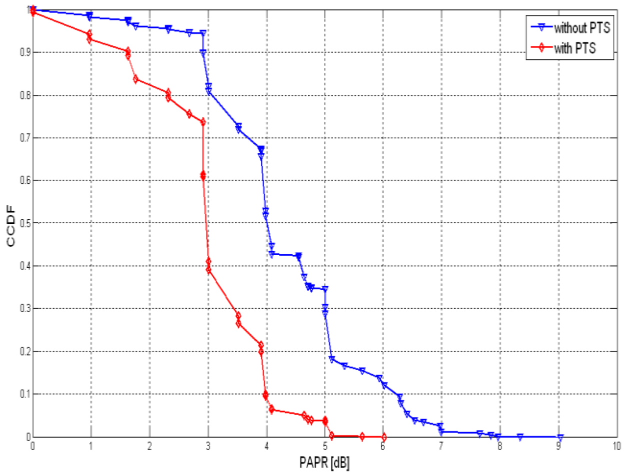

Fig.8 Comparison of PAPR with PTS technique and without PTS technique

Table II

SUMMARY OF PROBABILITY OF PAPR WITH AND WITHOUT PTS

PAPR	Pr (PAPR)	
	WITH PTS	WITHOUT PTS
2	0.8	0.99
4	0.1	0.5
6	0	0.1

Beamforming technique is done to reduce the interference among a number of users. For different number of transmitters and receivers Beamforming technique was employed. It is shown that when the number of transmitters increases, the bit error rate will decrease

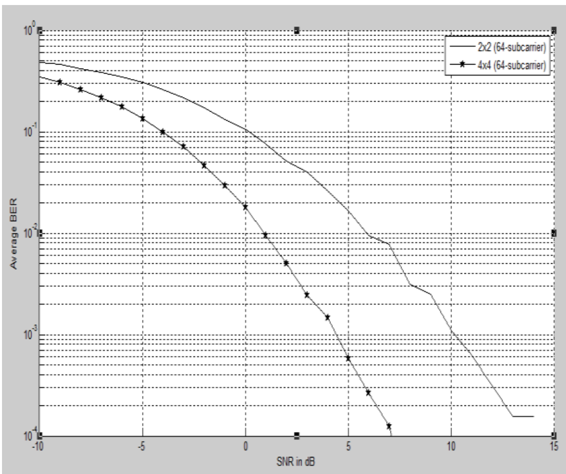

Fig.9 Beamforming for 2x2 and 4x4 Cognitive radio system

IV. CONCLUSION

The results shown above bequeath an increase in the performance when the Beamforming technique is worn amongst the numeral of users. It was also given away that bit error rate is less when the number of transmitters is increased. The interference is further decreased by employing OFDM and PTS.

V. FUTURE WORK

Spectrum sensing is an essential feature in cognitive radio network, which is done using a signal detector. This detector for spectrum sensing work well in Gaussian noise scenarios. The cooperative sensing strategies have been considered, where the multiple cognitive users independently detect the unused primary channel and the result is reported to the fusion center. A combined detection and report analysis is essential to optimize the cooperative sensing performance, since the two phases have an effect on each other and cannot be alienated.

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A. Suban, received B.E in the department of Electronics and Communication Engineering from Anna university, Chennai and M.E in the discipline of Wireless Technology from Thiagarajar College of Engineering, Madurai in 2011.
He is currently working as Assistant Professor in the Department of Electronics and Communication Engineering, Velammal College of Engineering and Technology, Madurai-625009, Tamil Nadu, India. His area of interest in Signal processing mainly focused on MIMO techniques with Beamforming, OFDM and power control techniques.

K.Mangayarkarasi, completed B.E in Vivekanandha college of Engineering for Womem, Thiruchengodu, Tamil Nadu, India, specialized in department of Electronics and Communication Engineering and pursuing M.E in the discipline of Communication Systems in Velammal college of Engineering and Technology, Madurai, Tamil Nadu, India. Her area of interest is Space time Mobile Communication