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ISI Reduction in MIMO-OFDM with Insufficient Cyclic Prefix- A Survey

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ABSTRACT:.MIMO-OFDM technologies are widely used in mobile multimedia communication systems. The low peak to average power requirement in number of application has led to the use of insufficient cyclic prefix in OFDM. This will result in ISI (inter symbol interference). To attain high data rate which is one of the major advantage of OFDM system, ISI should be reduced.The objective of this paper is to study various methods to reduce ISI in MIMO-OFDM system. Here we have studied methods like precoding using modulo operation, two stage equalization, frequency domain equalization, turbo equalization, interference alignment method and precoding using channel information. The study shows that all the precoding methods reduces the ISI but the precoding using channel information helps in reducing receiver complexity.

KEYWORDS:MIMO-Multi input Multi output, OFDM-orthogonal frequency division multiplexing, CP-cyclic prefix, ISI-Inter Symbol Interference.

I. INTRODUCTION

MIMO-OFDM has gained considerable attention in wireless communication system. The high data rate and bandwidth efficiency of OFDM along with diversity techniquehas led to the use of this technology in many advanced wireless communication systems. The MIMO-OFDM technique is used as the air interface in 4G/LTE and 5G technology.

The high data rate is attained by the use of cyclic prefix in OFDM system. If the cyclic prefix is greater than the channel length then the effect of inter symbol interference can be reduced. But in most case in-order to reduce the peak to average power ratio (PAPR) of MMO-OFDM system, insufficient cyclic prefix is used[1] which in turn will result in Inter Symbol Interference (ISI).Therefore this paper deals with different methods to reduce ISI in MIMO-OFDM system with insufficient cyclic prefix.

The remaining part of the paper is divided as follows, section II: Literature Survey, Section III: Proposed method, Section IV: Conclusion.

II. LITERATURE SURVEY

BASIC CONCEPTS OF MIMO-OFDM

Orthogonal frequency division multiplexing is a multi-carrier transmission technique. The input information is divided in to different OFDM blocks which are transmitted using orthogonal subcarriers generated by IFFT. If N point IFFT is used then N subcarriers are produced. Figure 1 shows the basic block diagram of OFDM system.

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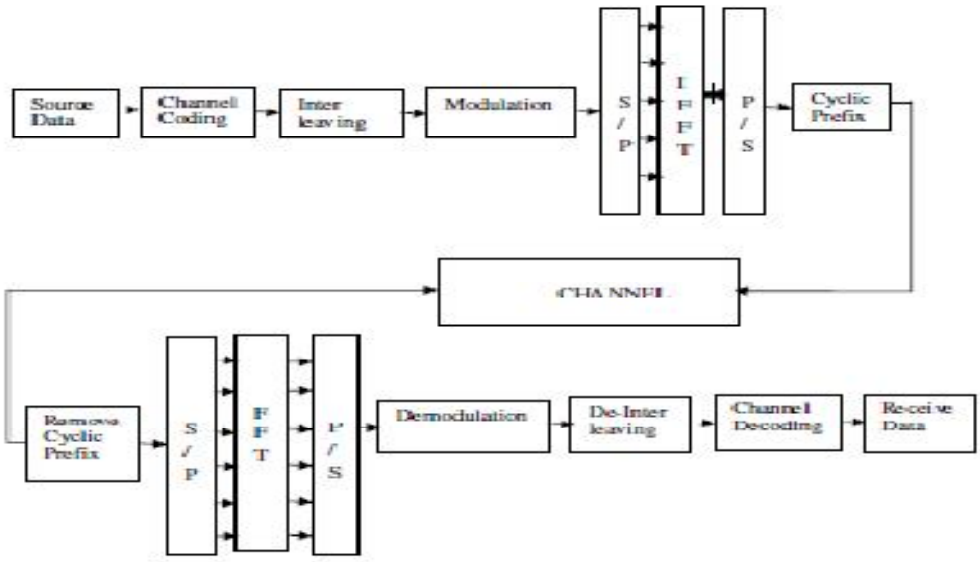

Fig 1 . Block diagram of OFDM system [3]

The input information is coded using different coding methods such as convolutional, turbo etc. The coded data is then interleaved to avoid burst error. The interleaved data is then modulated and transmitted after taking IFFT. The mainly used modulation techniques are QAM,QPSK and BPSK. The last v symbols of the IFFT signal is added as cyclic prefix to the OFDM block before transmission. If v>L,where L is the channel length, then ISI can be avoided. This signal is then transmitted through multiple antenna. The transmission through multiple antenna can occur in two way 1) Diversity technique 2) Spatial multiplexing method.Diversity method uses multiple antennas to compact for fading ie: the each OFDM block is transmitted through each antenna.

In the spatial multiplexing method each antenna is used to transmit the OFDM block of each user which is then spatially combined and transmitted through the channel. At the receiver side the FFT of the received signal is taken after removing the cyclic prefix which is then demodulated, de-interleaved and decoded to obtain the message. But in most MIMO-OFDM application low peak to average power ratio and high spectral efficiency are pre-requisite. In-order to achieve this the length of IFFT is reduced which in turn will reduce the cyclic prefix length ie: in most MIMO-OFDM application v<L this will result in ISI. Therefore in-order to obtain high performance ISI should be reduced. Recently many methods have been proposed to reduce the effect of ISI. Some of this method and their comparisons are listed in the next section.

METHODS TO REDUCE ISI IN MIMO-OFDM

The methods to reduce ISI are:

A.*Precoder design for DMT(discrete multi-tone) signal*

This method is based on adding redundant bits to information to reduce the ISI [3]. Like the basic precoder schemes here also channel side transfer function is known at both the transmitter and receiver side. The precoding operation is done by using modulo operator and set of block filters, whose parameter decides the number of redundant bits that is to be added to the information bits to avoid ISI. At the receiver side the inverse of modulo operator along with frequency domain equalization helps in determining the information bits.

B. *Frequency domain equalization method(FEQ)*

This method is also based on addition of redundant carrier. Here thecarrier is divided into redundant and data carrier [4].The redundant carrier is used to carry the redundant bits and the data carrier is used to carry the data bits. This

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redundant carrier along with the data carrier is transmitted through the filter, into which the IFFT operation performed and the insufficient cyclic prefix is added. This data is then transmitted through the channel.At the receiver side the cyclic prefix is removed and FFT operation is performed. From this signal redundant carrier is sorted out and is subtracted from the received data signal to get the original data.

C. *Two stage equalization method*

Here at the receiver side a two stage equalization is performed to reduce the effect of ISI [5]. The first stage include the Time domain equalization and the second stage include the Frequency Domain Equalization.The equalizer coefficient for both time domain and frequency domain equalizer is obtained using the training information. The training information is obtained from the received signal and the decoded signal. The time domain equalization suppress the ISI by shortening the channel. After this cyclic prefix is removed from the signal and then FFT is performed. In the second stage the frequency domain equalization of the signal is done ie: the per-tone equalization. After this two stages the signal is detected using the Maximum Likelihood detection (ML). Even though this method helps to reduce the ISI the main disadvantage of this method is that it reduces the bandwidth efficiency.

D.*Turbo Equalization method*

Turbo equalization is a soft interference cancellation method. After the estimation of the channel a soft feedback of the channel information is used at the turbo receiver to reduce the effect of ISI [6]. The information that we used as feedback include the jamming information as well as the channel information. After the ISI cancelation the minimum mean square filtering is used to obtain the correct information. The main disadvantage of this is method is that only the significant ISI terms are considered and also using Turbo Equalization at the receiver increases the receiver complexity.

E. *Interference Alignment method*

Here the input information is multiplied by the precoding matrix before the OFDM modulation [7]. The rank of the precoder matrix is increased by zero padding. So that the input information when multiplied by the precoding matrix aligns the signal and the interference to disjoint sets. At the receiver side the interference can be removed by zero forcing operation. Such a precoder matrix is not an optimal precoder matrix ie: no channel side information is used here.

F. *Precoder design with channel information.*

The information bits are first transmitted through a precoding matrix [8]. The precoding matrix is designed in such a way that it maximizes the cost function. The cost function considered is

$$\min_{Q_u} \mathcal{F}_o \left(\left[\frac{1}{\sigma_s^2} I + Q_u^H R_c Q_u \right]^{-1} \right) \quad \text{eq.(1)}$$

$$s.t.\ tr\{Q_u Q_u^H\} \leq P_T \quad \text{eq.(2)}$$

Here the cost function is the lower bound of the minimum mean square equalizer at the receiver side. Thus the precoder is designed using the channel information which is given as feedback to the receiver side.

The survey conducted shows that all the methods discussed above reduced ISI effectively and helpedin attaining reliable data transmission. But ISI reduction using turbo equalization, two stage equalization, and frequency domain equalization increases the receiver complexity whereas using precoder at the transmitter side reduces the receiver complexity. The various BER values obtainedin the above discussed methods are:

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Table 1 : BER Vs SNR performance

Methods	SNR	BER
MIMO-OFDM	25 dB	0.0000001
Modulo based precoder	25 dB	0.000003
Frequency domain equalization method.	25 dB	0.000001
Two stage equalization method.	25 dB	0.000009
Turbo equalization method.	25dB	0.000001
Interference alignment method.	25 dB	0.000008
Precoder with channel information	25 dB	0.00005

III. PROPOSED METHOD

Even though all the methods discussed above reduces ISI none of this concentrates on capacity. Addition ofredundant bits and zero padding reduces the capacity of the system.Thus we are proposing a method to increase the capacity of the system as well to reduce the ISI.

In the proposed method we are using complete channel side information. The precoder matrix is designed by taking the singular value decomposition of the channel matrix H.

$$svd(H) = U\lambda V \qquad \text{eq.(3)}$$

Here U and V are the unitary matrix and λ is the singular value matrix. The optimal precoder is then given as $Q = U\varepsilon$ where ϵ is the power allocation matrix.

IV. CONCLUSION

MIMO-OFDM is a widely used technology in wireless communication and even though it has many advantages such as high bandwidth efficiency and higher bit rate,the problem of insufficient cyclic prefix is a major issue. The study of different methods to reduce ISI shows that insufficient cyclic prefix is no more an issue in MIMO-OFDM system. All the system design that we studied eliminates ISI completely and help in attaining high data rate.

REFERENCES

1. Theodore S. Rappaport "Wireless communication principles and practice" second edition.
2,A. Goldsmith, S. A. Jafar, N. Jindal, and S. Vishwanath, "Capacity limits of MIMO channels," IEEE J. Sel. Areas Commun., vol. 21, no. 5, pp. 684–702, 2003.
3. G. G. Raleigh and J. M. Cioffi, "Spatio-temporal coding for wireless communication," IEEE Trans. Commun., vol. 46, no. 3, pp. 357–366,1998.
4. L. CiminiJr, B. Daneshrad, and N. R. Sollenberger, "Clustered OFDM with transmitter diversity and coding," in Proc. 1996 IEEE Global Communications Conference, pp. 703–707.
5. K.-W. Cheong and J. M. Cioffi, "Precoder for DMT with insufficient cyclic prefix," in Proc. 1998 IEEE Int. Conf. Commun., pp. 339–343.
6.C.-J. Park and G.-H. Im, "Efficient DMT/OFDM transmission with insufficient cyclic prefix," IEEE Commun. Lett., vol. 8, no. 9, pp. 576–578, 2004.
7. T. Tang and R. W. Heath Jr, "Space-time interference cancellation in MIMO-OFDM systems," IEEE Trans. Veh. Technol., vol. 54, no. 5, pp.1802–1816, 2005
8. M. Grossmann, C. Schneider, and R. S. Thoma, "Turbo equalization for MIMO-OFDM transmission with insufficient guard interval," in Proc. 2006 IEEE Int. Zurich Seminar Commun., pp. 114–117.
9. Y. Jin and X.-G. Xia, "An interference nulling based channel independent precoding for MIMO-OFDM systems with insufficient cyclic prefix," IEEE Trans. Commun., vol. 61, no. 1, pp. 131–143, Jan. 2013.
10. Y. Jin and X.-G. Xia," A Robust Precoder Design Based on Channel Statistics for MIMO-OFDM Systems with Insufficient Cyclic Prefix" IEEE transactions on communications, vol. 62, no. 4, april 2014
11.Chengwen Xing, Dan Li, Shaodan Ma, ZesongFei, and JingmingKuang "Robust Transceiver Design for MIMO-OFDM Systems Based on Cluster Water-Filling" IEEE communications letters, vol. 17, no. 7, july 2013.
12. Daniel Pérez Palomar, Member, IEEE, Miguel Angel Lagunas, Fellow, IEEE, and John M. Cioffi, Fellow, IEEE "Optimum Linear Joint Transmit-Receive Processing for MIMO Channels with QoS Constraints" IEEE transactions on signal processing, vol. 52, no. 5, may 2004.

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