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Parallel Interference Cancellation Scheme in MC-CDMA over Frequency Selective Fading Channel

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Abstract

From the past few years, the variant technologies of multi carrier code division multiple access (MC- CDMA) has gained importance in providing the broadband services through wireless communication. MC-CDMA could be a reliable technology wherever multiple users can communicate expeditiously in wireless medium. the key issue ought to be self-addressed within the MC-CDMA is multiple access interference (MAI) from totally different users. to beat this, the effective parallel interference cancellation mechanism is projected in this paper. in the initial stage, PIC is introduced to estimates the users interference. in the second stage, MMSE equalisation is employed to urge the users desired information. The projected methodology with success restricts the MAI and improved the performance of the MC-CDMA.

Keywords: *multiple access, MC-CDMA, multiple access interference*

1. INTRODUCTION

In the recent years, the wireless communications area unit advanced in providing the services of multimedia system with prime quality giving the reliability, high output and bandwidth. the foremost implementation drawbacks for wireless communications are multipath attenuation, multiple access interface and delay spread while providing high rate to the end users. The multi user thought permits multiple accesses over a similar channel with efficiency. In [1], the authors uses the direct sequence code division multiple access (DS-CDMA) to improve the coverage and system capability compared with the FDMA and TDMA.

In CDMA, each user has their own code sequence to access the channel bandwidth. The code sequence has zero or less cross correlation that overcome multipath inheritance or multiple access interference (MAI) [2]. In [3], the authors made a survey on drawbacks of signature sequences like M-sequence, Gold Codes, Walsh-Hadamard sequence, KasamiSequence.The existing sequences aren't helpful within the real time eventualities likes multiple access, uplink transmission, MAI that minimizes the system capability. In [4], the authors introduced the orthogonal complementary codes that provides zero cross correlation and autocorrelation for all doable

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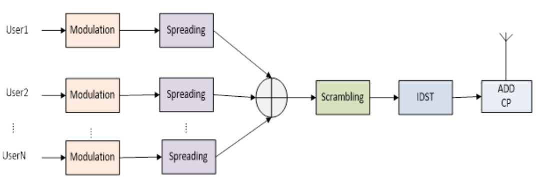
shifts in orthogonal complementary codes. In [5], the hybrid MC-CDMA is projected by combining the CDMA and OFDMs properties. By utilizing the properties of OFDM, the clients will access the channel non-concurrently and uses the spreading sequences.

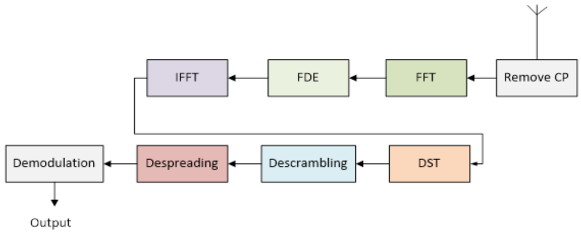
In MC-CDMA, the MAI and ISI can arise due to the involvement of multi user [6]. the key problems caused by the interference cancellation mechanisms are lacking in simplicity. PIC and sic are major interference cancellation schemes that area unit used in the communication channels. Parallel interference cancellation (PIC) is a multi-user mechanism that uses specific behaviour of interference to decrypt the coincident information transmissions. MC-CDMA is one in all the foremost vital multicarrier frameworks that contain the data sequence multiplied with spreading sequence.This framework has the advantage of reconfiguration, high ability and high degree of chance [7].

.2. SYSTEM MODEL

Figure 2.1 shows the downlink MC-CDMA transmission system over an AWGN channel with N users is given. Each user in the system transmits BPSK symbols using the associated spreading code. As a next step, the input signal is scrambled and applied the Inverse Discrete Sine Transform (IDST). The cyclic prefix (CP) is attached to the each block before transmission. The size of the CP is larger than the channel delay to allow the interference. At the reliever side the CP is removed from the block and sent to the FFT for demultiplexing.



Transmitting Unit



2.1. Block diagram of MC-CDMA systems

At the transmitter end, the input information of the Nth user is applied with modulation, spreading and scrambling. Each user spreading code has the length of K. As a next step, the Inverse Discrete Sine Transform (IDST) is applied to the scrambled data. Eq. 1 shows the output of the IDST.

$$\beta = X^{-1}\delta Cm \text{................ [1]}$$

Here X-1 represents the Inverse Discrete Sine Transformation (IDST), δ represents the KS x KS matrix of scrambled code, where S represents the amount of transmitted symbols form each user. C represents the KS x NS matrix of spreading codes. ‘m’ is that the NS x 1 vector which holds the Nth user modulated symbols along side S. Each individual structure in Eq. 1 is given below

$$C = diag[\overline{C}\,\overline{C}...\overline{C}] \text{................[2]}$$

$$\overline{C} = [c_1 c_2 ......C_N] \text{..................[3]}$$

$$C_N = [C_N(0), C_N(1)........C_N(K-1)]^T \text{...[4]}$$

$$m = [m^T(1), m^T(2)....m^T(S)] \text{....[5]}$$

$$\delta = diag[\delta(1), \delta(2), ...\delta(KS)] \text{....[6]}$$

$$m(k) = [A_1 m_1(k), A_2 m_2(k)........, A_N m_N(K)] \text{............................ [7]}$$

Where CN defines the Nth user spreading code, and mN(K) represent the kth data bit of the Nth user. At the last stage a cyclic prefix (CP) is attached to the start of every block. Then it's

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forwarded as a transmission block. At the receiver end, the CP is subtracted from the received block and therefore the received block is formulated as follows.

$$R = Y_c \beta + L \text{..........[8]}$$

Here Y_c represents the matrix and L represents the Gaussian Noise Vector (IID)

Equation 8 is reformed based on the Muli user interference is given as follows

$$R = Y_c \beta_{\text{int}} + Y_c \beta_{des} + L \text{.......[9]}$$

Where β_{int} and β_{des} is represented as

$$\beta_{\text{int}} = X^{-1} \delta D m_{\text{int}} \text{..........[10]}$$

$$\beta_{des} = X^{-1} \delta C_\beta m_{des} \text{........[11]}$$

Here m_{int} represents the (N-1)S x 1 vector having the data of uncorrelated user bits. m_{des} represents the S x 1 vector consisting of concerned data user bits. D represents the KS x (N-1)S matrix which contains the uncorrelated users jamming code. It is observed that in Eq. 9, the initial quantity representsthe uncorrelated data from the user, the second quantity represents the concern data and the third quantity represents about the noise. The received block is given in Eq. 12. representsfrequency domain

$$R = HFX^{-1} \delta C m + L \text{........... [12]}$$

Here H represents the diagonal matrix which consists of algorithm of DFT(FFT) of the Y_c. L represents the Fast Fourier Transformation of the noise. In Figure 2, it is observed that as a next step Frequency domain equalization (FDE), followed by Inverse Fast Fourier Transformation (IFFT), Discrete Sine Transform (DST), descrambling, dispreading and the demodulation mechanism is applied to receive the symbols transmitted by the concern users. The complete methodology is given as follows.

$$\hat{m}_{des} = f_{dec}(C_\beta^T \delta^Y X F^{-1} G R) \text{......[13]}$$

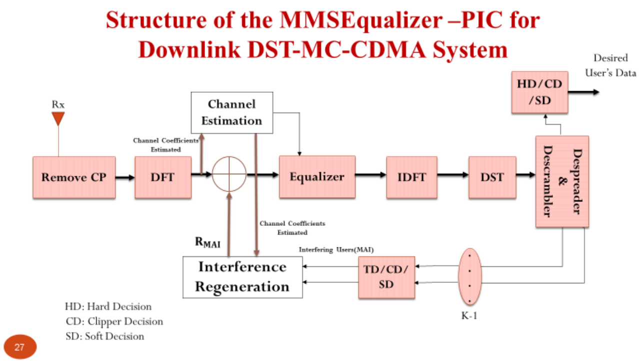
Here F^{-1} represents the IFFT in matrix, f_{dec} represents the decision function, X represents the DST in matrix. G represents FDE. This equalization is applied based upon MMSE criteria is given as follows.

$$G_{MMSE} = (H^Y H + 1/SNR)^{-1} H^Y \text{....[14]}$$

Signal-to-Noise ratio is defined as SNR .

3. ALGORITHM FOR MMSE-PIC IN MC-CDMA SCHEME

This module deals with the MMSE-PIC scheme avoiding the effect of uncorrelated users in MC-CDMA initially. The structure of proposed MMSE-PICbased MC-CDMA is shown in Figure 3. The proposed scheme is distributed into three modules. In the initial module, estimating the data of all users by stating the Channel information and suppressing the effects of channel. In the subsequent module, before equalization is performed, the PIC method is done by using the generating and suppressing of MAI from the signal. In the last module, using MMSE Equalizer concern user's data is estimated.



Algorithm: MC-CDMA using MMSE-PIC scheme

Input: Adding CP Transmitter block

Output: Relevant user's data is Estimated.

Begin

1. In the Received block CP is removing.
2. The FFT is applied on the received section and the resultant is given in Eq. 15

$$R_T = HX_{int} + HX_{des} + N' \ldots\ldots[15]$$

Here X_{int}, X_{des} and N' are the Fourier transformations of the β_{int}, β_{des} and N respectively.

1. By Employing frequency domain Equalizer suppress the ISI caused by other users.
2. The DST followed by IFFT is employed to the output data of the Equalizer.
3. The output of DST is then descrambled and applied to the despreader.
4. Antentative decision is performed on the output data to approximate the Interference symbols after the dispreading. is given in Eq. 16.

$$\hat{m}_{\text{int}} = f_{dec}(C^T \delta^Y XF^{-1} G_{MMSE} R_T) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [16]$$

3. The MAI is regenerated using the Eq. 17 in the frequency domain,

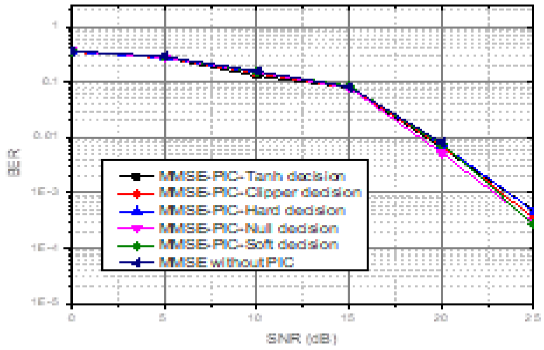
$$R_{MAI} = HFX^{-1} \delta D \hat{m}_{\text{int}} \ldots\ldots [17]$$

4. Subtracting MAI from R_T to get Interference free signal in frequency domain

$$R_{Fr} = R_T - R_{MAI} \ldots\ldots\ldots [18]$$

5. Finally, concern user's data can be obtained by using Eq. 19.With better approximation

$$\hat{m}_{des} = f_{dec}(C_\beta^T \delta^Y XF^{-1} G_{MMSE} R_{Fr}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [19]$$



End

4. SIMULATION RESULTS

In this module, Table 1 shows the parameters for the explained cancellation scheme in downlink MC-CDMA system. In this MATLAB simulation, transmission power of all the users is equal. The BPSK modulation is used with carrier frequency of 900MHz along with noise model as AWGN.

Table 1: Simulation Parameters

Parameters	**Value**
Orthogonal code	Walsh-Hadamard code
Digital Modulation Scheme	BPSK
Number of Users	N=8 and 16
FFT points	128
Total no of Symbols	S=8
Length of Cyclic Prefix	16
Combining Technique Used	MMSEC
Channel Estimation	Idle

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Channel Type	NLOS channel, Vehicular A [16]

Performance Comparison of BER

Figure 4 shows the BER performance of the MMSE-PIC scheme with different tentative decisions. The BER is calculated for data transmission which compares the transmission bits and received bits. The data frame length is taken as 640 bits.

Bit Error Rate (BER): BER is defined as the total number of bit errors occurred in unit time.

Figure 1: BER Vs SNR for the proposed system with different decision function under S=8, N=8 and N'=16

$$BER = \frac{1}{2}(1 - erf)\sqrt{\frac{E_b}{N_0}} \ldots\ldots..[20]$$

Where, *erf* denotes the error function, E_b represents the energy consumption in one bitand N_0 denotes the noise power spectral density.

$$SNR = 10\,log(\frac{P_{signal}}{P_{noise}}) \ldots\ldots[21]$$

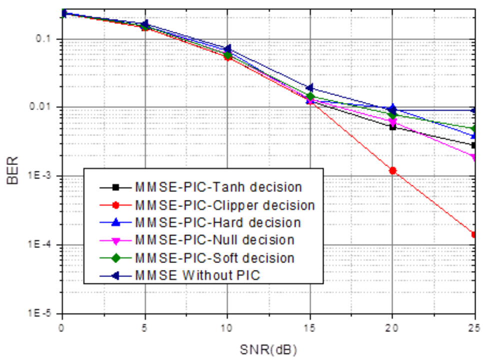

Figure 2: BER Vs SNR for the proposed system with different decision function under N=16 and N'=16 in Vehicular A channel

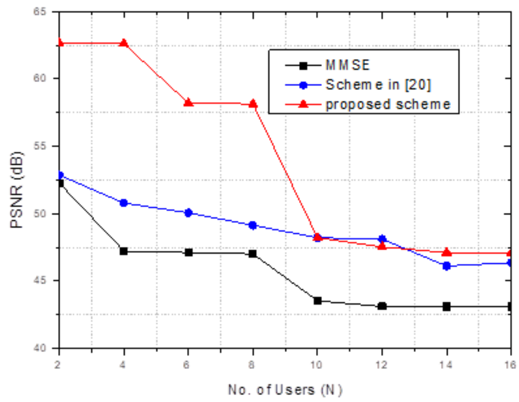

Figure 3: MSE Vs SNR Data Transmission with the MMSE, Scheme in [20] and the proposed scheme at N=8

The assessment of the proposed system is made with the MMSE system. It is proved that the proposed system with all selectionfunctionsincrease the overall performance of the BER with according to MC-CDMA and outperforms the MMSE. From the figure it'sobserved that, the clipper choice PIC and null decision PIC reduces the BER compared to the other tentative decisions. In Figure 5, the MMSE-PIC scheme is also experimented with the channel of vehicular A [16]. It is observed that the clipper selection PIC and null choice PIC performance is higheras compared to the ultimate tentative

Data Transmission

To evaluate the ability of the proposed model, the information transmission method is considered for all the users. Figure 6 shows the contrast of MMSE-PIC with conventional MMSE together with scheme in [20]. The information is transmitted and received for 8 users (N=eight) in MMSE, proposed and scheme in [20]. It is discovered the MSE has been decreased for the proposed method ascompared to the MMSE and Scheme in [20] with respect to increase in SNR. Figure 7 shows the PSNR for the proposed systemin conjunction withthe two schemes. It is tested that the

PSNR isextended for the three schemes along with the growth in SNR value. At the low SNR, the 3 schemes performance is equal. It is because of the domination of noise as compared to the interference. At high SNR, the MAI cancellation scheme works well to lessen the interference within the proposed scheme as compared to the other schemes.

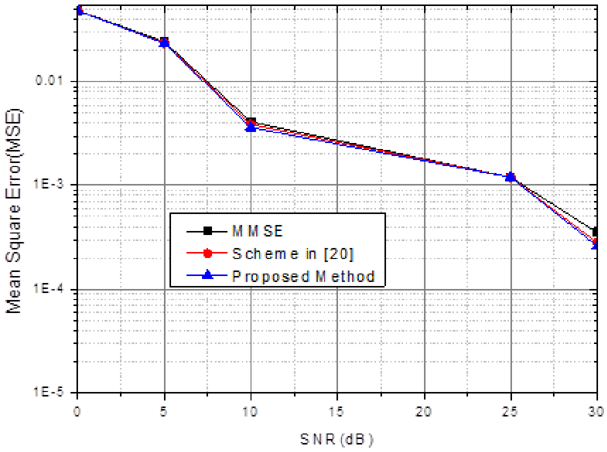

Figure 4: PSNR for Data Transmission with the MMSE, Scheme in [20] and the proposed scheme at N=8 and SNR= 25dB

5. CONCLUSION

This paper evolved the MMSE-PIC scheme for lowering the interference in MC-CDMA over a frequency domain. The proposed modeldeveloped the tentative decision-making characteristicto enhance the performance of the BER. The clipper selection PIC and null selection PIC reduces the BER compared to the other tentative decisions. Simulation results proved that the proposed model had betterperformanceas compared to other schemes according to the values of MSE and PSNR. By examining the effects, it's also proved that the MMSE-PIC also performed nicely by reducing the MAI whileusers are high. The PSNR appeared for the MMSE-PIC for distinctiveusers is almost equal to 6.3dB.

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