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PERFORMANCE EVALUATION OF MC-CDMA UNDER THE EFFECT OF MULTIPATH FADING CHANNEL USING RAKE RECEIVER

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ABSTRACT

In this paper we have shown the performance evaluation of multi-carrier CDMA (MC-CDMA) wireless communication system with orthogonal frequency division multiplexing (OFDM) in the presence of Rayleigh fading environment. Due to the effect of multipath propagation the quality of signal received is degrade. For minimizing the effect of multipath fading (MC- CDMA) RAKE receiver is used. Equal Gain Combining (EGC), Maximal Ratio Combining (MRC) and Minimum Mean Square Error (MMSE) Equalization techniques are used.

I. INTRODUCTION

The interest for wireless communications administrations has developed gigantically. In spite of the fact that the arrangement of third generation cellular frameworks has been slower than was initially expected, scientists are now examining fourth generation cellular systems. These frameworks will transmit at much higher rates than the genuine 2G frameworks, and even 3G frameworks, in an ever packed frequency spectrum. The essential objective of next-generation wireless systems (4G) won't just be the acquaintance of new innovations with spread the requirement for higher data rates and new services, additionally the incorporation of existing advances in a typical stage. The strategy of multi-carrier transmission has recently been receiving wide interest, particularly for high data rate broadcast applications. The fundamental points of multi-carrier transmission are its forcefulness in frequency selective fading channels and specifically, the decreased signal processing complexity by equalization in the frequency domain. In a mobile communication environment the channel is not time invariant and is slowly varying. This characteristic feature of the channel leads to a phenomenon called Fading. Fading channels induce rapid amplitude fluctuations in the received signal. If they are not compensated for then this will lead to serious performance degradation.

Multicarrier code-division multiple access (MCCDMA) is a promising approach to the challenge of providing high data rate wireless communication. MC-CDMA combines the benefits of CDMA with the natural robustness to frequency selectivity offered by OFDM. Multi-carrier CDMA is a digital modulation technique This scheme involves the original data stream over different subcarriers using a known spreading is transmitted all the way through a different subcarrier. The narrowband subcarriers are generated using BPSK modulated signals, each at different frequencies which at baseband are at multiples of a harmonic frequency, Consequently, the subcarriers are orthogonal to each other at baseband, and the component at each subcarrier may be filtered out by modulating the received signal with the frequency corresponding to the particular subcarrier of interest and integrating over a symbol duration. The orthogonality between subcarrier frequencies is maintained if the subcarrier frequencies are spaced apart by multiples of F/T_b where F is an integer. The codes widely used in this scheme are the Hadamard Walsh Codes since the auto-correlation characteristics of the spreading codes are neglected.

II. TRANSMITTER FOR MC-CDMA

In the transmitter for the MC-CDMA, data from k users are spread using different spreading sequences of length L and they are combined. This is explained by the following equations.
U_k Is the k^{th} user with data rate$1/T_d$. The spreading code is $Ck_0, Ck_1, \ldots Ck_{L-1}$. After spreading of each user and combining, the signal is $Sk_0, Sk_1, \ldots Sk_{L-1}$

$$S = \sum_{k=0}^{k-1} s_k = (s_0, s_1 \ldots.. s_{L-1})^T \quad (1.1)$$

Where,

$$S = CU$$
$$U = (U_0, U_1 \ldots.. U_{L-1})^T$$
$$C = (C_0, C_1 \ldots.. C_{L-1})^T \quad (1.2)$$

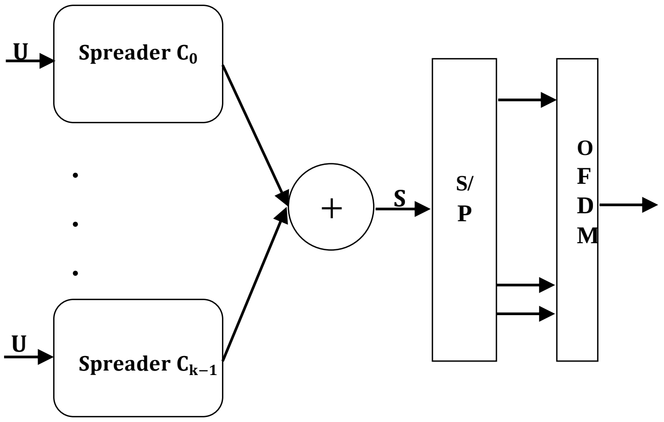

Figure 5.1: Transmitter configuration of MC-CDMA system

The combined signal is send to serial to parallel converter and each data element is given a particular frequency slot using IFFT. Then the output is joint to create an OFDM symbol.

Now the received OFDM symbol can be given as fallow:

$$r = \sum_{k=0}^{k-1} H_k S_k + \eta = (R_0, R_1 \ldots\ldots R_{L-1}) \qquad (1.3)$$

The 'r' is the received OFDM symbol but a signal element from the user. It is also to be noted that 'r' will have all 'k' users data and each spreading code assigned to each user in the transmitter will be used again in the receiver to get the single signal element from 'r'. The number of spreading codes are equal to number of users. But the OFDM symbol length is the size of the spreading code.

$$r = XS + \eta = (R_0, R_1 \ldots\ldots R_{L-1})$$
$$X = HC \qquad (1.4)$$

X is called as system matrix.

III. RAKE RECEIVER

The rake receiver consists of multiple correlators, in which the receive signal is multiplied by time-shifted versions of a locally generated code sequence. The intention is to separate signals such that each finger only sees signals coming in over a single (resolvable) path. The spreading code is chosen to have a very small autocorrelation value for any nonzero time offset. This avoids crosstalk between fingers .In practice, the situation is less ideal. It is not the full periodic autocorrelation that determines the crosstalk between signals in different fingers, but rather two *partial* correlations, with contributions from two consecutive bits or symbols. It has been attempted to find sequences that have satisfactory partial correlation values, but the crosstalk due to partial (non-periodic) correlations remains substantially more difficult to reduce than the effects of periodic correlations.

The rake receiver is designed to optimally detect a DS-CDMA signal transmitted over a dispersive multipath channel. It is an extension of the concept of the matched filter.

In the matched filter receiver, the signal is correlated with a locally generated copy of the signal waveform. If, however, the signal is distorted by the channel, the receiver should correlate the incoming signal by a copy of the expected received signal, rather than by a copy of transmitted waveform. Thus the receiver should estimate the delay profile of channel, and adapt its locally generated copy according to this estimate.

In a multipath channel, delayed reflections interfere with the direct signal. However, a DS-CDMA signal suffering from multipath dispersion can be detected by a rake receiver. This receiver optimally combines signals received over multiple paths.

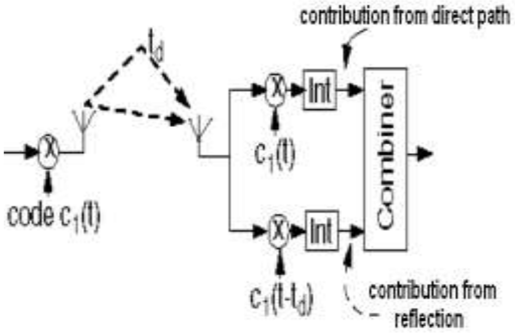

Figure 3: RAKE Receiver

Rake receiver gathers the energy received over the various delayed propagation paths. According to the maximum ratio combining principle, the SNR at the output is the sum of the SNRs in the individual branches, provided that

1. Only AWGN is present (no interference)
2. Codes with a time offset are truly orthogonal.

Signals arriving with the same excess propagation delay as the time offset in the receiver are retrieved accurately, because

$$\sum_{n=1}^{N} c_1^2(nT_c + t_d) = \sum_{n=1}^{N} c_1^2(nT_c) = N \tag{5}$$

This reception concept is repeated for every delayed path that is received with relevant power. Considering a single correlator branch, multipath self-interference from other paths is attenuated here, because one can choose codes such that

$$\sum_{n=0}^{N} c_1(nT_c)c_1(nT_c + t_d) \cong 0 \tag{6}$$

IV. EQUALIZATION TECHNIQUES

The goal of equalization techniques should be to reduce the effect of the fading and the interference while not enhancing the effect of the noise on the decision of what data symbol was transmitted. Whenever there is a diversity scheme involved whether it may involve receiving multiple copies of a signal from time, frequency or antenna diversity, the field of classical diversity theory can be applied. These equalization techniques may be desirable for their simplicity as they involve simple multiplications with each copy of the signal. However, they may not be optimal in a channel with interference in the sense of minimizing the error under some criterion.

Equal Gain Combining

With EGC, the gain factor of the *ith* subcarrier is chosen to be

$$d_{o,i} = 1$$

That is, this technique does not attempt to equalize the effect of the channel distortion in any way. This technique may be desirable for its simplicity as the receiver does not require the estimation of the channel's transfer function. Using this scheme, the decision variable of Eq. (3) is given as

$$v_0 = a_0[k]\sum_{i=0}^{N-1} \rho_{0,i} + \sum_{m=0}^{M-1} a_m[k] \sum_{i=0}^{N-1} c_m[i]c_0[i]\rho_{m,i} cos\hat{\theta}_{m,i} + \eta \tag{7}$$

Where the noise can be approximated by a zero mean Gaussian random with a variance of

$$\sigma_\eta^2 = N\frac{N_0}{T_b} \tag{8}$$

Maximal Ratio Combining

With MRC, the scheme squares the amplitude of each copy of the signal by using a gain factor for the i^{th}subcarrier of

$$d_{o,i} = \rho_{0,i} \qquad (9)$$

The motivation behind Maximal Ratio Combining is that the components of the received signal with large amplitudes are likely to contain relatively less noise. Thus, their effect on the decision process is increased by squaring their amplitudes.The corresponding decision variable is

$$v_0 \ = a_0[k]\sum_{i=0}^{N-1}\rho_{0,i} + \sum_{m=0}^{M-1} a_m[k]\sum_{i=0}^{N-1} c_m[i]c_0[i]\rho_{m,i}\rho_{0,i}cos\hat{\theta}_{m,i} + \eta \qquad (10)$$

Where the noise can be approximated by a zero-mean Gaussian random variable with variance

$$\sigma_\eta^2 = N\frac{N_0}{T_b}E_{\rho_{0,i}^2} \qquad (11)$$

Minimum Mean Square Error

Minimum Mean Square Error (MMSE) approach alleviates the noise enhancement problem by taking into consideration the noise power when constructing the filtering matrix using the MMSE performance-based criterion. The vector estimates produced by an MMSE filtering matrix becomes

$$\tilde{x}= [[(H^HH + (\sigma^2I))^{-1}]\ H^H]\ r \qquad (14)$$

Where σ^2 is the noise variance. The added term ($1/SNR = \sigma^2$, in case of unit transmit power) offers a trade-off between the residual interference and the noise enhancement. Namely, as the SNR grows large, the MMSE detector converges to the ZF detector, but at low SNR it prevents the worst Eigen values from being inverted. At low SNR, MMSE becomes Matched Filter

$$[(H^HH + (\sigma^2I))^{-1}]\ H^H \approx \sigma^2\ H^H \qquad (15)$$

At high SNR, MMSE becomes ZF:

$$(H^HH + (\sigma^2I))^{-1}]\ H^H \approx (H^HH)^{-1}\ H^H \ (16)$$

SIMULATION AND RESULTS

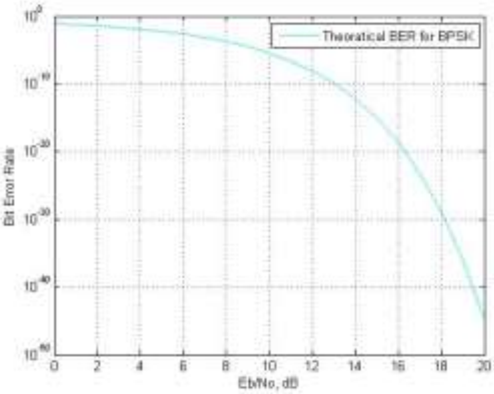

Figure 6.1: Simulation result for MC-CDMA system for BPSK in Rayleigh fading channel

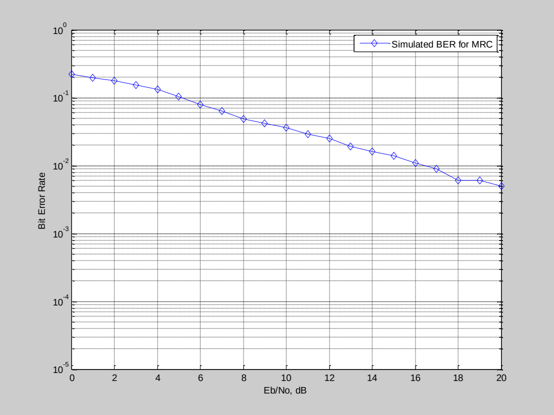

Figure 6.2: Simulation result for MC-CDMA system for MRC in Rayleigh fading channel

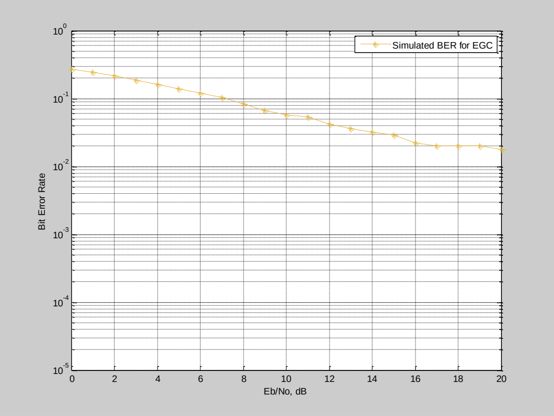

Figure 6.4: Simulation result for MC-CDMA system for EGC in Rayleigh fading channel

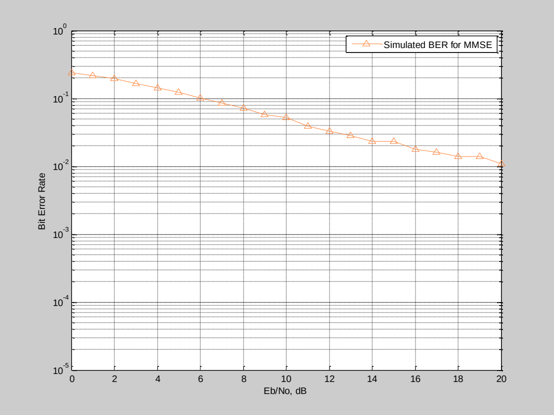

Figure 6.5: Simulation result for MC-CDMA system for MMSE in Rayleigh fading channel

V. CONCLUSION

In this paper, bit error rate performances of MC-CDMA with Rake receiver in Rayleigh fading channel for various equalization techniques like Equal Gain Combining (EGC), Maximal Ratio Combining (MRC) and Minimum Mean Square Error (MMSE) Equalization techniques are Evaluated. The simulation results shows that Rake receiver with MMSE gives better BER performance as we increase SNR.

VI. REFERENCE

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