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Performance Enhancement of MIMO-OFDM System Using Hybrid Equalization Technique

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ABSTRACT

Multiple-Input Multiple-Output (MIMO) orthogonal frequency division multiplexing (OFDM) is the foundation for more advanced wireless local area network (Wireless LAN) and mobile broadband network standards, it provides the higher data rates, greatest spectral efficiency and, delivers the highest capacity in different channel conditions. But due to the wireless channel number of impairments occurs, one of them is the ISI, which affects system performance and increases Bit Error Rate. Equalization is the process to combat ISI, noise effect from the channel and different linear and nonlinear equalizers are in literature. The paper focuses on the individual advantages of these equalizers and proposed a technique in which hybridization of linear and nonlinear equalizers have been made for a flat fading Rayleigh channel to reduce Bit Error Rate in MIMO-OFDM system.

Keywords: MIMO, OFDM, ISI, Linear and Nonlinear Equalizer.

INTRODUCTION:

The goal of wireless communication systems is to provide high data rate wireless access at high quality of service. Multiple input multiple output frequency division multiplexing (MIMO-OFDM) combines the simple equalization of OFDM modulation with capacity, diversity, and array gain of MIMO systems. Currently MIMO-OFDM is being considered in various multiuser systems including high speed wireless local area networks and next generation cellular systems [1]. The MIMO OFDM system model provides high data rates and high performance in different channel conditions. The MIMO system containing multiple antennas both at the transmitter and receiver end can potentially meet the growing demand for higher capacity in wireless communications [2].

Highest spectral efficiency, throughput which makes the system irresistible for high-data-rate wireless applications is achieved by the MIMO-OFDM system. But still there are four main obstacles in wireless communication, namely ISI (Inter Symbol Interference), multipath propagation, co-channel interference and noise in the channel which further increases the BER (Bit error rate) and reduces system performance [3]. Numbers of equalization techniques are there to minimize ISI and reduce BER. The paper proposed a new equalization technique with combining the linear and nonlinear techniques together and the combination of linear and nonlinear equalizer performs better with enhanced SNR (Signal to noise ratio) and reduced BER, thus system performance is enhanced.

Thus the paper gives an introduction to the Equalization and types of Equalizers in section I, a literature of these techniques and algorithms for equalizers in section II, the proposed technique and comparison of equalizers is discussed in section III followed by a conclusion.

1. EQUALIZATION:

Equalization is the process to remove ISI and noise effect from the channel. The equalizer is placed on receiving end of the channel. The transfer function of the equalizer is just an inverse of the channel transfer function [4]. Equalization is an iterative process of reducing the mean square error. Equalization can be done in both time and frequency domain. Equalization in frequency domain is simple in comparison to time domain.

Equalizers basically use an adaptive algorithm for reducing the effects of deep fades as well as inter-symbol interference. Equalization techniques can be subdivided into two general categories- linear and nonlinear equalization [5]. In linear equalizer there is no feedback path to adapt the equalizer, and then the equalization is linear. The ZF and MMSE are the linear equalizers [6]. On the other hand, in nonlinear equalizer there is fed back to change the subsequent outputs of the equalizer, the equalization is nonlinear. The MLSE, SIC, and decision feedback equalizer (DFE) are nonlinear equalizers [6].

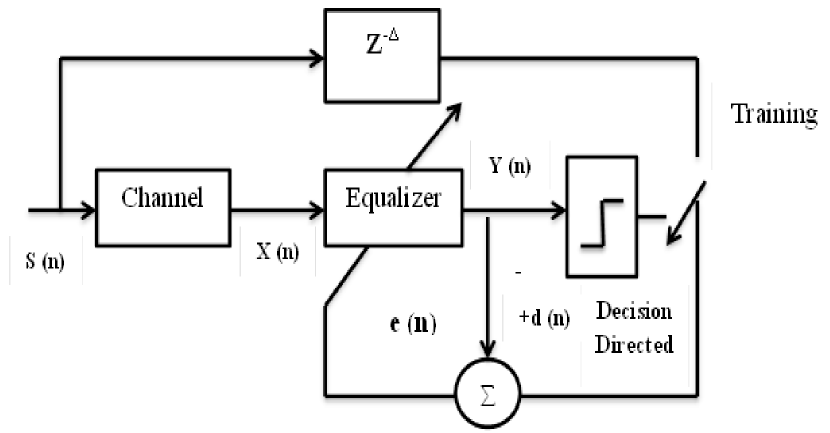

Figure 1: Channel Equalizer

In figure 1 [7], S (n) is the signal that transmits through the communication channel, and x (n) is the distorted output signal. Y (n) is output signal and d (n) is desired signal. The e (n) is denoted as error signal. The adaptive equalizer competes with signal distortion in two modes: Training and decision directed.

2. LITERATURE REVIEW:

Table 1: Literature Review

Author	Research Methodology	Conclusion
M.E. Kalantari et al 2010 [8]	A comparative investigation on various channel estimation and equalization algorithms for OFDM based high rate wireless MAN networks is presented and analyzed in terms of Mean-Square-Error (MSE), Bit-Error Rate (BER) and computational complexity.	MMSE shows best performance, its computational complexity is the highest among all the schemes considered. The LS estimate with linear interpolation has much reduced complexity.
Junjie Ma et al 2005 [9]	Study the equalization problem for Linearly pre coded multiple-input multiple-output (MIMO) systems. Develop novel iterative equalization algorithms based on message-passing principles. Establish an evolving technique to analyze the performance of the proposed iterative equalization algorithms.	The simulated performance of the proposed linear pre coding and iterative equalization scheme agrees well with the evolutionary analysis, and the proposed scheme can significantly outperform the existing schemes. The performance advantage of the proposed scheme is achieved without exploiting any knowledge of channel state information at the transmitter.

Dhammika Jayalath et al 2012 [10]	Linear adaptive channel equalization using the least Mean square (LMS) algorithm and the recursive least-squares (RLS) algorithm for an innovative multi-user (MU) MIMO OFDM Wireless broadband communications system is proposed. The proposed equalization method adaptively compensates the channel impairments caused by frequency selectivity in the propagation environment. Simulation results for the proposed method are conducted using a training sequence method to determine optimal performance through a comparative analysis.	The proposed equalization method automatically equalizes the behavior of the channel and compensate for channel impairments. LMS and RLS adaptive algorithms as well as training sequence based equalization methods are employed in the proposed AE to determine optimal performance. At a SNR of 16 dB show a lower BER when using AE, BER equals to 0.05 for LMS and 0.01 for RLS algorithms, in comparison with a 0.16 BER when AE is not used.
Mohsen Shiva et al 2007 [11]	A new channel-estimation algorithm based on maximum-likelihood (ML) algorithm for estimation and tracking of the multiple-input–multiple output (MIMO) channels are presented. The ML algorithm presents the optimal estimation when the exact channel model is known. The proposed algorithm is simulated for flat-fading time-varying MIMO channels for the different values of fDT, Eb/N0, and training lengths via Monte Carlo simulation technique.	The derived channel-estimation algorithm is very efficient with a computational complexity comparable to the least mean square and much lower than the recursive least squares and the Kalman algorithms. By simulating the proposed algorithm for different values of the training length required for different channel conditions is extracted.
Manish Kumar et al 2012 [12]	In this paper, we study the equalization problem for multiple-input multiple-output (MIMO) systems & by using numerical results simulated performance of the equalization techniques for MIMO systems is carried out & it is shown that BER decreases as number of receiving antenna increases.	To achieve an objective a strong equalization technique, the MMSE equalizer is taken. The receiver is based on MMSE. Bit Error Rate performance for MIMO-OFDM shows that MMSE in correlated Rayleigh flat fading channel is better than Zero Forcing Equalizer.

3. COMPARISON OF EQUALIZERS:

Table2: Comparison of equalizers [10], [12]

Equalizer	Advantages	Disadvantages
Least Mean squares (LMS)	Low computational complexity	Slow convergence, poor tracking
Recursive Least squares (RLS)	Fast convergence ,excellent tracking ability	High computational complexity
Zero Forcing Equalizer (ZF)	Removes all ISI and is ideal only when the channel is noiseless	Zero forcing equalization fails when the channel impulse response has finite length and channel is noisy
MMSE	The main feature of MMSE equalizer is that it does not usually eliminate ISI completely, but, minimizes the total power of noise and ISI components in the output.	Requires Channel impulse response & training symbols

3.1. PROPOSED TECHNIQUE:

The equalization technique is proposed for Rayleigh Flat fading channel [3]. In this, we first implemented ZF and MMSE and compare the BER performance in terms of SNR and found MMSE outperforms the ZF. So, a combination of those equalization techniques is made which have outperform others existing, namely MMSE, SIC (Successive interference Cancellation), MRC and ML. MMSE, the minimum mean square equalizer is the optimal one that seeks to balance between the cancellation of the interference and reduction of noise enhancement. The result of this is further enhanced by combining it with SIC. In addition, there is another opportunity to improve the performance by optimal ordering the SIC process [13]. The ordering is based on the norm of the nulling vector. At each stage of cancelation, instead of randomly selecting the stream to detect, we choose the nulling vector that has the smallest norm to detect the corresponding data stream.

Then the Euclidean distance between received signal vector and the product of all possible transmitted signal vectors with the given channel H is calculated and finds the one with minimum distance [14], the technique is called the technique maximum likelihood ML, The ML receiver performs optimum vector decoding and is optimal in the sense of minimizing the error probability. Maximal Ratio Combining (MRC) obtains the weights that maximize the output SNR, i.e., it is optimal in terms of SNR and reducing the BER [15]. The equations to be used are enclosed in figure 2.

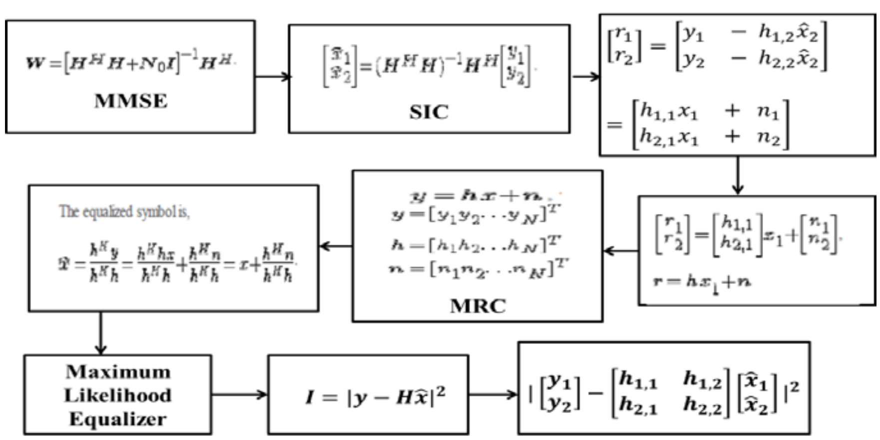

Figure2: Proposed Techniqu

CONCLUSION:

The paper discussed about the problem of ISI which occurs in MIMO-OFDM systems and its effects on the system performance and the equalization techniques to overcome these performance reducing problems mainly ISI. The paper gives a comparison table of the existing techniques and proposed a hybrid equalization technique to minimize BER with improved SNR and receiver diversity.

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