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Performance Assessment of STBC Encoded MIMO MC-CDMA System over AWGN Channel

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Abstract:- This article presents the performance of a MIMO MC-CDMA system using Alamouti Space Time Block Code (STBC) scheme to transmit voice signals over an AWGN channel with QAM and QPSK digital modulation scheme in terms of bit error rate (BER). According to the results of this study, QPSK modulation outperforms QAM modulation in the MIMO MC-CDMA STBC-based wireless communication system. In comparison to QPSK digital modulation, QAM digital modulation performs the worst in voice signal transmission. The present MATLAB simulation study shows that the STBC encoded 4×4 MIMO MC-CDMA wireless communication system with minimum mean square error (MMSE) signal detection and ½-rated convolution and cyclic redundancy check (CRC) channel encoding strategies perform well when transmitting voice signals using QPSK digital modulation.

Keywords:- *MIMO, STBC, AWGN, MC-CDMA, MMSE, BER, Voice Signal Transmission.*

I. INTRODUCTION

The primary use of wireless communications has increased every year [1]. The current third-generation telecommunications system provides a more flexible data rate, greater capacity, and more tightly integrated service. The communication system's primary goal is to transmit unit information [2].The main characteristics for transmitting and receiving information on a wireless system are modulation and demodulation. As a result, the modulator is an essential component of wireless equipment. Instead of analog modulation, which was previously used, current mobile and wireless communication systems use the digital modulation scheme as an essential module for signal processing.

In terms of noise immunity and channel deterioration strength, digital modulation is extremely beneficial. The reuse of the same allocated frequency spectrum in different geographical areas in cellular wireless communication is fascinating for the development of large-scale mobile-cellular networks. Most of the time, the transmission of audio signals comes at a high cost in terms of bandwidth, and a lossless reproduction at the receiving end is required. As a result, it is critical to investigate the performance of a mobile wireless communication system employing M-ary (MPSK, MQAM, MFSK) modulation techniques for audio signals. Because of their improved spectral efficiency, these improved and most successful digital modulation schemes are widely used [3-5]. The effectiveness of a communication system is determined by a variety of factors, one of which is the bit error rate of the technique [6, 7].

The purpose of this paper is to evaluate the bit error rate (BER) performance of the STBC architecture with 4×4 antenna configuration for MIMO MC-CDMA wireless communication system, using MMSE signal detection scheme and ½-rated convolution and cyclic redundancy check (CRC) channel encoding strategies under QPSK, and QAM digital modulation schemes on voice signal transmission in the presence of Additive White Gaussian Noise (AWGN) channel.

II. RELATED WORKS

The effectiveness of encrypted color image transmission in an MC-CDMA wireless communication encoded using D-BLAST-aided LDPC is introduced in [6]. They demonstrated that combining the QAM digital modulation technique with the MMSE-SIC channel equalization technique yields a satisfactory result for the LDPC encoded MC-CDMA system when compared to the MMSE, ZF, and ZF-SIC. Naznin et al.[7] demonstrated that using 4QAM digital modulation strategies to implement the MMSE-SIC signal detection technique verifies the effectiveness of the LDPC encoded and MP-WFRFT-based physical layer protection scheme used by the MIMO wireless communication system to retrieve color images transmitted over noisy and Rayleigh fading channels.

The authors of [8] investigated image transmission over the MC-CDMA system and evaluated system performance, concluding that the MC-CDMA image transmission system with chaotic LMMSE equalization transmits images more efficiently than the LMMSE helical interleaving system. In [9] presents the performance of the MIMO MC-CDMA system in Rayleigh fading environments using QPSK, 8PSK, 8QAM, 16QAM, 32QAM, and 64QAM modulation approaches. They demonstrated that MIMO MC-CDMA output using QPSK modulation outperforms other modulation techniques with very low error probability and high gain.

An overall survey of MIMO technology using the V-BLAST detection scheme is provided in [10]. The performance of a MIMO MC-CDMA wireless system with noise reduction and MMSE signal detection methods for color image signal transmission and recovery are analyzed [11]. The authors observe that the Median Filter is more effective than statistical filter ordering in detecting MMSE signals. A performance assessment of MIMO MC-CDMA uplink

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systems that rely on the V-BLAST linear zero-force algorithm is addressed in [12]. According to findings, a MIMO MC-CDMA system based on the linear ZF V-BLAST algorithm can achieve better BER performance than an ordinary MC-CDMA system by decreasing the number of transmitting or increasing the number of receiving antennas.

The potential of a V-Blast encoded MIMO MC-CDMA wireless communication system in encrypted color image transmission is studied in [13]. Using ZF and MMSE signal detection and 16QAM digital modulation methods, a V-Blast encoding scheme is very efficient and effective in extracting encrypted color images, according to studies. A study of video transmission performance in a V-Blast encoded MIMO MC-CDMA system is described in [14]. According to the findings of the study, V-BLAST encoded 22 MIMO MC-CDMA wireless systems with ZF signal detection and 12-rated Convolution and CRC channel coding techniques outperform BPSK digital modulation in video transmission. Secure data transmission in a V-Blast encoded MIMO MC-CDMA wireless communication system is presented in [15]. According to the results of this study, for BPSK digital modulation, the ZF with a ½-rated Convolution coding scheme outperforms the MMSE with CRC coding scheme.

The impact of antenna diversity on secured text message transmission for a wireless system with dual transmit and multiple receive antennas that employs single user Alamouti's space-time block coding (STBC) and maximal ratio combining (MRC) is investigated in [16]. According to the investigation, in the absence of receive antenna diversity, the system performs poorly in the 16-DPSK scheme but well in the 16-QAM scheme. An analytical approach for determining the BER of an OFDM system and a space-time block coded (STBC)-OFDM system in a fading environment while taking into account all three channel impairments such as AWGN, fading, and jitter is described in [17]. Studies have shown that STBC-OFDM shows better BER performance than the OFDM system.

A new perspective on system performance using STBC encoded MIMO-OFDM radio interface technology, four-channel equalization techniques (ZF, MMSE, ZF-SIC, and MMSE-SIC), and three digital modulation schemes (BPSK, QPSK, and QAM) is provided in [18]. On encrypted voice frequency signal transmission, simulation results of this study demonstrated that the STBC encoded single relayed MIMO-OFDM cooperative wireless communication with BPSK and MMSE-SIC performs better than other digital modulations and channel equalization methods.

The performance of a 2×2 spatially multiplexed MIMO MC-CDMA wireless communication system with STBC and MIMO Beamforming schemes implemented using various digital modulations and channel coding strategies is studied in [19]. According to studies, implementing BPSK digital modulation scheme with a BCH channel Encoded MIMO MC-CDMA wireless communication system gives superior performance in recovering the transmitted text message in a hostile fading channel environment. The performance of Alamouti's STBC MC-CDMA schemes in outdoor scenarios utilizing a realistic MIMO channel model and configuration is investigated in [20]. The authors show that spatial diversity improves the performance of MC-CDMA systems, even in outdoor scenarios, and provides a good trade-off between performance and complexity.

III. COMMUNICATION SYSTEMS MODEL

Fig. 1 depicts a simulated 4×4 Alamouti Space Time Block Code (STBC) multi-user multi-channel encoded MIMO MC-CDMA wireless communication system. This communication system model employs various digital modulation schemes (QPSK and QAM) as well as MMSE signal detection. The diagram depicts each functional block's step-by-step operation. The recorded voice signal generates the input binary data stream on the transmitter side. As the signal must be transmitted, the retrieved binary data stream is passed through the other required steps (encryption: Vigenere Cipher and RSA encryption, channel encoder, interleaver). Our main concern is with the next block of the communication system model under consideration, where it was planned to vary the various modulation schemes in order to analyze their performance. The choice of digital modulation scheme has a significant impact on the system's performance and characteristics. There are no general guidelines for selecting a scheme. However, depending on the channel, the required level of performance, and the objective hardware trade-offs, one methodology outperforms the other [21]. The required data rate, latency, link budget, and available bandwidth must all be taken into account. In order to reproduce the transmitted voice signal, the received signal is demodulated on the receiver side and passed through the other subsequent blocks.

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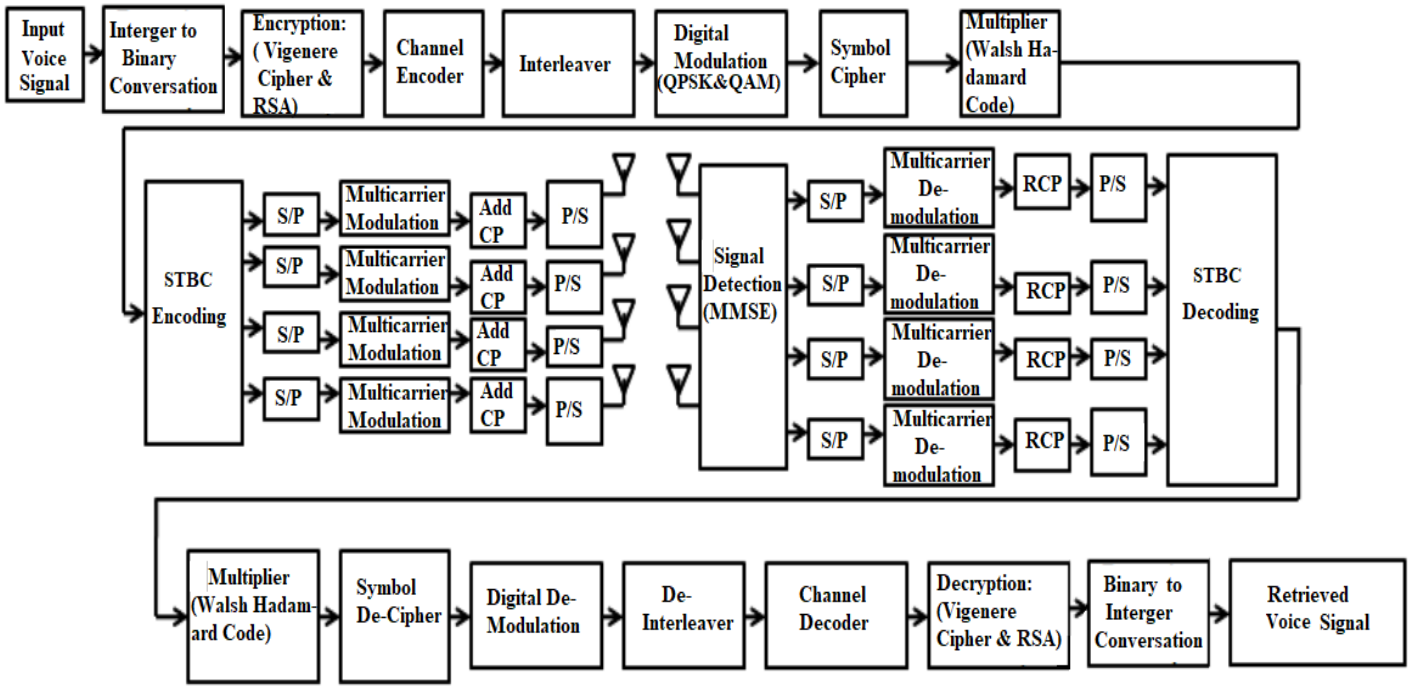

Fig. 1:- Block diagram of a STBC encoded MIMO MC-CDMA wireless communication system model.
Here S/P = serial to parallel converter; P/S = parallel to serial converter,
Add CP = adding cyclic prefix; CP = cyclic prefix.

IV. RESULTS AND DISCUSSION

Different modulation techniques (QPSK and QAM) for wireless communication systems are assessed using voice signals as a function of bit error rate (BER). This is Matlab's simulation work, which takes into account the simulation parameters listed in TABLE 1. The work focuses on the voice signal that is transmitted via the AWGN channel, with no consideration given to fading channels like Rayleigh fading and Ricean fading.

Fig. 2 depicts the system performance with various digital modulation schemes (QPSK, and QAM). In comparison to the signal-to-noise ratio, the Bit Error Rate (BER) is significantly reduced (SNR). This figure clearly shows that QPSK outperforms QAM in terms of performance. At SNR=0 dB, QAM has a higher BER value than QPSK modulation techniques.

Parameters	Values
Data Types	Voice Signal
Input Voice size	1,48,408 bytes
Channel Coding	½-rated Convolution and CRC Channel encoding
Modulation	QPSK, QAM
Cryptographic algorithm	Vigenere Cipher and RSA
Antenna configuration	4 × 4
Channel	AWGN
Signal to noise ratio, SNR	0 to 10 dB
Spreading Code	Walsh Hadamard
Signal detection	MMSE

Table 1:- Summary of the simulation model parameters

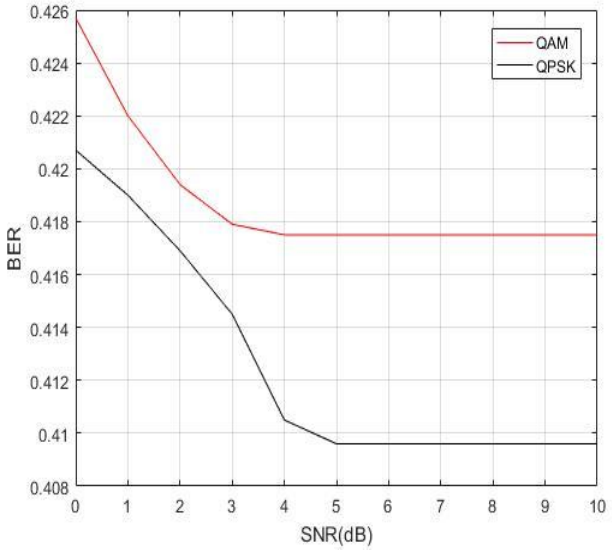

Fig. 2:- System performance under different modulation

TABLE 2 summarizes the BER values of the system at various SNRs for different modulation methods of the voice signal. The table clearly shows that for different SNR values (SNR = 1 to10 dB), QPSK outperforms QAM in terms of BER performance. These simulation results show that the QPSK modulated the STBC MIMO MC-CDMA system with the use of convolution and CRC channel encoding and the MMSE signal detection technique outperforms voice data transmission, whereas the QAM modulated system shows the worst performance.

SNR (dB)	BER values for different modulations	
	QAM	QPSK
0	0.4257	0.4207
1	0.4220	0.4190
2	0.4194	0.4169
3	0.4179	0.4145
4	0.4175	0.4105
5	0.4175	0.4096
6	0.4175	0.4096
7	0.4175	0.4096
8	0.4175	0.4096
9	0.4175	0.4096
10	0.4175	0.4096

Table 2:- BER values of the STBC encoded MIMO MC-CDMA system at a different SNR for various modulation schemes

V. CONCLUSION

In this paper, the bit error rate (BER) performance of STBC encoded 4×4 MIMO MC-CDMA wireless communication system communication in the presence of Additive White Gaussian Noise (AWGN) channel is reported using MMSE signal detection scheme and ½-rated convolution and cyclic redundancy check (CRC) channel encoding strategies under QPSK and QAM digital modulation schemes. Based on the findings of this study, it is clear that QPSK modulation outperforms the QAM digital modulation scheme. As a result, it can be concluded that a lossless reproduction of the voice signal can be achieved at the receiver end of the proposed STBC encoded 4×4 MIMO MC-CDMA wireless communication system using the MMSE signal detection scheme and ½-rated convolution and cyclic redundancy check (CRC) channel encoding strategies under QPSK digital modulation scheme.

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