International Journal of Recent Engineering Science (IJRES) Volume 7 Issue 3, 52-56, May-Jun 2020
ISSN: 2349 – 7157 / doi: 10.1445/23497157/IJRES-V7I3P111

Performance Analysis of V-Blast Encoded MIMO MC-CDMA Wireless Communication System in Encrypted Color Image Transmission

Md. Sofiqul Islam[1], Md. Firoz Ahmed[1] and A. Z. M. Touhidul Islam[2]
[1] *(Department of Information and Communication Engineering, Rajshahi University, Bangladesh)*
[2] *(Department of Electrical and Electronic Engineering, Rajshahi University, Bangladesh)*

Abstract
*Multicarrier-code division multiple access (MC-CDMA) technique based wireless communications system provides robustness to frequency selective fading, high spectral efficiency, and flexibility to support multiple users with the high data rate. In this paper, a comprehensive simulation study for the performance evaluation is undertaken of V-Blast encoded MIMO MC-CDMA wireless communication system in encrypted Color Image Transmission**.** The 4 ×4 multi-antenna configured simulated system under investigation incorporates a combination of Minimum Mean Square Error (MMSE) and Zero-Forcing (ZF) signal detection techniques under different digital modulation schemes (BPSK, QPSK, and 16QAM). MATLAB based simulation study shows that V-Blast encoded system is very much robust and effective in retrieving encrypted color image under the utilization of ZF and MMSE signal detection and 16QAM digital modulation schemes.*

Keywords - *MIMO, V-Blast, MC-CDMA, ZF, MMSE, BER, Signal to Noise Ratio (SNR)*

I. INTRODUCTION

With the rapid growth of wireless communication techniques and mobile internet and multimedia services, there is a significant increase in the demand for high data rate transmission. Reliable data transmission across wireless channels poses significant challenges, including fading, interference, and multipath propagation [1, 2].

Given the increasing demand for multi-user communication like cellular systems, multiple access capabilities are needed to transmit multiple signals through the channel simultaneously. A new transmission technique called Multicarrier - Code Division Multiple Access (MC-CDMA) [3,4] combining Code-Division Multiple-Access (CDMA) [5] and Orthogonal Frequency Division Multiplexing (OFDM) has become the most promising data transmission system in wireless communications in recent years.

Because these combined systems have many desirable properties for high data rate and efficient data transmission over wireless channels, this multi-carrier transmission system has received significant attention. The main benefit of the multi-carrier technique is that compared to other transmission techniques, it needs a lower symbol rate. For N carriers, the entire system bandwidth is divided into N sub-bands with a multi-carrier CDMA system; hence the symbol rate for each subcarrier can be made low.

MC-CDMA technique incorporates the capabilities of both OFDM and CDMA schemes to provide a communication system that has the benefits of both.

Because of the simultaneous transmission nature of the OFDM technique, this hybrid scheme has become desirable for broadband communication and can have greater resource management efficiency and flexibility due to the advanced CDMA allocation technique.
A further significant characteristic of MC-CDMA is that the use of OFDM makes it bandwidth-efficient [6]. Modulation or demodulation in OFDM can be easily performed using IFFT or FFT algorithms, respectively [7]. Because of its high spectral efficiency, MC-CDMA is an appropriate candidate for the downlink of a cellular system. The main benefits of the MC-CDMA system are that the reliability and performance of wireless radio links are improved, and the signal delivered to the receiver provides not only a direct line-of-sight radio wave but also a massive number of reflected radio waves [8].

Multiple-input multiple-output, or MIMO, is a radio communication network or RF system, used by Wi-Fi, LTE; Long Term Evolution, and much other radio, wireless, and RF systems to provide enhanced coverage and spectrum capacity along with improved transmission stability using what had previously been known as interference routes[9]. Such technologies implement various forms of multi-antenna techniques such as Alamouti space-time coding for diversity transmission, Eigen beam forming spatial multiplexing, BLAST spatial multiplexing architectures, Traditional beam, and the null formation and Traditional receiving diversity.

Three Bell Laboratory layered space-time (BLAST) SM technique were classified as Vertical BLAST (V-BLAST), Horizontal BLAST (H-BLAST), and Diagonal BLAST (D-BLAST) under the BLAST spatial multiplexing(SM) architectures [10, 11]. The report in [12] investigates the performance of 4 x 4 antenna configuration D-BLAST architecture for an LDPC encoded MC-CDMA wireless communication system on secure color image transmission.

The purpose of this research is to investigate the bit error rate (BER) performance of V-BLAST architecture with 4 x 4 antenna configuration for MC-CDMA wireless communication system, using a combination of MMSE and ZF signal detection schemes under various digital modulation schemes (BPSK, QPSK, and 16QAM) on secure color image transmission.

The paper is organized as follows. Section 2 presents a literature review of related works. A description of the system model is given in Section 3. Section 4 provides the simulation results and discussion. Finally, Section 5 concludes the work.

II. RELATED WORKS

The performance of encrypted color image transmission in an MC-CDMA wireless communication system encoded in the D-BLAST Aided LDPC is studied [12]. They showed that the implementation of the QAM digital modulation technique with the deployment of the MMSE-SIC channel equalization technique provides a satisfactory result for such an LDPC encoded MC-CDMA system as compared with MMSE, ZF, and ZF-SIC. Naznin*et al*. [13] demonstrated that the implementation of MMSE-SIC signal detection scheme using 4QAM digital modulation schemes confirms the robustness of LDPC encoded and MP-WFRFT based physical layer protection scheme implemented by MIMO wireless communication system to retrieve color image transmitted over noisy and Rayleigh fading channels.

Performance of image transmission through the use of the MC-CDMA system where it was concluded that the MC-CDMA image transmission system with chaotic interleaving with LMMSE equalization transmits image efficiently compared to the LMMSE helical interleaving system is analyzed in [2]. The performance of the MIMO MC-CDMA system in QPSK, 8PSK, 8QAM, 16QAM, 32QAM, and 64QAM modulation techniques in a Rayleigh fading environment is presented in [14]. They showed that MIMO MC-CDMA the output using the QPSK modulation technique outperforms other modulation techniques with very low error probability and high gain.

In [15], an extensive survey on MIMO technology is presented using the V-BLAST detection technique. The performance of a MIMO MC-CDMA wireless communication system with the implementation of techniques for spatial domain noise reduction and MMSE signal detection for color image signal transmission and recovery has been studied in [16]. The authors concluded that Median Filter outperforms with MMSE signal detection than order statistical Filter’s.

In [17], the performance analysis of MIMO MC-CDMA uplink systems based on the V-BLAST linear zero-forcing algorithm is presented. The studies demonstrated that the MIMO MC-CDMA system based on a linear ZF V-BLAST algorithm can achieve better BER performance than that of the conventional MC-CDMA system by reducing the number of transmitting antennas or increasing the number of receiving antennas.

III. SYSTEM MODEL

The simulated model of a multi-user 4 x 4 Vertical Bell Labs Layered Space-Time (V-BLAST) spatially multiplexed channel encoded MIMO MC-CDMA wireless communication system is shown in Figure 1. An RGB color image with 1366 pixels width and 768 pixels height has been considered. The color image is converted into its respective three Red, Green, and Blue components, with each component is of 100 × 200 pixels in size.

In such a communication system, a color image is encrypted two times using the Vigenere Cipher and RSA encryption scheme. The doubly encrypted data are converted into binary bits, and channel encoded using ½-rated Convolutional channel encoding scheme. To minimize the burst errors, the encrypted data are interleaved. Different types of digital modulation schemes such as BPSK, QPSK, and 16QAM are used to modulate the interleaved bits. The ciphered and Walsh-Hadamard coded digitally modulated symbols are then fed into the V-BLAST encoder to produce four independent data streams. In the V-BLAST encoding portion, a single complex signal stream is multiplexed in space over multiple antennas.

The output of the V-BLAST encoder is fed into the four serial to parallel converter; each data stream is serial to parallel converted. The output of the serial to parallel converter generates a complex data symbol, which is fed into each of the OFDM modulators with 1024 subcarriers which perform IFFT on each of the OFDM systems are followed by a parallel to serial conversion. To mitigate the effects of inter-symbol interference (ISI) caused by channel time spread, each block of IFFT coefficients is typically preceded by a cyclic prefix. The modulated complex symbols are parallel to serial converted and finally transmitted.

In the receiving section, all the transmitted signals are detected with linear signal detection schemes (ZF and MMSE), and the detected signals are subsequently sent up to the serial to parallel (S/P) converter and fed into OFDM demodulator, which performs FFT operation on each OFDM block. The FFT operated signal is then processed with cyclic prefix removing scheme and are undergone from parallel to serial conversion and are fed into V-BLAST decoder. Its output is multiplied with Walsh Hadamard codes. The multiplexed data are digitally demodulated, de-ciphered, de-interleaved, channel decoded, and decrypted to recover the transmitted color image.

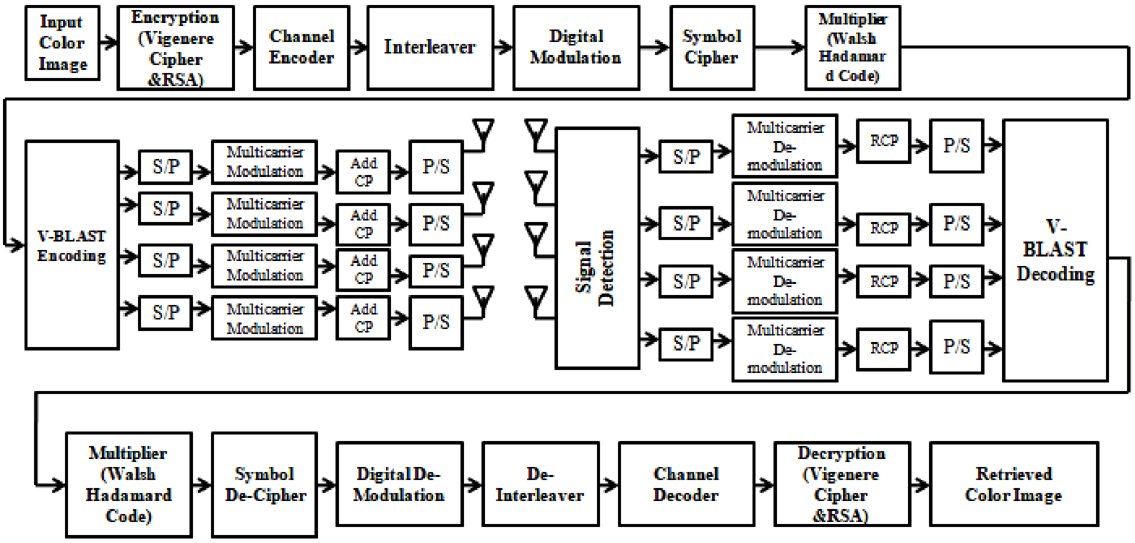


Figure 1 Block diagram of V-BLAST encoded channel encoded MC-CDMA Wireless Communication System. Here S/P = Serial to parallel, P/S= Parallel to Serial, Add CP = Adding Cyclic Prefix, RCP= Removing Cyclic Prefix.

IV. RESULTS AND DISCUSSION

This section presents the computer program's simulation results written in MATLAB R2014 platform following the analytical approach of a wireless communication system. The V-BLAST encoded MIMO MC-CDMA system model has been deployed with consideration of simulation parameters listed in Table1.

Table 1: Summary of the simulation model parameters.

Parameters	Values
Data Type	Color image
Image Size	(100×200) pixels
Channel Coding	½-rated Convolutional Encoding
Modulation	BPSK, QPSK,16 QAM
Cryptographic algorithm	Vigenere Cipher and RSA
Antenna configuration	4 × 4
Channel	AWGN
Signal to noise ratio, SNR	0 to 45dB
Spreading Code	Walsh Hadamard
Signal detection	Combination of MMSE and ZF

The simulation results are presented in terms of signal to noise ratio (SNR) and the bit error rate (BER). The graphical illustrations presented in Fig. 2 show the V-BLAST encoded MIMO MC-CDMA system's performance compared with the implementation of a combination of Minimum Mean Square Error (MMSE) and Zero-Forcing (ZF) based signal detection schemes under various digital Modulation techniques (16QAM, BPSK, and QPSK).

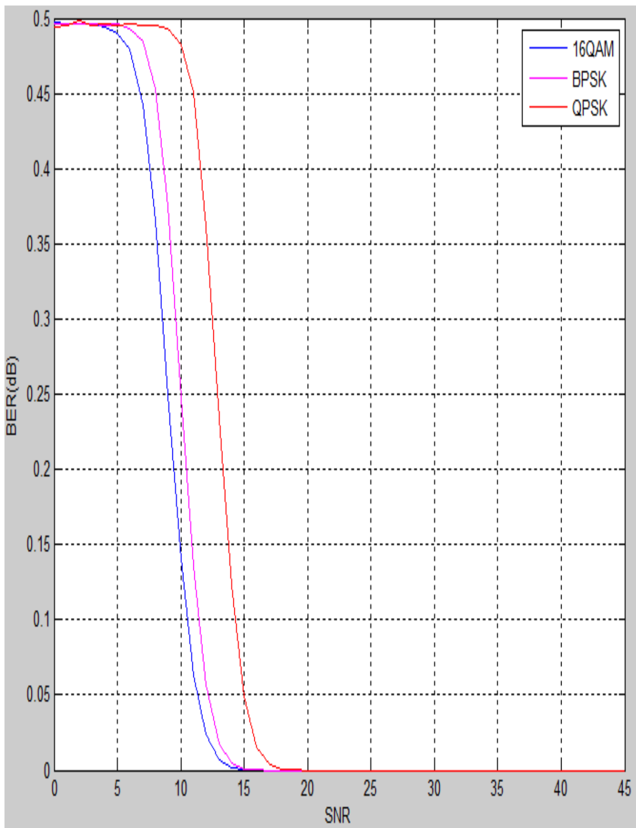
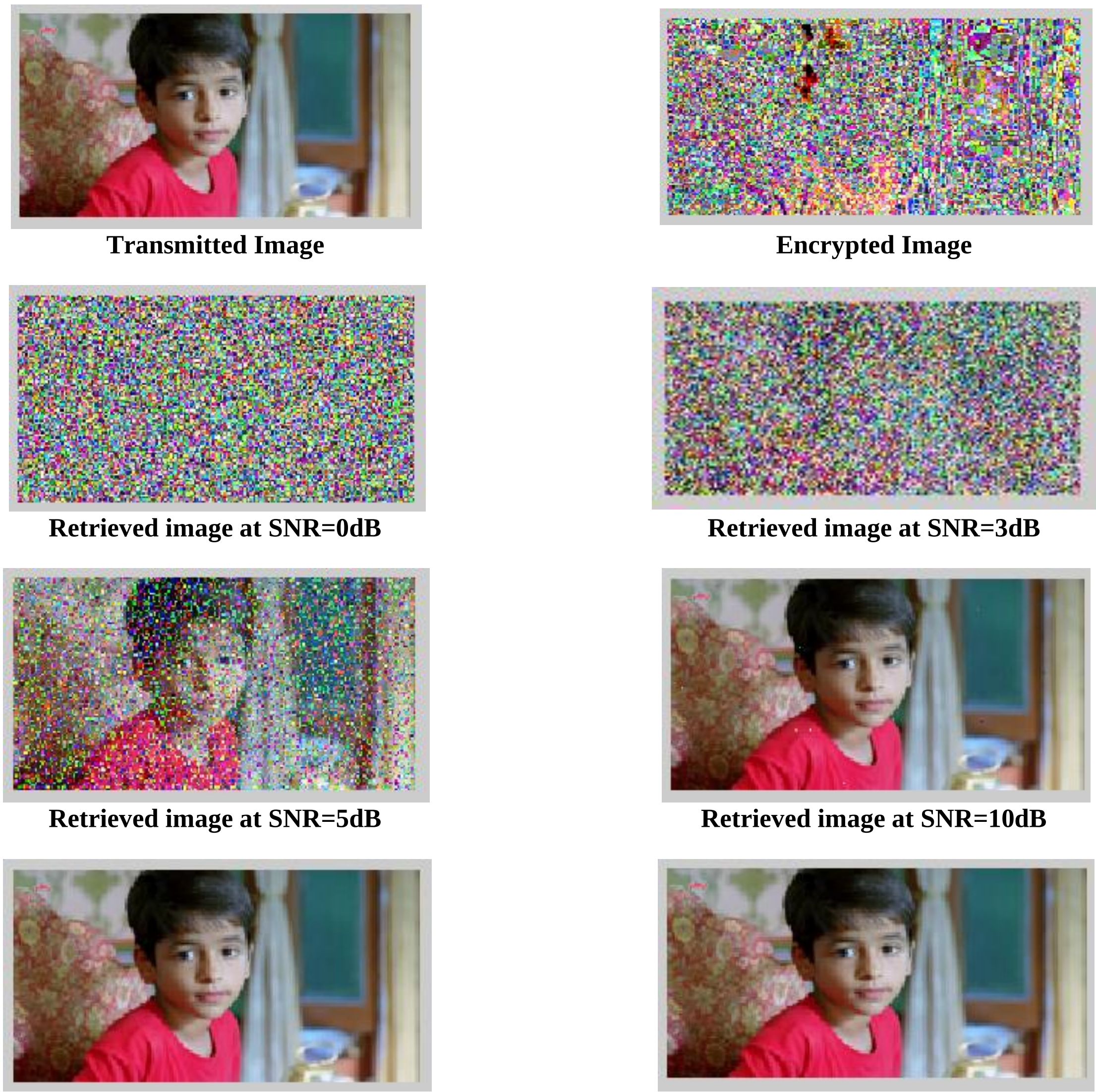


Figure 2: BER performance comparison of the V-BLAST encoded 4×4 MIMO MC-CDMA system with the employment of BPSK, QPSK, and 16QAM digital modulation schemes under Convolution channel coding and combination of MMSE and ZF based signal detection schemes.



Transmitted Image | **Encrypted Image**

Retrieved image at SNR=0dB | **Retrieved image at SNR=3dB**

Retrieved image at SNR=5dB | **Retrieved image at SNR=10dB**

Retrieved image at SNR=15dB | **Retrieved image at SNR=30dB**

Figure 3: Transmitted image, corresponding encrypted image, and the retrieved image at different typical SNR values over V-BLAST encoded 4×4 MIMO MC-CDMA system with 16QAM modulation and a combination of MMSE and ZF signal detection schemes.

From the graph, it is seen that when the transmitted signal is quite a week, that means the SNR is on 0 dB, the system performance is disrupted. When the SNR value is 3 dB, almost the same BER performance is obtained on 0 dB for each modulation. However, when the value of SNR increases from 5 dB to 45 dB, the BER values decline, and hence the system performance increases gradually under all modulation techniques employed. It is also observed that the BER performance of 16-QAM modulation is better than that of the BPSK and QPSK modulation techniques. At SNR of 15 dB, the bit error rate for 16-QAM modulation is relatively low, i.e., 0.01, while the BER value for BPSK and QPSK are 0.02 and 0.05, respectively. So, the performance of 16-QAM modulation is better as compared with the BPSK and QPSK modulation schemes. For the SNR value at 20dB, it is seen that the BER value is zero for each modulation, which implied that the transmitted color image is received by the system correctly.

It is also noticeable that the system outperforms in 16 QAM and shows the worst performance in QPSK digital modulation. In Figure 2, the BER values in the case of 16-QAM and QPSK are 0.01 dB and 0.05 dB, respectively, for a 15 dB SNR value that is indicative of the system achieves a performance gain of 6.98 dB for 16-QAM modulated 4×4 MIMO MC-CDMA employing a combination of MMSE and ZF signal detection schemes.
Figure 3 shows pictorial views of the transmitted color image, corresponding encrypted image, and the retrieved image at typical SNR values of 0, 3, 5, 10, 15, and 30 dB in a simulated V-BLAST encoded 4×4 MIMO MC-

CDMA system performance with the employment of a combination of MMSE and ZF signal detection schemes under 16QAM digital Modulation technique. It is observable that at SNR values of 0 and 3 dB, the system's performance is disrupted, and the transmitted color image is not retrieved. After that, as the SNR value increases, the system performance in retrieving the color image increases. At an SNR value of 5 dB, the original transmitted image is not retrieved. For SNR value 10 dB, the retrieved image quality has improved, but we are not able to recover the image correctly. However, it is clear from Fig. 3 that the transmitted image is quite satisfactorily retrieved at the receiving end for SNR values of 15 dB and 30 dB.

V. CONCLUSION

In this paper, the performance of V-Blast encoded 4×4 MIMO MC-CDMA Wireless Communication System has been investigated based on their bit error rates and signal-to-noise ratio on secure color image transmission with the utilization of a combination of MMSE and ZF based signal detection schemes under BPSK, QPSK, and 16-QAM digital modulation techniques. Based on the simulation results presented, it can be concluded that the deployment of 16-QAM digital modulation technique with the combination of MMSE and ZF signal detection schemes in V-Blast encoded 4×4 MIMO MC-CDMA system provides satisfactory results in retrieving color image transmitted over AWGN channel.

REFERENCES

[1] T. S. Rappaport., Wireless communications principles and practice, 2nd ed. New Jersey: Pearson Education. (2002).
[2] ShikhaJindalandDiwakarAgarwal., Proceedings of the International Conference on Advances in Computing, Communications and Informatics (ICACCI). (2014) 1331-1347.
[3] K. Fazel and S. Kaiser., Multi-carrier and spread spectrum systems, Chichester: Wiley. (2003).
[4] S. Hara and R. Prasad., Overview of multi-carrier CDMA, IEEE communications magazine, 35(12) (1997) 126-133.
[5] H. Schulze and C. Luders., Theory and application of OFDM and CDMA, New York: Willey. (2005).
[6] S. B. Slimane., Bandwidth efficiency of MC-CDMA signals, Electron. Lett. 35 (1999) 1797–1798.
[7] S. B. Weinstein and P. M. Ebert, Data transmission by frequency division multiplexing using the discrete Fourier transform, IEEE Trans, Commun. Technol. 19(5) (1971) 628–634
[8] Viterbi A. J., CDMA: Principles of Spread Spectrum Communication. Reading: Addison-Wesley. (1995).
[9] Jerry R. Hampton., Introduction to MIMO Communication, Cambridge University Press, United Kingdom. (2014).
[10] D. Gesbert et al., IEEE Journal on Selected Areas in Communication.21(3) (2003) 281-302.
[11] Md. SarwarHosain, ShaikhEnayetUllah, and RubaiyatYasmin, International Journal of Scientific & Engineering Research. 5(7) (2014) 744-749.
[12] TonusreeSaha, Md. SarwarHosain and Shafi Ahmed Istiaq., Advances in Networks. 4(2) (2016) 13-20.
[13] LailaNaznin, Mohammad ReazHossain&ShaikhEnayetUllah, Global Journal of Computer Science and Technology: A Hardware& Computation.17(1) (2017) pp. 27-38.
[14] Mr. Atul Singh Kushwah and Mr. Mayank Mittal., International Journal of Engineering Research & Technology (IJERT). 3(1) (2014) 2484-2490.
[15] Sudhanshu Kumar Chourasia and RashmiPandey., International Journal of Computer Applications (0975 – 8887). 98(5) (2014) 38-42.
[16] Sharmin Sultana, AurangzibMdAbdurRahman and Foez Ahmed., Journal of Multidisciplinary Engineering Science and Technology (JMEST).3(3) (2016) 4386-4391.
[17] Wei Yang., Science in China Series F Information Sciences, 51(9) (2008) 1305-1318.
[18] SonaliVairagade and PallaviPahadiya., Performance Analysis of MIMO-OFDM System using Turbo Coding, SSRG International Journal of Electronics and Communication Engineering. 2(10) (2015).