COMPARATIVE PERFORMANCE ASSESSMENT OF V-BLAST ENCODED 8×8 MIMO MC-CDMA WIRELESS SYSTEM

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ABSTRACT

The bit error rate performance of a V-Blast encoded 8x8 MIMO MC-CDMA wireless communication system for different signal detection (MMSE and ZF) and digital modulation (BPSK, QPSK, DPSK, and 4QAM) schemes for grayscale image transmission has been investigated in this paper. The proposed wireless system employ ½-rated Convolution and cyclic redundancy check (CRC) channel encoding over the AWGN channel and Walsh Hadamard code as an orthogonal spread code. The present Matlab based simulation study demonstrates that the V-Blast encoded 8×8 MIMO MC-CDMA wireless system with the employment of 1/2-rated convolution and cyclic redundancy check (CRC) channel encoding strategies shows good performance utilizing BPSK digital modulation and ZF signal detection scheme in grayscale image transmission.

KEYWORDS

V-Blast, MIMO, MC-CDMA, MMSE, ZF

1. INTRODUCTION

In recent times, the Multicarrier Code Division Multiple Access (MC-CDMA) system has received widespread importance in future wireless communications. Combining Orthogonal Frequency Division Multiplexing (OFDM) Modulation and Code Division Multiple Access (CDMA) Modulation, a modern approach is being developed which will take full advantage of both strategies. A patented fourth generation (4G) wireless technology, such as higher spectral efficiency, results in higher bit rate and multi-access capability, robustness in the case of selective frequency channels. MC-CDMA is a multi-access technique used in Orthogonal Frequency Division Multiplexing (OFDM) telecommunications systems, which allows the system to support multiple users at the same time. The key concept of the MC-CDMA system depends on data transmission by dividing the high data rate stream into several low data rate subcarriers. The MC-CDMA spreads the frequency domain to each user [1, 2].

By using orthogonal spread codes, multiple data symbols share common subcarriers and their signals remain separable from the receiver. In order to improve the bit error rate (BER) over the OFDM standard, the frequency diversity created by multipath propagation in the communication channel is exploited with appropriate selections of spreading codes [3]. Because the use of multiple antennas at both transmit and receive ends (MIMO) became one of the most important examples for the deployment of current and new wireless communication systems, work has been conducted to exploit the maximum multiplexing gain as part of the implementation of the V BLAST system for MIMO transmission.

The Vertical Bell Labs Layered Space-Time (V-BLAST) method was proposed in [4] to provide a multiplexing benefit, i.e. it provides for an increase in the effective bandwidth efficiency of a specific user without the need for any increase in the transmitting power or bandwidth of the system. In addition, the MIMO scheme incorporating the advantages of V-BLAST and STBC was presented in [5] and known as the "Double Space-Time Transmit Diversity (D-STTD)". The D-STTD benefits from the diversity gains of the STBC and the multiplexing gains of the V-BLAST arrangement. Joshi et al. [6] carried out a simulation study based on the performance evaluation of the V-BLAST encoded MIMO wireless communication system with the implementation of Maximum Likelihood (ML), Zero Force (ZF), Minimum Mean-Square Error (MMSE), and Successive Interference Cancellation (SIC) channel equalization (signal detection) schemes. 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. 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] introduces 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. In [10] provides an in-depth evaluation of MIMO technology using the V-BLAST detection technique. In [11] investigated the performance of the MIMO MC-CDMA wireless communication system with noise reduction and MMSE signal detection techniques for the transmission and recovery of color image signals. The study found that the Median Filter is more effective than statistical filter ordering in detecting MMSE signals. In [12] presents a performance analysis of MIMO MC-CDMA uplink systems based on the V-BLAST linear zero-force algorithm. According to the investigation, a MIMO MC-CDMA system based on the linear ZF V-BLAST algorithm can achieve better BER performance than a conventional MC-CDMA system by reducing the number of transmitting or increasing the number of receiving antennas.

In this paper, we propose a V-Blast encoded 8×8 MIMO MC-CDMA wireless communication system where different signal detection and different digital modulation techniques are used over AWGN channel with the implementation of a convolutional coding scheme such as error control coding and cryptographic algorithms like Vigenere cipher, and Rivest–Shamir–Adleman (RSA) for the secure transmission of grayscale images.

2. PROPOSED SYSTEM MODEL

Figure 1 shows the simulated multi-user 8 x 8 Vertical Bell Labs Layered Space-Time (V-BLAST) spatially multiplexed channel encoded MIMO MC-CDMA wireless communication system. A grayscale image with a width of 250 pixels and a height of 200 pixels has been considered. The system model has been used different (BPSK, DPSK, QPSK, and 4QAM) modulation and different signal detection (MMSE and ZF) schemes. This figure represents the step-by-step function of each system component. In this communication system, twice the grayscale image is encrypted using Vigenere Cipher and the RSA encryption technique. Doubly encrypted data is converted into binary bits and a channel encoded using a ½-rated Convolutional channel encoding scheme. Encrypted data is interleaved to minimize burst errors. Various types of digital modulation schemes, such as BPSK, QPSK, and 4QAM, are used for modulating interleaved bits. The ciphered and Walsh-Hadamard encoded digitally modulated

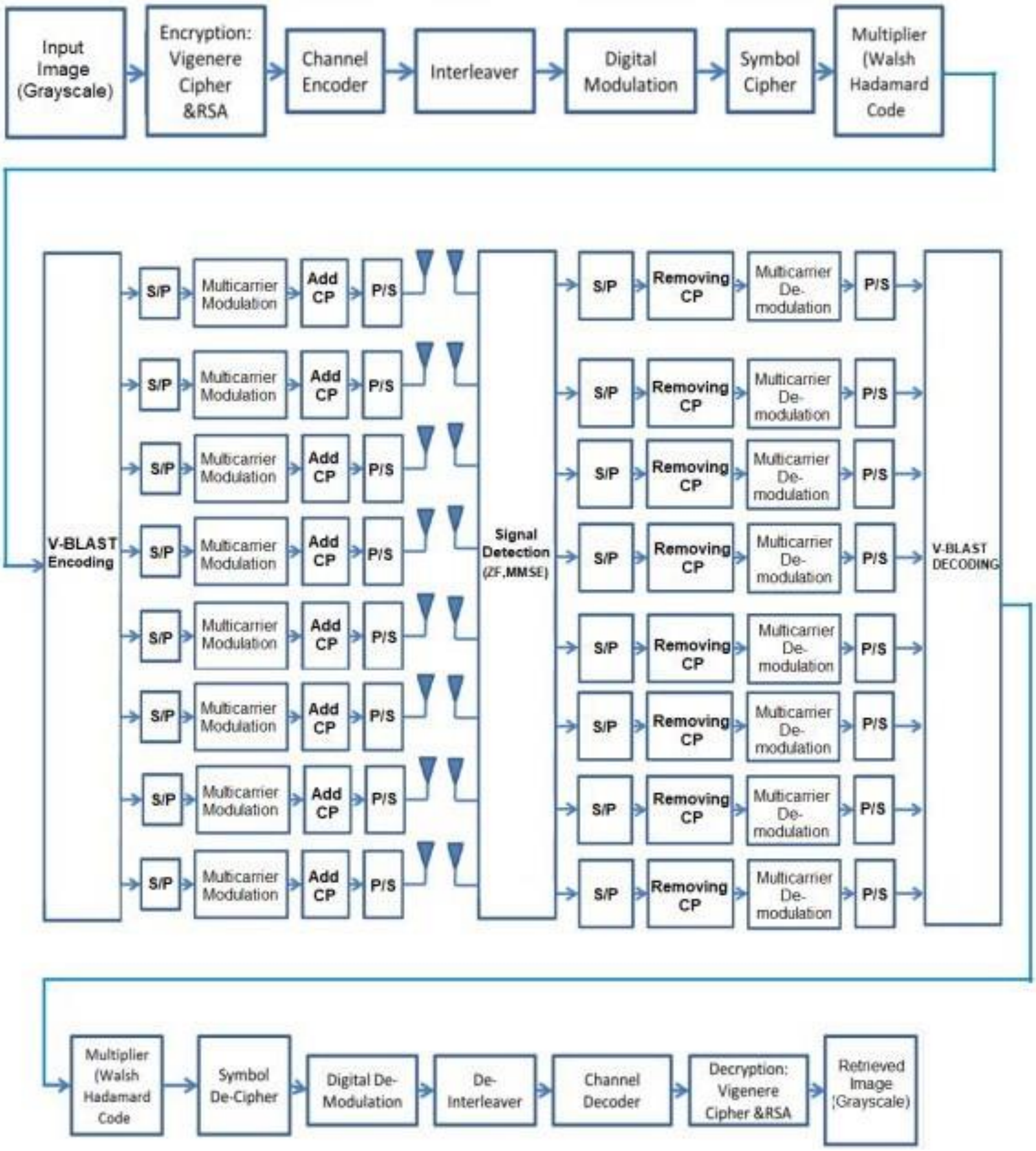

Figure 1. Block diagram of a V-Blast encoded MIMO MC-CDMA wireless communication system model. Here, S/P = serial to parallel converter; P/S = parallel to serial converter, Add CP = adding cyclic prefix; CP = cyclic prefix.

symbols are then fed into the V-BLAST encoder to generate four separate data streams. A single complex signal stream is multiplexed in space across multiple antennas in the V-BLAST encoding portion. The output of the V-BLAST encoder is fed into four serial to parallel converters, each data stream being converted serial to parallel. The output of the serial to parallel converter generates a complex data symbol that is fed into each of the 1024 subcarrier OFDM modulators that perform IFFT on each of the OFDM systems, followed by a parallel to the serial conversion. In order to mitigate the effects of inter-symbol interference (ISI) caused by channel time spread, each block of IFFT coefficients is usually preceded by a cyclic prefix. Modulated complex symbols are converted parallel to the serial and finally transmitted. In the receiving section, all transmitted signals are detected by linear signal detection schemes (MMSE and ZF) and the detected signals are then sent to the serial to parallel (S/P) converter and fed to the OFDM demodulator, which operates FFT on each OFDM block. The FFT-operated signal is then processed with a cyclic prefix removal scheme and is subjected to parallel to serial conversion and is fed into a V-BLAST decoder. Its output is multiplied by the Walsh Hadamard codes. Multiplexed data is digitally demodulated, decrypted, de-interleaved, decoded, and decrypted to retrieve the transmitted grayscale image.

3. RESULTS AND DISCUSSION

This section presents the simulation results of the computer program written on the MATLAB R2014 platform following the analytical technique of the wireless communication system. The V-BLAST encoded MIMO MC-CDMA system model has been deployed taking into account the simulation parameters set out in Table 1.

Table 1. Summary of the simulation model parameters

Parameters	**Values**
Data Types	Grayscale image
Image size	200pixels (height) × 250 pixels (width)
Channel Coding	½-rated Convolution and CRC Channel encoding
Modulation	BPSK,DPSK,QPSK,4QAM
Cryptographic algorithm	Vigenere Cipher and RSA
Antenna configuration	8 × 8
Channel	AWGN
Signal to noise ratio, SNR	0 dB to 10 dB
Spreading Code	Walsh Hadamard
Signal detection	MMSE, ZF

In this paper, the performance of the various signal detection (MMSE and ZF) and digital modulation methods (BPSK, DPSK, QPSK, and 4QAM) is compared with the MIMO MC-CDMA system bit error rate based on V-Blast simulation, where convolutional coding techniques and cryptographic algorithms (Vigenere Cipher and the RSA) are performed for security purposes through the AWGN channel for a wide range of SNRs from 0 dB to 10 dB.

The graphic illustrations shown in Fig. 2 show the performance comparison of the V-BLAST encoded MIMO MC-CDMA system with the implementation of Zero-Forcing (ZF) based signal detection schemes under various digital modulation techniques (BPSK, DPSK, QPSK, and 4QAM). For example, in the case of BPSK and QPSK digital modulations, the BER values are 0.200 and 0.364, respectively, in the typical assumed SNR value of 3 dB as shown in Table 2, i.e. the system performance achieves a gain of 11.76 dB. It is also noticeable from Fig.2 that at a higher SNR value area (4 dB – 7 dB), the estimated BER values at various digital modulations (BPSK, DPSK QPSK, and 4QAM) range from a minimum of 0.175 to a maximum of 0.220 with the utilization of the Zero Forcing (ZF) signal detection scheme (Table 2). Here, BPSK also has the best performance among others as shown in the figure. The system has almost identical performance in the low SNR value area (1 dB – 3 dB) with DPSK and 4QAM digital modulations. After the SNR value of 4 dB – 10 dB, the BER value decreases the digital modulation of BPSK, DPSK, QPSK, and 4QAM.

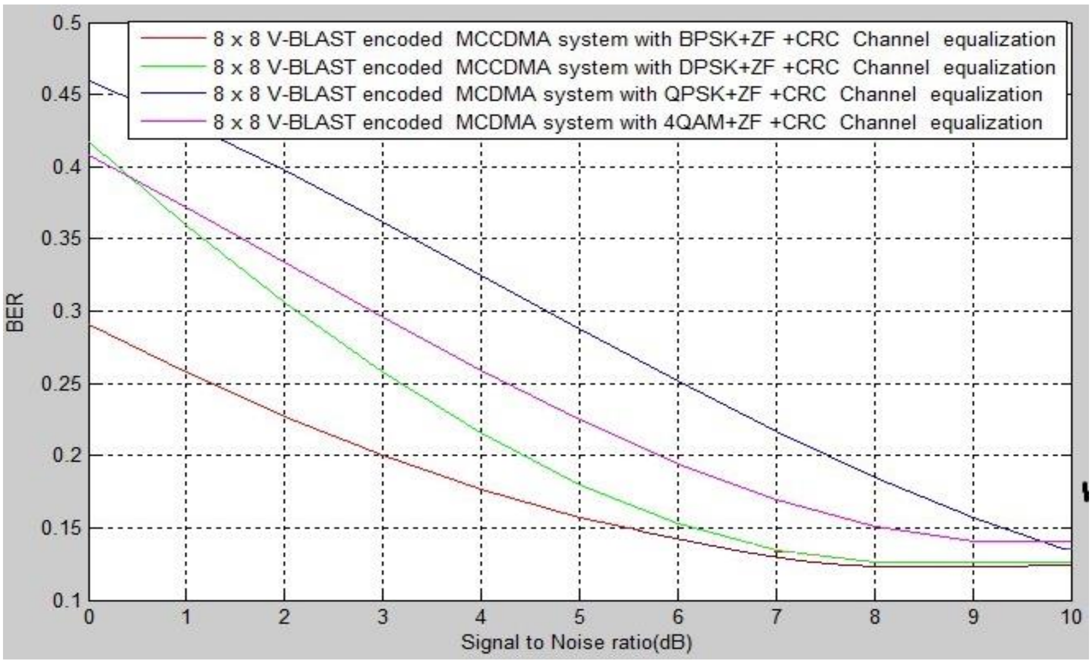

Figure 2. BER performance comparison of the V-BLAST encoded 8×8 MIMO MC-CDMA system with the employment of BPSK, DPSK, QPSK and 4QAM digital modulation under Convolution channel coding and ZF based signal detection schemes

Table 2. BER performance of the V-BLAST based MIMO MC-CDMA system with the implementation of ZF signal detection, convolutional coding, and various digital modulation schemes.

Signal-to -Noise Ratio (SNR) dB	**Bit Error Rate (BER)**			
	BPSK	**DPSK**	**QPSK**	**4QAM**
1	0.252	0.358	0.446	0.375
2	0.230	0.309	0.408	0.338
3	0.200	0.261	0.364	0.295
4	0.175	0.218	0.325	0.261
5	0.155	0.170	0.293	0.225
6	0.146	0.151	0.252	0.192
7	0.139	0.141	0.220	0.171
8	0.123	0.125	0.190	0.153
9	0.123	0.125	0.157	0.143
10	0.124	0.125	0.138	0.143

Figure 3 shows the BER performance comparison of the V-BLAST encoded 8×8 MIMO MC-CDMA system with the employment of BPSK, DPSK, QPSK, and 4QAM digital modulation schemes under Convolution channel coding and MMSE based signal detection schemes. The bit error rate (BER) is considerably lower than the signal-to-noise ratio (SNR). It is evident from this figure that the performance of BPSK is better than that of the others. However, DPSK and 4QAM have an almost smaller result, whereas QPSK has a higher bit error rate (BER). A higher BER value can be found in QPSK at SNR= 1 dB compared to other modulation techniques. The BER values of the system with the implementation of MMSE signal detection, convolutional coding, and various digital modulations (BPSK, DPSK, QPSK, and 4QAM) schemes at a different SNR (1 dB – 10 dB) are shown in Table 2. It is obvious from the table that for different SNR values (SNR = 1 dB – 10 dB), BPSK shows better BER performance than DPSK, 4QAM, and QPSK.

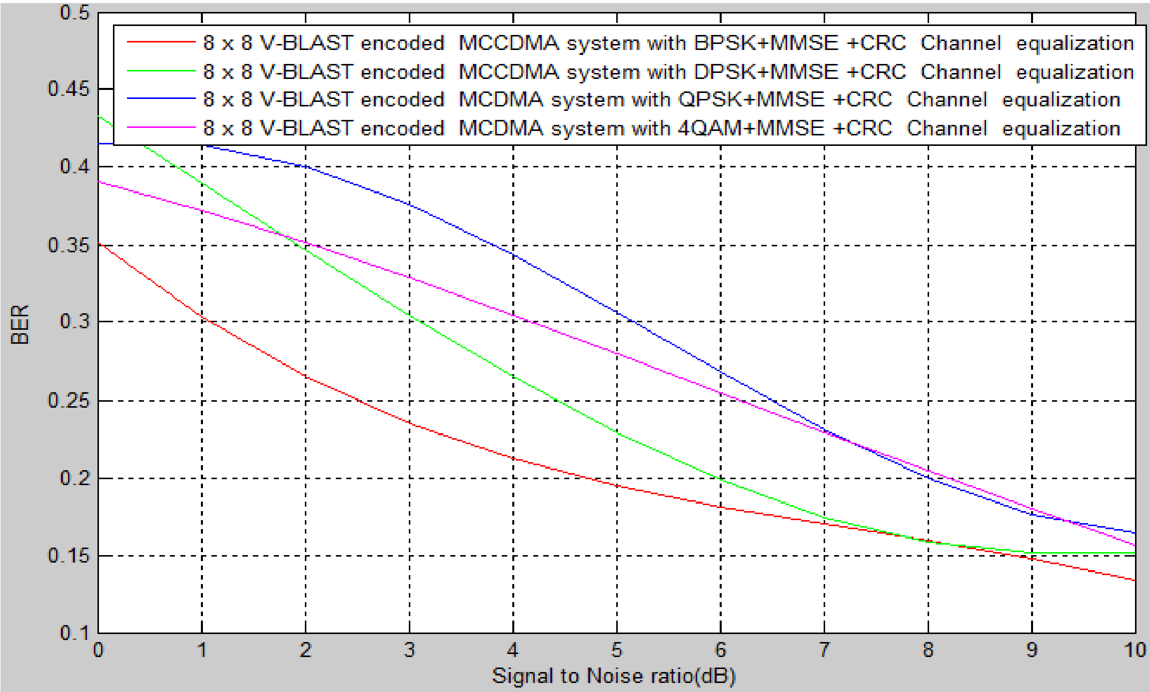

Figure 3. BER performance comparison of the V-BLAST encoded 8×8 MIMO MC-CDMA system with the employment of BPSK, DPSK, QPSK and 4QAM digital modulation under Convolution channel coding and MMSE based signal detection schemes

From the above analysis of the Matlab based simulation results of Figures 2 and 3 and Tables 2 and 3, it can be concluded that the proposed system shows the worst performance with MMSE based signal detection scheme and best performance with ZF signal detection scheme under BPSK lower-order digital modulation in grayscale images transmission over the AWGN channel.

Table 3. BER performance of the V-BLAST based MIMO MC-CDMA system with the implementation of MMSE signal detection, convolutional coding, and various digital modulation schemes.

Signal-to -Noise Ratio (SNR))dB	Bit Error Rate(BER) dB			
	BPSK	DPSK	QPSK	4-QAM
1	0.312	0.390	0.422	0.374
2	0.261	0.347	0.400	0.356
3	0.242	0.306	0.377	0.336
4	0.213	0.261	0.346	0.308
5	0.195	0.235	0.308	0.280
6	0.180	0.200	0.270	0.254
7	0.175	0.175	0.238	0.237
8	0.159	0.161	0.200	0..208
9	0.148	0.152	0.175	0.170
10	0.132	0.152	0.165	0.155

4. CONCLUSION

In this paper, the bit error rate (BER) performance of V-Blast encoded 8 x 8 MIMO MC-CDMA wireless communication system communication using MMSE and ZF signal detection schemes and 1⁄2-rated convolution and cyclic redundancy check (CRC) channel encoding strategies under various digital modulation schemes (BPSK, DPSK, QPSK, and 4QAM) on grayscale image transmission over the AWGN channel have been investigated. Based on the results of the current Matlab-based simulation study, it is clear that BPSK digital modulation with the ZF signal detection scheme provides the best performance when compared to other modulation (DPSK, QPSK, and 4QAM) and MMSE signal detection schemes. It can therefore be concluded that a lossless reproduction of the grayscale image signal can be achieved at the end of the receiver of the projected V-Blast encoded 8 x 8 MIMO MC-CDMA wireless communication system using 1⁄2-rated convolution and CRC channel encoding strategies with the deployment of ZF signal detection and the BPSK digital modulation schemes.

REFERENCES

[1] B. Sarala and D.S. Venkateswarlu, "Code Division Multiple Access Transmission Techniques for 3G & 4G Wireless Communication Systems," International journal on recent trends in engineering & technology. Vol 05, No 02, pp. 190-194 (2011).

[2] B. Sarala and D.S. Venkateswarlu, "Performance Analysis of Multicarrier Code Division Multiple Access Transmission Techniques," 5th International Conference on Information Processing, ICIP, Bangalore, India, August 5th -7th, and also published by Springer in the Proceedings Computer Networks and Intelligent Computing, pp. 311-319 (2011).

[3] M. Furudate, H. Ishikawa, and T. Suzuki," Evaluation of MC-CDMA with frequency interleaving technique in frequency selective fading channel," IEICE Trans. Commun., vol. E88-B, no. 2, pp. 443-451 (2005).

[4] P.W. Wolniansky, G.J. Foschini, G.D. Golden and R.A. Valenzuela," VBLAST: an architecture for realizing very high data rates over the rich scattering wireless channel," Proceedings of International Symposium on Signals, Systems and Electronics, (Pisa, Italy), pp. 295–300 (1998).

[5] E.N. Onggosanusi, A.G. Dabak and T.A. Schmidl," High rate space-time block coded scheme: performance and improvement in correlated fading channels," IEEE Wireless Communications and Networking Conference, vol. 1, pp. 194–199 (2002).

[6] Joshi, S.A.; Rukmini, T.S.; Mahesh, H.M." Error rate analysis of the V-BLAST MIMO channels using interference cancellation detectors, 2011," IEEE Wireless Communications and Networking Conference, pp. 614 – 618 (2011).

[7] Laila Naznin, Mohammad Reaz Hossain & Shaikh Enayet Ullah,"Encrypted Color Image Transmission in LDPC Encoded MIMO Wireless Communication System with implementation of MP-WFRFT based Physical Layer Security Scheme," Global Journal of Computer Science and Technology: A Hardware & Computation, Vol.17, Issue 1, Version 1.0, pp. 27-38, (2017).

[8] Shikha Jindaland Diwakar Agarwal, "Performance Evaluation of Image Transmission over MC-CDMA System using two Interleaving Schemes," Proceedings of the International Conference on Advances in Computing,Communications and Informatics (ICACCI), pp. 1331-1347 (2014).

[9] Mr. Atul Singh Kushwah and Mr. Mayank Mittal, "Performance Estimation of 2*2 MIMO-MC-CDMA Using Convolution Code in Different Modulation Technique, "International Journal of Engineering Research & Technology (IJERT), Vol. 3, Issue 1, pp. 2484-2490 (2014).

[10] Sudhanshu Kumar Chourasia and Rashmi Pandey, "Extensive Survey on MIMO Technology sing V-BLAST Detection Technique," International Journal of Computer Applications (0975 – 8887) Vol. 98, no.5, pp. 38-42 (2014).

[11] Sharmin Sultana, Aurangzib Md Abdur Rahman and Foez Ahmed, "Performance Analysis of a MIMO MC-CDMA Wireless Communication System Implementing Spatial Domain Noise Reduction Techniques with MMSE Signal Detection," Journal of Multidisciplinary Engineering Science and Technology (JMEST), Vol. 3, Issue 3, pp. 4386-4391 (2016).

[12] Wei Yang and Wei Yang , "Performance analysis of uplink MIMO MC-CDMA systems based on linear zero-forcing V-BLAST algorithm," Science in China Series F Information Sciences, Vol. 51, no. 9, pp. 1305-1318 (2008).