IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 5, Issue 5 (Mar. - Apr. 2013), PP 71-76
www.iosrjournals.org

Performance Analysis of Various Symbol Detection Techniques in Wireless MIMO System With MQAM Modulation Over Rayleigh Fading Channel

Badal S.Mali[1], Prof. Milind S. Shah[2]
[1](Research student, Department of EC engineering, Govt.Engg. College, Surat, Gujarat, India)
[2](Asso. Prof., Department of EC engineering, Govt.Engg. College, Surat, Gujarat, India)

Abstract : *Wireless communication is one of the most effective areas of technology development of our time. Wireless communications today covers a very wide array of applications. In this paper, we study the performance of general MIMO system, the performance of Zero Forcing (ZF), Linear Least Square Estimator (LLSE), V-BLAST/ZF, V-BLAST/LLSE of 4x4, 4x6 & 4x8 with 4-QAM & 16-QAM modulation in i i d Rayleigh fading channel. We seen that SER performance of 4x8 antennas and 4-QAM modulation scheme outperforms others. Result shows that for higher modulation schemes SER performance degrades as well as SER performance increases for higher no of receiver antennas.*

Keywords *- Multi Input Multi Output, Zero-forcing receiver, Linear Least Square Estimation, V-BLAST.*

I. INTRODUCTION

Multiple antennas placed at the transmitter and/or receiver in wireless communication systems can be used to substantially improve system performance by leveraging the "spatial" characteristics of the wireless channel. These systems, termed as Multiple Input Multiple Output (MIMO), require two or more antennas placed at the transmitter and at the receiver. In these systems, performance gains are achieved as multiple transmitters simultaneously **input** their signal into the wireless channel and then combinations of these signals simultaneously **output** from the wireless channel into the multiple receivers. Multiple antenna systems take advantage of the spatial diversity obtained by placing separate antennas in a dense multipath scattering environment [2]. There are two modes of employing MIMO – spatial multiplexing and diversity. Spatial multiplexing mode is aimed at transmitting independent data through each transmit antenna; thereby increasing data transmission rate. In diversity mode, same data is transmitted through more than one antenna; thus increasing the chances of the transmitted data reaching the receiver correctly[4].

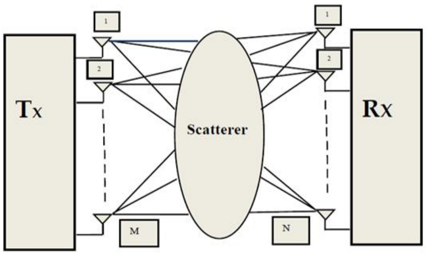

Fig. 1 MIMO Communication System.

There are many schemes that can be applied to MIMO systems such as space time block codes, space time trellis codes, and the Vertical Bell-Labs Layered Space Time Architecture (V-BLAST). The aim of this paper is to approach AWGN channel performance from Rayleigh fading channel performance by using the symbol detection algorithms such as Zero Forcing (ZF), Linear Least Square Estimator (LLSE), V-BLAST/ZF, V-BLAST/LLSE with M order QAM modulation technique.

First we define the problem formulation in section II. After that study various detection algorithm for the successfully detection of the received signal in section III, then according to that algorithm implementation will be carried out in section IV, and finally conclusion can be derived from that results in section V.

II. PROBLEM FORMULATION

Let H be the channel matrix of $N \times M$ dimensions, where M is the number of the transmit antennas and N is the number of the receive antennas. In the ideal case, each path is assumed to be statistically independent from the others. Herein, consider a transmitted vector $x=[x_1, x_2, x_3,......x_M]^T$, the vector is then transmitted via a MIMO channel characterized by the channel matrix H whose element h_{ij}~$CN(0,1)$ is the random Gaussian complex channel coefficient between the j^{th} transmit and i^{th} receive antennas with zero mean and unity variance. We also assume throughout that n is a complex Gaussian random vector with elements $n_i \sim CN(0,N_0)$. The received vector $r=[r_1, r_2, r_3,......r_N]^T$ can then be given as following:

$$r=Hx+n \tag{1}$$

It is assumed that H and n are independent of each other and of the data vector. Several additional assumptions on the input vector x should be taken, each element of x belongs to a common modulation alphabet A such that $\boldsymbol{x_i \epsilon A}$, also symbols in $\boldsymbol{A}$ have equal a priori probabilities and are uncorrelated, also we will assume that the receiver has perfect knowledge of the channel realization H, while the transmitter has no such channel state information (CSI).

III. MIMO DETECTION ALGORITHMS

In this section, we compare the various linear detection techniques like Zero-Forcing (ZF), Linear Least Squares Estimation (LLSE) detection algorithms. The idea behind linear detection schemes is to treat the received vector by a filtering matrix W, constructed using a performance-based criterion and also nonlinear technique such as VBLAST.

A). Zero-Forcing (ZF) Receiver

In a linear detector, the receive signal vector x is multiplied with a filter matrix W, followed by a parallel decision on all layers. Zero-forcing means that the mutual interference between the layers shall be perfectly suppressed[6], [10]. Zero-Forcing (ZF) receiver is a low-complexity linear detection algorithm that outputs

$$\hat{x}=Q(Wr) \tag{2}$$

Where

$$W = H^+ =(H^H H)^{-1} H^H$$

Q(.) is Quantizer, H^+ denotes the Moore-Penrose pseudo inverse of H, which is a generalized inverse that exists even when H is rank-deficient and eliminates co-channel interference, H^H is the Hermitian transpose of H. Because the pseudo-inverse of the channel matrix may have high power when the channel matrix is ill-conditioned, the noise variance is consequently increased and the performance is degraded[10].

B). Linear Least Squares Estimation (LLSE) Receiver

The LLSE receiver is a receiver that outputs the estimate

$$\hat{x}=Q(Wr)$$

Where

$$W = (\rho/M)\, H^H \left((\rho/M) HH^H + N_0 I_N\right)^{-1}$$

ρ is Average receive energy for each symbol, N_0 is Noise power, I_N is identity matrix. Weighting matrix is used to obtain received vector due to this it does not eliminated co-channel interference but it does not enhances noise power[10].

C). V-BLAST Detection

V-Blast is one of the non-linear technique have gained much attention due to their capabilities to improve the transmission reliability and/or increase the channel capacity. In order to reduce detection complexity due to the enormous data rate, in this technique of successive interference cancelation (SIC) & the performance of SIC depends on the order in which the data sub-streams are detected. The purpose of V-BLAST is that it maximizes the minimum signal-to-noise ratio (SNR)[5]. This emerging technique is used in MIMO communication systems. A single data stream is de-multiplexed into M sub-streams, and each sub-stream is then encoded into symbols and fed to its respective transmitter. Transmitters 1 - M operate co-channel at symbol rate 1/ T symbols/sec, with synchronized symbol timing. Each transmitter is itself an ordinary QAM transmitter. The collection of transmitters comprises, in effect, a vector-valued transmitter, where components of each transmitted M-vector are symbols drawn from a QAM constellation. We assume that the same constellation is used for each sub-stream, and that transmissions are organized into bursts of L symbols. The power launched by each transmitter is proportional to 1/ M so that the total radiated power is constant and independent of M.

D). V-BLAST/ZF Detection Algorithm

The V-BLAST/ZF algorithm is a variant of V-BLAST derived from ZF rule.

Initialization:

$$W_1 = H^+$$
$$i = 1$$

Recursion:

$$K_i = arg\ \min_{j \notin \{k_1 \cdots k_{i-1}\}} \left\| (W_i)_j \right\|^2 \tag{3}$$

$$y_{ki} = (W_i)_{ki} r_i \quad (4)$$
$$\hat{x}_{ki} = Q(y_{ki}) \quad (5)$$
$$r_{i+1} = r_i - \hat{x}_{ki}(H)_{ki} \quad (6)$$
$$W_{i+1} = H^{+}_{\overline{k}i} \quad (7)$$
$$i = i + 1$$

where H^+denotes the Moore-Penrose pseudo inverse of H, $(w_i)_j$is the j'th row of Wi, Q(.) is a quantized to the nearest constellation point, $(H)_{ki}$ denotes the k_i^{th} column of H, $H_{\overline{k}i}$denotes the matrix obtained by zeroing the columns $k_1, k_2, k_3, .., k_i$ of H, and $H^{+}_{\overline{k}i}$ denotes the pseudo-inverse of $H_{\overline{k}i}$.

In the above algorithm, Equ (3) determines the order of channels to be detected; Equ (4) performs nulling and computes the decision statistic; Equ (5) slices compute decision statistics and yields the decision; Equ (6) performs cancellation by decision feedback, and Equ (7) compute the new pseudo-inverse for the next iteration. In V-BLAST-ZF may be seen as a successive-cancellation scheme derived from ZF scheme[10].

E). V-BLAST/LLSE Detection Algorithm

The V-BLAST-LLSE algorithm is a variant of VBLAST derived the weighting matrix is chosen according to the Linear Least Squares Estimation (LLSE) rule.

Initialization:

$$W = (\rho/M)\, H^H ((\rho/M)HH^H + N_0 I_N)^{-1}$$
$$i = 1$$

Recursion:

$$K_i = arg\ \min_{j \notin \{k_1 \cdots k_{i-1}\}} \|(W_i)_j\|^2 \quad (8)$$
$$y_{ki} = (W_i)_{ki} r_i \quad (9)$$
$$\hat{x}_{ki} = Q(y_{ki}) \quad (10)$$
$$r_{i+1} = r_i - \hat{x}_{ki}(H)_{ki} \quad (11)$$
$$W_{i+1} = (\rho/M)\, H^H_{ki} ((\rho/M)H_{ki}H^H_{ki} + N_0 I_N)^{-1} \quad (12)$$
$$i = i + 1$$

IV. Simulation Result

The performance curves in Figure 2-7 show that combining V-BLAST with ZF and with LLSE provides significant improvement in SER compared to ordinary ZF and LLSE versions. The number of transmitter and receiver can be varied. Here we tried out with combinations of transmitter and receiver as (4, 4), (4, 6), (4, 8) with 4-QAM and 16-QAM modulation constellations and the simulation results were shown.

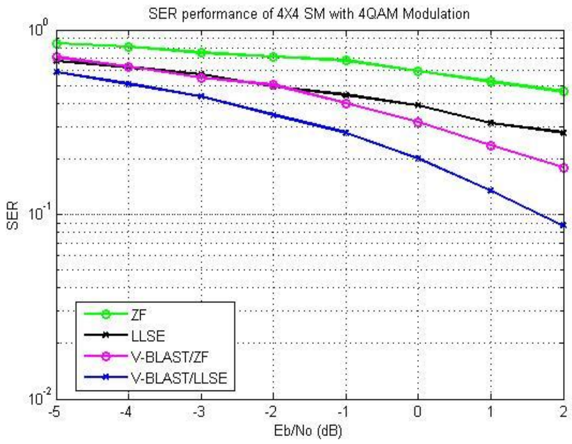

Fig. 2 Symbol Error Rates (SER) of ZF receiver, LLSE receiver, V-BLAST/ZF receiver and V-BLAST/LLSE receiver. Simulations are for (M, N) = (4, 4) and 4-QAM modulation.

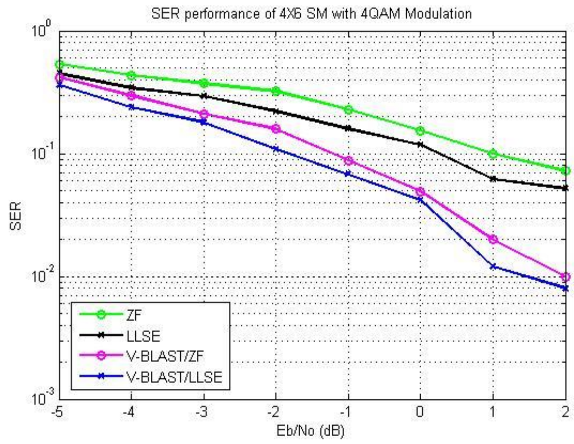

Fig. 3 Symbol Error Rates (SER) of ZF receiver, LLSE receiver, V-BLAST/ZF receiver and V-BLAST/LLSE receiver. Simulations are for (M, N) = (4, 6) and 4-QAM modulation.

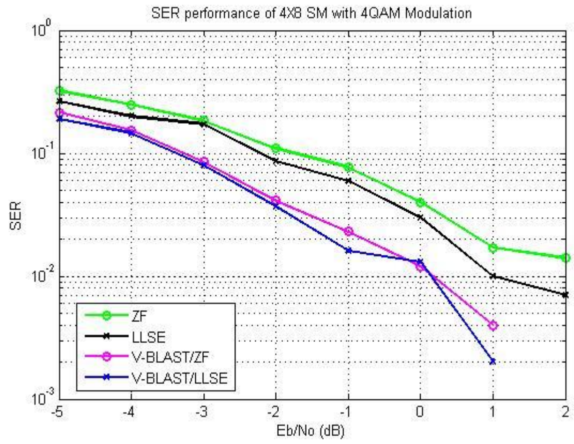

Fig. 4 Symbol Error Rates (SER) of ZF receiver, LLSE receiver, V-BLAST/ZF receiver and V-BLAST/LLSE receiver. Simulations are for (M, N) = (4,8) and 4-QAM modulation.

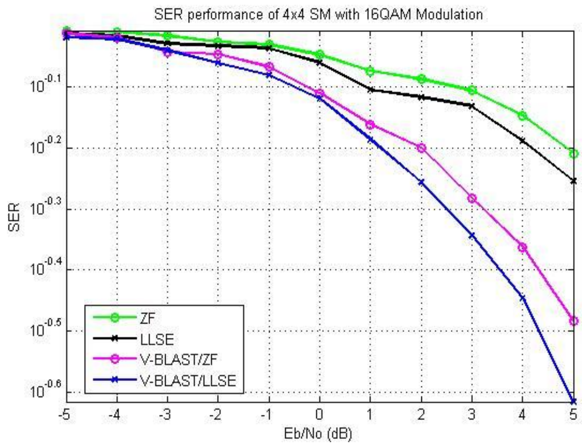

Fig. 5 Symbol Error Rates (SER) of ZF receiver, LLSE receiver, V-BLAST/ZF receiver and V-BLAST/LLSE receiver. Simulations are for (M, N) = (4, 4) and 16-QAM modulation.

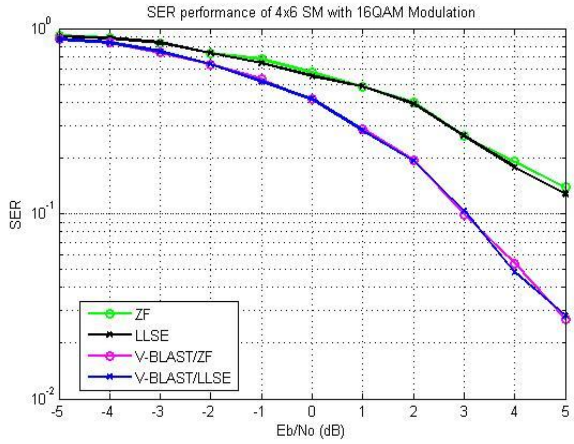

Fig. 6 Symbol Error Rates (SER) of ZF receiver, LLSE receiver, V-BLAST/ZF receiver and V-BLAST/LLSE receiver. Simulations are for (M, N) = (4, 6) and 16-QAM modulation.

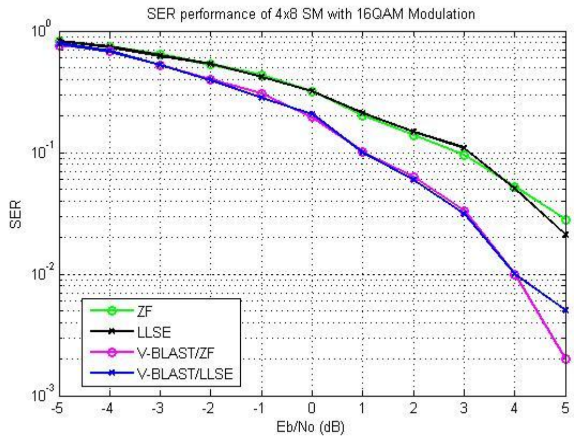

Fig. 7 Symbol Error Rates (SER) of ZF receiver, LLSE receiver, V-BLAST/ZF receiver and V-BLAST/LLSE receiver. Simulations are for (M, N) = (4, 8) and 16-QAM modulation.

V. Conclusion

We have studied the performance of ZF, LLSE, V-BLAST/ZF, V-BLAST/LLSE of 4x4, 4x6 & 4x8 antennas with 4-QAM & 16-QAM modulation in i i d Rayleigh fading channel. First in ZF receiver, co-channel interference was eliminated but it enhanced noise power. In LLSE receiver noise power was reduced but co-channel interference could not be eliminated. The V-BLAST detection algorithm is a recursive procedure that extracts the components of the transmitted vector according to a certain ordering. The order selection rule prioritizes the sub-channel with the smallest noise variance. V-BLAST/ZF performs significantly better than both ZF and LLSE receivers in terms of symbol error rate. Combining V-BLAST with ZF produced better performance not so as V-BLAST with LLSE which has slight improvement compared to the performance of V-BLAST/ZF. We concluded that SER performance of 4x8 antennas and 4-QAM modulation scheme outperforms others .Result shows that for higher modulation schemes BER performance degrades as well as BER performance increases for higher no of receiver antennas.

REFERENCES

Book:

[1] D.Tse and P. Viswanath, "Fundamentals of Wireless Communications." Cambridge Press. 1074- 1080,2005.

Journal papers:

[2] Neelam Srivastav, "Diversity Schemes for Wireless Communication –A Short Review" Journal of Theoretical and Applied Information Technology,Islamabad Pakistan.Vol.15.No.2.

[3] Sana Ullah, Mohammed Jashim Uddin, "Performance Analysis of Wireless MIMO System by Using Alamouti's Scheme and Maximum Ratio Combining Technique Muhamma."

[4] Lizhong Zheng, *Member, IEEE,* and David N. C. Tse, *Member, IEEE* "Diversity and Multiplexing: A Fundamental Tradeoff in Multiple-Antenna Channels", IEEE TRANSACTIONS ON INFORMATION THEORY, VOL. 49, NO. 5, MAY 2003.

[5] Nirmalendu Bikas Sinha, R. Bera, M. Mitra, "Capacity and V-Blast techniques for MIMO Wireless Channel" , Journal of Theoretical and Applied information Technology, 2010.

[6] Sang Goo Kim*, Dongweon Yoon*, Zhengyuan Xu**, and Sang Kyu Park* * Department of Electronics and Communications Engineering, Hanyang University, Seoul, Korea ** Department of Electrical Engineering, University of California at Riverside, CA, USA "Performance Analysis of the MIMO Zero-Forcing Receiver over Continuous Flat Fading Channels".
[7] Alberto Zanella, *Member, IEEE*, Marco Chiani, *Senior Member, IEEE*, and Moe Z. Win, *Fellow, IEEE*, " MMSE Reception and Successive Interference Cancellation for MIMO Systems With High Spectral Efficiency:" IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 4, NO. 3, MAY 2005.
[8] Bengt Holter, Geir E.Øien, Kjell J. Hole, and Henrik Holm Norwegian, "Limitations in Spectral Efficiency of a Rate-Adaptive MIMO System Utilizing Pilot-Aided Channel Prediction" University of Science and Technology, Department of Telecommunications O.S.Bragstads plass 2B, N-7491, Trondheim, Norway.
[9] Matilde Sánchez-Fernández, *Member, IEEE*, Eva Rajo-Iglesias, *Member, IEEE*, Óscar Quevedo-Teruel, *Student Member, IEEE*, and M. Luz Pablo-González , "Spectral Efficiency in MIMO SystemsUsing Space and Pattern Diversities Under Compactness Constraints:" IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 57, NO. 3, MAY 2008.

Theses:

[10] Yavuz Yapici, "V-BLAST/MAP: A NEW SYMBOL DETECTION ALGORITHM FOR MIMO CHANNELS" 2005, January.