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Performance Analysis of Different types of Decoders for MIMO Technique in Wireless Communication: A Review

S.N.Raut[1], Rajesh M Jalnekar[1], Snehal G. Katre[1,*],

Abstract—The requirement of the high data rate in communication systems had a remarkable increase in the last decagon due to the rising interest in wideband services like video, especially in mobile functions. Although, several blockades must be burst to accomplish the need of future communication system. Analyzing activity in order to give answers to the challenge of increasing the spectral performance and improving the BER of a signal by reducing the interference. Various methods had developed in the last decagon and analyzer are working for new standards and future generation system. The demand for increasing high-speed data rates specifically in wireless communication technology, systems with several receivers and transmitter antennas, also called MIMO system. This paper provides the overview of the basic concept of MIMO communication system also its analysis of different type of decoders by comparing its BER.

Index Terms— BER, MIMO, STBC, ZF, MMSE, MRC, ML, LTE.

1. Introduction

In wireless communication, the word wireless is defined as "having no wire connection". In networking nomenclature, wireless is the term used to define any computer network where there is no physical wired connection between source and destination. The numerous attainable technologies avow users to store and transfer information to others. The requirement of high data and speed give rise to LTE. And the main challenges of high data rate transition over multiple antenna is fading, interference, spectral efficiency, improving the link reliability. Wireless Communication is very important as future point of view. Before MIMO different technology where present, which has various disadvantages if data rate increase. Various different technology, with different frequency are used to transmit the data from sender to receiver to improve the connection and data rate.

1G is technology is introduced in 1980s and finished in 1990s and it was a mobile telecommunication. 1G is referred as first generation wireless technology. It allows only the voice call and uses analog signal with 2.4kbps speed. So, the drawback was poor voice quality, poor battery life, no security and limited capacity. The 2G system, furthermore cited to second generation which is depends on GSM and begun in year 1991. Second generation system uses digital signal for communication and 64kbps is the data speed. The drawback of 2G network, system are unable to handle complex data such as videos. The next technology which was develop after 2G is third generation .i.e. 3G technology, which was made known in year 2000s. And data transmission speed upgrade from 144kbps-2mbps, much higher than 2G and 1G networking. The disadvantage of 3G technology, due to high data and speed, there is requirement of high bandwidth. Fourth generation .i.e. 4G which was invented late 2000s and had speed of 100Mbps-1Gbps. It provide high speed, high capacity, high security and high quality of service. It provide end to end IP solution where data, voice and Streamed multimedia can be served to user on an anytime, anywhere basis at higher data rates than previous generations. MIMO is intelligent antenna technique. 4G network faster speed is because of MIMO technology. There is improvement in communication performance by the use of several antenna arrays at the receiver and transmitter it grant more data to be transferred without needing additional bandwidth or drawing more power. MIMO is multiple input and multiple output at the transmitter and receiver. At the transmitter multiple antenna are connected to transmit the data and for receiving the data multiple antennas are connected at the receiver. Data which is transmitted are divided into different time slots, and then it is transmitted. At first time slot the data is transmitted from 1*st* antenna. Because of these type of transmission of data through different time slot the interference occur in the signal get reduced. MIMO is the use of several antennas at both the transmitter and receiver to boost communication performance. MIMO make full use of spatial diversity by

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having several transmit and receive antennas. Spatial diversity technique, N replica copies of signal are generated and it will be assigned to each individual transmission antennas. Because of this signal fading effect can be reduced highly and many simultaneous transmission are possible which result in improve throughput at Rx terminal & decrease BER. In these paper transmitter is an MIMO which is connected to different antennas to transmit the signal in small samples as shown in figure 1.

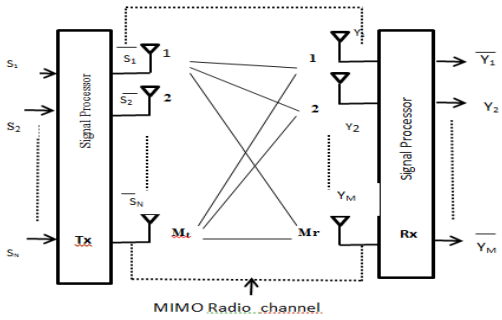

Fig.1. MIMO system representation.

By the use of space time block coding (STBC) alamouti code. MIMO Alamouti scheme is an ingenious transmit diversity scheme for two or more transmitting antennas that does not require transmitting channel knowledge. The MIMO alamouti code is a simple space time block code (STBC) that alamouti was developed in 1998. STBC are used for MIMO systems to enable the transmission of several copies of a data stream across a number of antennas and to exploit the various received version of the data to improve the reliability of data send. STBC combines all the copies of the received signal in a perfect way to select as much information as possible from every signal. Space time block coding involves the transmission data that are multiple in copies. This help to solve the problem of channels such as fading and noise. There are several technique which were used before MIMO such as SISO, SIMO and MISO all the technologies are differentiated by the number of antenna used in transmitter and receiver side. As shown in the figure 2, it is two transmitter and one receiver so the system is MISO.

	T	t+T
Antenna 1	x_1	$-x_2^*$
Antenna 2	x_2	x_1^*

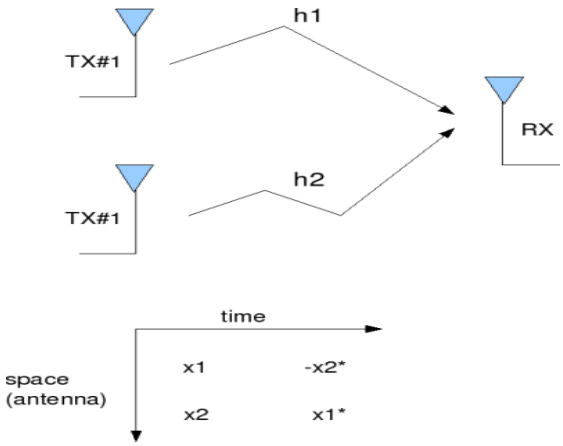

Fig.2. 2-Transmitter and 1-Receiver Alamouti code

As shown in the figure 2, there are two transmitting antenna and one receiving antenna. For example $\{x_1, x_2, x_3, \ldots\ldots, x_n\}$ is transmission sequence. We will be sending x_1 in the first time instant, x_2 in the second time instant, x_3 and so on. Although, Alamouti suggest that we group the symbols into two group. In the first time instant, send x_1 and x_2 from the first and second antenna. In second time instant send $-x_2^*$ and x_1^* from the first and second antenna. The different types of Decoder are MRC, ML, ZF and MMSE. In telecommunications, MRC is a method of diversity combining technique in which the signal from each channel are added together, the gain of each channel is made proportional to the root mean square signal level and inversely proportional to the mean square noise level in that channel and different proportionality constants are used for each channel. ML is a method of estimating the parameters of a statistical model given observations, by finding the parameter values that maximize the likelihood of making the observations given the parameters. ZF detector is a method of spatial signal processing by which the multiple antenna transmitter can null multiuser interference signal in wireless communication. MMSE detector is a decoding method in which minimizes the mean square error (MSE), which is a common measure of decoding quality, of the fitted values of a dependent variable.

2. Literature Survey

The author Swapnil T. Patil, Pratap N. Shinde in [1] explained about MIMO and introduction of STBC .i.e. Space Time Block Coding. By MIMO and STBC techniques the data transition and for decoding Maximum likelihood estimator

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is used. And this paper had shown the increase of diversity in signal due to multiple antenna at both transmitter and receiver. Different supporting ideas are given like one, two and four user. By analysis the conclusion is use of multiple receive and transmit antenna SNR ration increases for both single and multiple users. [2] In has presented a view based on signal detection scheme and standard linear detection by using the methods of ZF tecuu8hnique and MMSE technique and explanations of communication system model. The author S.N.Raut in [3] present the study of SU and MU MIMO-OFDM Techniques, this paper provides the detail of Multiuser MIMO system. It provide a detail about rising performance and decrease in different fading environment The author in [4] conferred different modulating techniques for transmission characteristics of MIMO system, and calculate the performance of ZF and ML alamouti for two receive transmitter system and the result is that by comparing performance with ZF and ML alamouti is better . In MIMO different technique had achieved better SNR performance by the technique like ZF and MLD. [4] Comparison of Signal to noise ratio for absolute and normalized scheduling is done for heterogeneous and homogeneous wireless communication is used but only for N- fading channel, there is possibility of different fading in the signal.

In [5] had analysis the comparison of BER of the signal for ML-VBLAST, two different modulation schemes BPSK and QPSK are used with various antenna configuration. In [6] had being studied and analyzed about MIMO-OFDM system and there channel estimation and also about Mean Square Error rate (MSE). In [7] have studied the MIMO performance analysis with the help of alamouti code. They had introduced the Space Time Block Coding method and there system model, explained the block diagram of MIMO system and also analysis bit error rate by three types of decoder ZF, MMSE, ML. In [8] had developed new algorithm for several user. With the help of this algorithm the video quality had increased. High data rate transition is possible. In this paper author had consider only urban area for better performance. There are some mathematical limitation so only for limited user this can be applied. In [9] this paper multiple user can use the signal and can communicated with each other without any difficulty. With different types of decoders ZF and MMSE. In this paper it provide approximate distribution of SNR for the output of ZF and SINR of an MMSE receiver. In [10] this paper ZF-BF and ZF-R technique uses various number of user, so this technique are analyzed in multiuser MIMO system. It is observed that the number of user achieve largest ergodic with sum of throughputs which result in analyzing with exhaustive search.

[11]In this paper analyzed that GFDM is multicarrier modulation technique used for 5G networking. And for receiving of signal MMSE technique is being used because MMSE technique give less BER even if the data rate is high.[13] Ivan B. Djordjevic had introduced about MIMO technique which is capable of improving single input single output and different diversity technique for example zero forcing (ZL), MMSE, ML and MSE.[14] This paper was published by Long Zhao, Hui Zhao, Kan Zheng, Wei Xiang, they analysis about massive MIMO technology, including application and physical Layer and networking technique. They had compared Zero forcing and maximum ratio combiner (MRC) and conclude that MRC had worse performance then zero forcing and minimum mean square error (MMSE). The possibility of occurring error in the signal is more in MRC so signal strength get reduced. The paper [15] In this paper massive MIMO is explained, a brief introduction about how the communication between he transmitter and receiver is explained. Different types of MIMO system are explained for example fuul dimension and hyper MIMO. It provide overview of Massive MIMO concept and contemporacy research on it. In [16] over both time and frequency selection fading channel ,the performance of a decoder and forward method is used, using OFDM mehod. In this paper detection based Zf is used to remove ICI caused by high mobility. In this paper [17], it provide breif inteoducation about MIMO-OFDM. This paper give Palatino

3. Research Method

3.1 For MIMO system (Alamouti code):

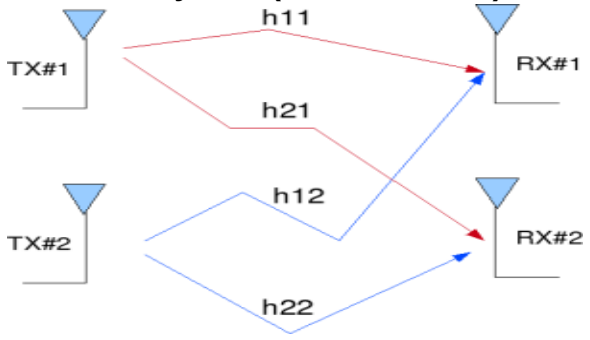

Fig. 3. 2 Transmit and 2 Receive (2×2) MIMO system

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From the above figure, in the first time instant the receiver signal on the first receive antenna,

$$y_1 = h_{11}x_1 + h_{12}x_2 = [h_{11}\ \ h_{12}]\begin{bmatrix}x_1\\x_2\end{bmatrix} + n_1 \quad (1)$$

And at the second time slot the receiver signal on the second antenna is,

$$y_2 = h_{21}x_1 + h_{22}x_2 = [h_{21}\ \ h_{22}]\begin{bmatrix}x_1\\x_2\end{bmatrix} + n_2 \quad (2)$$

Where:

- y_1 and $y_2$are the received symbol on the first and second antenna respectively,
- h_{11} is channel from first transmit antenna to first receive antenna,
- h_{12} is channel from second transmit antenna to first receive antenna,
- h_{21} is channel from first transmit antenna to second receive antenna,
- h_{22} is channel from second transmit antenna to second receive antenna,
- x_1,x_2 are the transmitted symbols and
- n_1 , $n_2$is noise on first and second receive antennas.

$$\begin{bmatrix}y_1\\y_2\end{bmatrix}=\begin{bmatrix}h_{11} & h_{12}\\h_{21} & h_{22}\end{bmatrix}\begin{bmatrix}x_1\\x_2\end{bmatrix}+\begin{bmatrix}n_1\\n_2\end{bmatrix}$$

$$y=H\,x+n \quad (3)$$

3.2 For Zero Forcing Decoder (ZF) :

The ZF is the pseudo inverse of the channel matrix. Hence, ZF equalizer is purely a function of the channel state or the channel matrix from figure 3.

$$W=\min ||y - Hx||^2 \quad (4)$$

Let W be the received signal vector,

$$W= (y - Hx)^H (y - Hx)$$

By multiplying the above equations we get,

$$W= \bar{y}\bar{y}^H - \bar{x}^H H^H \bar{y} - \bar{y}^H H\bar{x} + \bar{x}^H H^H H\bar{x}$$

$$\bar{y}\bar{y}^H = 0$$

$$H^H\bar{y} = constant$$

$$W=0 - H^H\bar{y} - H^H\bar{y} + H^H H\bar{x} + H^H H\bar{x}$$

$$W=-2(H^H\bar{y} + H^H H\bar{x})$$

So, differentiating each component with x, we get

$$\frac{d||\bar{y}-H\bar{x}||^2}{d\bar{x}} = -2H^H\bar{y} + 2H^H H\bar{x}$$

$$-2H^H\bar{y} + 2H^H H\bar{x}=0$$

$$H^H H\bar{x}=H^H\bar{y}$$

$$\bar{x}=(H^H H)^{-1}H^H\bar{y}$$

.i.e.

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

This is the estimate of H. This is not the exact solution but the approximate solution. $\bar{x}$ is the approximate solution that minimizes the least square error. So, the above equation is known as the zero forcing receiver,

$$W = (H^H H)^{-1}H^H \quad (5)$$

3.3 For Minimum Mean Square Error (MMSE):

The MMSE criterion is formulated as shown in equation below -

$$\min[E\{|W_{mmse}y - x|\}]$$

$$\min[E\{(Wy - x)(Wy - x)^H\}]$$

$$\min[E(Wy - x)(W^H y^H - x^H)]$$

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$$\min[E\{Wyy^HW^H - Wyx^H - xy^HW^H + xx^H\}]$$

$$\min(WR_{yy}W^H - WR_{yx} - R_{xy}W^H + R_{xx})$$

R_{yy}, R_{xx} represents the auto-correlation of x, y respectively. R_{xy}, R_{yx} are cross-correlation of x ,y respectively. The minima of a function with respect to a variable can be found by partial differential of the function set to zero.

$$\frac{\partial(WR_{yy}W^H - WR_{yx} - R_{xy}W^H + R_{xx})}{\partial W} = 0$$

$$\frac{\partial T^HVT}{\partial T} = V^HT + VT$$

Using above equation,

$$W = R_{yy}^{-1}R_{xy}$$

$$R_{yy} = E\{yy^H\}$$

$$R_{yy} = E\{(HX + N)(HX + N)^H\}$$

$$R_{yy} = (HH^H + N_0I)$$

$$R_{xy} = E(xy^H)$$

$$R_{xy} = E(x(HX + N)^H)$$

$$R_{xy} = H^H$$

$$W = (HH^H + N_0I)^{-1}H^H$$

So, the coefficient W which minimize the criteria,

$$W = [H^HH + N_0I]^{-1}H^H \qquad (6)$$

Where:

I= Identity Matrices

$$I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = \begin{pmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{pmatrix}$$

$$N_0 = \frac{1}{SNR}$$

3.4 For Maximum Ratio Combining (MRC):

From equation 3-

For the i^{th} receive antenna, the receive signal is,

$$y_i = H_i\, x + n_i$$

Where,

- y_i is the received symbol on the i^{th} receive antenna,
- H_i is the channel on the i^{th} receive antenna,
- x is the transmitted symbol
- n_i is the noise on i^{th} receive antenna.

$W = H^Hy$

So, the Maximum ratio combining (MRC) estimator is given as

$$W = H^H(Hx + n) = H^HHx + H^Hn \qquad (7)$$

3.5 Maximum likelihood Estimator (ML) :

From equation 3,

$$y = H\,x + n$$

So, the maximum likelihood estimator is given as,

$$W = \min ||y - Hx||^2 \qquad (8)$$

Where,

- y is the received symbol for the received antenna
- x is the transmitted symbol for the transmit antenna
- H is the channel matrix

From equation 8, we get

$$W = x^HGx - 2Re(yHx) + ||y||^2 \qquad (9)$$

Where,

$$G = H^H$$

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4. Conclusion

In several papers different type of changes are done to get less interference and better quality of signal in wireless communication. By reducing BER of the signal we can achieve better quality of network. For this signal need to be analyzed and use of MIMO as an encoder and different types of decoders are used in this paper. In this paper you had studied performance of different types of decoder in MIMO system which are used to reduce the bit error rate and to increase the quality of signal. So it is very difficult to low BER for higher data rate. It is necessary to have high quality of signal for better communication in the system and this can only happen when error is removed. To eliminate the distortion and fading between signal, different types of decoder are compared and are used. So to eliminate all the issues for signal we had used several types of decoder ZF, MMSE, MRC, ML and there BER rate are measured. For the result we can analysis which decoder perform better when compared with all.

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