RESEARCH ARTICLE OPEN ACCESS

Performance Analysis of MIMO In Comparison with MU-MIMO Under Non Data Aided Technique

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ABSTRACT
Systems utilizing multiple transmit and multiple receive antennas are commonly known as multiple input multiple output (MIMO) systems. This wireless networking technology greatly improves both the range and the capacity of a wireless communication system. Modern techniques have to be developed and put in place to meet these requirements. Research has shown, that compared to conventional Single Input Single Output (SISO) systems, Multiple-Input Single Output (MISO), and Multiple-Input Multiple-Output (MIMO) can actually increase the data rate of a communication system, without actually requiring more transmit power or bandwidth. This paper aims at the investigation of the existing channel estimation techniques with out training symbols(Blind Channel Estimation) and with training symbols(Semi Blind Channel Estimation) .After this performance of MIMO and MU-MIMO is been analyzed.

Keywords: Channel Estimation, MIMO, MU-MIMO, Throughput ,BER,SNR

Date of Submission: 16-12-2017 Date of acceptance: 30-12-2017

I. INTRODUCTION

In recent years, Multi-Input Multi-Output (MIMO) communications are introduced as an emerging technology to offer significant promise for high data rates and mobility required by the next generation wireless communication systems. Using multiple transmit as well as receive antennas, a MIMO system exploits spatial diversity, higher data rate, greater coverage and improved link robustness without increasing total transmission power or bandwidth. However, MIMO relies upon the knowledge of Channel State Information (CSI) at the receiver for data detection and decoding [1] [2]. It has been proved that when the channel is flat fading and perfectly known to the receiver, the performance of a MIMO system grows linearly with the number of transmit or receive antennas, whichever less is [3]. Therefore, accurate and robust channel estimation is of crucial importance for coherent demodulation in wireless MIMO systems.

Use of MIMO channels, when bandwidth is limited, has much higher spectral efficiency versus Single-Input Single-Output (SISO), Single-Input Multi-Output (SIMO), and Multi Input Single-Output (MISO) channels [4]. It is shown that the maximum achievable diversity gain of MIMO channels is the product of the number of transmitter and receiver antennas [5]. Therefore, by employing MIMO channels not only the mobility of wireless communications can be increased, but also its robustness [6].Mobile communication systems transmit information by changing the amplitude or phase of radio waves. In the receiving side of mobile system, amplitude or phase can vary widely [7]. This causes degradation in the quality of system since the performance of receiver is highly dependent on the accuracy of estimated instantaneous channel [8]. However; these detectors require knowledge on the Channel Impulse Response (CIR), which can be provided by a separate channel estimator to minimize the error probability. In Section-II Comparison SISO SIMO & MIMO is analyzed based on capacity and through put. In Section –III channel estimation techniques are explained based on SISO and MIMO are compared. In Section-IV channel estimation is explained by TBCE & SBCE types along with comparison of MIMO & MU-MIMO is analyzed

II. COMPARISON OF SISO, SIMO, MIMO

Depends upon number of antennas used transmission scheme is divided into SISO, SIMO, MISO, and MIMO for wireless communication system as below.

2.1 SINGLE INPUT SINGLE OUTPUT

Single input single output (SISO) is less complex and easier to make for wireless communication system to transmit and receive signal. Assume input data stream is “S”, channel is $h_{11}$and output data stream be the “Y”. Antenna configuration and input output relation of SISO system is given in the fig. 1.

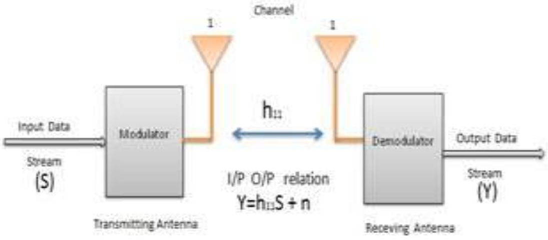

Fig. 1 SISO model

The SISO channel capacity is given by,

$$CSISO = Blog2(1+S/N) \qquad (1)$$

Where C is known as capacity of channel, B is known as bandwidth of the signal, S/N is known as signal to noise ratio.

2.2 SINGLE INPUT MULTIPLE OUTPUT

SIMO refers to the familiar wireless configuration with a single antenna at the transmitter and multiple antennas at receiver site. Now we assume we have two receiving signals"Y1" and "Y2" with different fading channel coefficient "h1" and "h2" with input data stream "S" .Antenna configuration and input output relation of SIMO (Receive Diversity)system is given by,

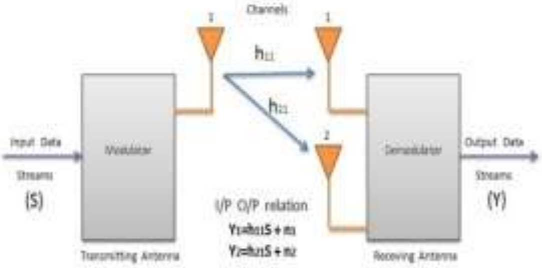

Fig. 2 SIMO model

The channel capacity has not increased. The multiple receive antennas can help us get a stronger signal through diversity. The SIMO channel capacity is given by,

$$C=MrBlog2(1+S/N) \qquad (2)$$

Where C is known as capacity, B is known as bandwidth, S/N is known as signal to noise ratio. Mr is the number of antennas used at the receiver side.

2.3 MULTIPLE INPUT SINGLE OUTPUT

MISO system has multiple antennas at the transmitter and single antennas at receiver site. Now we assume we have two transmitting signals "S1" and "S2" with different fading channel coefficient "h1" and "h2" with output data stream "Y". Antenna configuration and input output relation of MISO (Transmit Diversity) is given by,

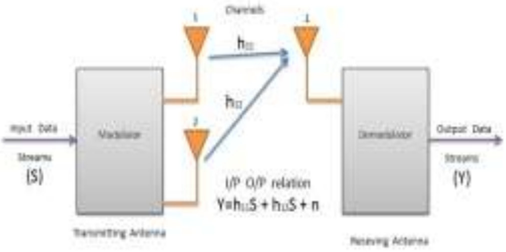

Fig. 3 MISO model

The channel capacity has not really increased because we still have to transmit two signals at a time 2.The MISO capacity is given by,

$$C=MtBlog2(1+S/N) \qquad (3)$$

Where C is known as capacity, B is known as bandwidth, S/N is known as signal to noise ratio. Mt is the number of antennas used at the transmitter side.

2.4 MULTIPLE INPUT MULTIPLE OUTPUT

MIMO is a method of transmitting multiple data streams at the transmitter side and also receiving multiple data streams at the receiver side. MIMO antenna configuration describes that use of multiple transmit and multiple receive antennas for a single user produces higher Capacity, spectral efficiency and more data rates for wireless communication. When the data rate is to be increased for a single user, this is called single user MIMO (SU-MIMO) and when the individual streams are assigned to various users; this is called multiuser MIMO (MU-MIMO) [3, 4]. Antenna configuration and input output relation of MIMO (Transmit Diversity) is given by [12],

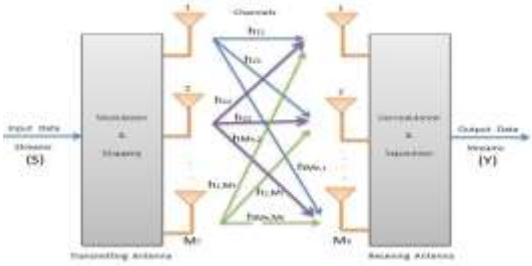

Fig. 4 MIMO model

From the above fig. 4 Output user data stream $y=Hs+\eta$ (input output relation of MIMO channel), where $s=[s1\ s2\ldots sM]t$ is the transmitted data vector, $y=[y1\ y2\ldots yM]t$ is the received data vector, and $\eta=[\eta1\ \eta2\ldots\eta M]t$ is the Additive White Gaussian noise (AWGN). BPSK modulation is used in each block modulation of signal for long distance transmission also it satisfies the good signal-to-noise ratio (SNR). Let us consider a MIMO system with MT transmit antennas and MR receive antennas, denote the impulse response between the jth (j= 1, 2,

… MT) transmit antenna and the ith (i= 1, 2, … MR) receiving antenna.

The MIMO channel can be represented using a MR× MT matrix format H is given by,

$$H = M_R \left[\begin{array}{ccc} h_{11} & h_{12} \cdots & h_{1MT} \\ h_{21} & h_{22} \cdots & h_{2MT} \\ \vdots & \vdots & \vdots \\ h_{MR,1} & h_{MR,2} & h_{MR,MT} \end{array}\right]$$
$$\longleftarrow \quad M_T \quad \longrightarrow$$

Where h_{ij} is a complex Gaussian random variable that models fading gain between the ith transmit and jth receive antenna. If a signal Sj(t) is transmitted from the jth transmitted antenna, the signal receive at the ith receive antenna. The input output relation is given by [10], $yi(t)$= $h_{i,j}MT_j$=1$S_j(t)$ i= 1, 2, … MR (4) Here we take MT transmit and MR receive antennas with input data stream is S and output data stream is Y. MIMO has higher capacity as compare to other system..The MIMO capacity is given by, C=$MtMrBlog$2(1+S/N) (5) Where C is known as capacity, B is known as bandwidth, S/N is known as signal to noise ratio. Mt is the number of antennas used at the transmitter side & $Mr$is the number of antennas used at receiver side.

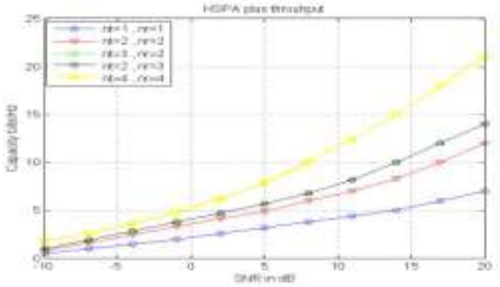

Fig 5 SNR vs Capacity with increase of antennas

III. DIFFERENT CHANNEL ESTIMATION TECHNIQUES USING SISO & MIMO

3.1 LEAST SQUARE ESTIMATION:

When the parameters appear linearly in these expressions then the least squares estimation problem can be solved in closed form .It is relatively straightforward to derive the statistical properties for the resulting parameter estimates. It is supposed that x is an independent (or predictor) variable which is known exactly, while y is a dependent (or response) variable [40] Consider the equation

$$Y=HX+Z$$

Where Y is Received Vector

X is Transmitted vector

H_{LS} or $\hat{H}$ channel vector with least square

Error vector is Y- $H_{LS}X$

By taking magnitude of error vector

$$J(H_{LS})=\| Y- H_{LS}X\|^2$$

For reduction of complexity of matrix magnitude is calculated. To get $J(H_{LS})$ as minimum differentiate $J(H_{LS})$ with respect to H_{LS} and equating to 0.

$$\frac{d(J(H_{LS}))}{d(H_{LS})} = 0$$
$$(Y - XH_{LS})^H(Y - H_{LS}X)$$
$$= YY^H - Y^H XH_{LS} - {H_{LS}}^H X^H Y + {H_{LS}}^H X^H XH_{LS}$$
$$H_{LS} = (X^H X)^{-1} X^H Y$$
$$H_{LS} = X^{-1}Y \qquad (4)$$

3.2 MINIMUM MEAN SQUARED ERROR ESTIMATION:

In this calculation noise is not considered if noise is dominant H_{LS} will give poor performance. To improve we are calculating error as follows. Choose a weight vector and multiply it with H_{LS} assume it as H_{MMSE}. To obtain error to be minimum i.e., we are choosing ω in such a way that error e and H_{LS} as orthogonal.

$$E\{e{H_{LS}}^H\} = 0 \qquad (5)$$
$$E\{(H - H_{MMSE})H_{LS}{}^H\} = 0$$
$$E\{(H - \omega H_{LS})H_{LS}{}^H\} = 0$$
$$E\{HH_{LS}{}^H - \omega H_{LS}H_{LS}H\} = 0$$
$$E\{HH_{LS}{}^H\} - E\{\omega H_{LS}H^H_{H_{LS}}\} = 0$$
$$R_{HH_{LS}{}^H} - \omega R_{H_{LS}H^H_{H_{LS}}} = 0$$
$$R_{HH_{LS}{}^H} = \omega R_{H_{LS}H^H_{H_{LS}}}$$
$$\omega = R_{HH_{LS}{}^H} . R_{H_{LS}H^H_{H_{LS}}}^{-1} \qquad (6)$$
$$H_{LS} = X^{-1}Y = X^{-1}(XH + Z)$$
$$= H + ZX^{-1} \qquad (7)$$
$$R_{H_{LS}H^H_{H_{LS}}} = E[H_{LS}H^H_{H_{LS}}]$$
$$= E[X^{-1}Y(X^{-1}Y)^H]$$
$$= E[(H + X^{-1}Z)(H + X^{-1}Z)^H]$$
$$= E[HH^H] + E[X^{-1}ZZ^H(X^{-1})^H]$$
$$= R_{HH^H} + \frac{\sigma_Z^2}{\sigma_X^2} I$$
$$H_{MMSE}=\omega H_{LS} \qquad (8)$$

3.3 MAXIMUM LIKELIHOOD (ML) ESTIMATION

In Maximum Likelihood the equation is given as,

$$J=|Y-HZ|^2 \qquad (9)$$

X is all possible symbol combinations

Y is received vector

J is Euclidian distance

In modulation techniques for example BPSK, Euclidian distance between received signal vector and product of all possible transmitted signal vector with given channel H is calculated out of all minimum Euclidian distance is calculated. In 2x2 MIMO with 16 QAM we have to find Euclidian distance for combination of 256 and minimum Euclidian distance corresponding 1/p vectors will be transmitted vector [9]. The Maximum Likelihood receiver tries to find *x which* minimizes, $J = |y - Hx|^2$, *for example the modulation is BPSK, the* possible values of *x1 and x2 are +1 or -1. T*he minimum from the all four combinations of *x1 and x2*

$$J_{+1,+1} = \left|\left|\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} - \begin{bmatrix} h_{1,1} & h_{1,2} \\ h_{2,1} & h_{2,2} \end{bmatrix}\begin{bmatrix} +1 \\ +1 \end{bmatrix}\right|\right|^2 \quad (10)$$

$$J_{+1,-1} = \left|\left|\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} - \begin{bmatrix} h_{1,1} & h_{1,2} \\ h_{2,1} & h_{2,2} \end{bmatrix}\begin{bmatrix} +1 \\ -1 \end{bmatrix}\right|\right|^2 \quad (11)$$

$$J_{-1,+1} = \left|\left|\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} - \begin{bmatrix} h_{1,1} & h_{1,2} \\ h_{2,1} & h_{2,2} \end{bmatrix}\begin{bmatrix} -1 \\ +1 \end{bmatrix}\right|\right|^2 \quad (12)$$

$$J_{-1,-1} = \left|\left|\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} - \begin{bmatrix} h_{1,1} & h_{1,2} \\ h_{2,1} & h_{2,2} \end{bmatrix}\begin{bmatrix} -1 \\ -1 \end{bmatrix}\right|\right|^2 \quad (13)$$

3.4 CIRCULAR DECODING ESTIMATION:

Let us consider a 2x2 MIMO channel with QAM. It can be expressed as

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} \eta_1 \\ \eta_2 \end{bmatrix} \quad (14)$$

We can decompose above term in real and imaginary parts.

$$\begin{bmatrix} y_{1real} + jy_{1imag} \\ y_{2real} + jy_{2imag} \end{bmatrix} = \begin{bmatrix} h_{11real} + jh_{11imag} & h_{12real} + jh_{12imag} \\ h_{21real} + jh_{21imag} & h_{22real} + jh_{22imag} \end{bmatrix} * \begin{bmatrix} x_{1real} + jx_{1imag} \\ x_{2real} + jx_{2imag} \end{bmatrix} + \left[\begin{bmatrix} \eta_{1real} + j\eta_{1imag} \\ \eta_{2real} + j\eta_{2imag} \end{bmatrix}\right] \quad (15)$$

Where y_{ireal} is real part [Y_i], y_{iimag} is imag part [Y_i] and x_i is the element which is transmitted from ith antenna.

The real part of above eqn is

$$\begin{bmatrix} y_{1real} \\ y_{2real} \end{bmatrix} = \begin{bmatrix} h_{11real} & h_{12real} \\ h_{21real} & h_{22real} \end{bmatrix}\begin{bmatrix} x_{1real} \\ x_{2real} \end{bmatrix} - \begin{bmatrix} h_{11imag} & h_{12imag} \\ h_{21imag} & h_{22imag} \end{bmatrix}\begin{bmatrix} x_{1imag} \\ x_{2imag} \end{bmatrix} + \begin{bmatrix} \eta_{1real} \\ \eta_{2real} \end{bmatrix}$$

$$= \begin{bmatrix} h_{11real} & h_{12real} & -h_{11imag} & -h_{12imag} \\ h_{21real} & h_{22real} & -h_{21imag} & -h_{22imag} \end{bmatrix}\begin{bmatrix} x_{1real} \\ x_{2real} \\ x_{2imag} \\ x_{2imag} \end{bmatrix} + \begin{bmatrix} \eta_{1real} \\ \eta_{2real} \end{bmatrix} \quad (16)$$

The imaginary part of the above equation is

$$\begin{bmatrix} y_{1imag} \\ y_{2imag} \end{bmatrix} = \begin{bmatrix} h_{11imag} & h_{12imag} & h_{11real} & h_{12real} \\ h_{21imag} & h_{22imag} & h_{21real} & h_{22real} \end{bmatrix}\begin{bmatrix} x_{1real} \\ x_{2real} \\ x_{2imag} \\ x_{2imag} \end{bmatrix} + \begin{bmatrix} \eta_{1imag} \\ \eta_{2imag} \end{bmatrix} \quad (17)$$

The circular decoding technique is following the relationship

$$\min\left|\left|\bar{y} - \bar{H}\bar{x}\right|\right|^2 = \min(\bar{x} - \hat{x})^T \bar{H}^T \bar{H}(\bar{x} - \hat{x}) \quad (18)$$

Where $\widehat{x} = (\bar{H}^H\bar{H})^T\bar{H}^H\bar{H}$ and said equ is not having any constraint and it is used in ML technique.

Assume a sphere radius as R_{CD} and consider the vectors which are sphere. i.e.,

$$(\bar{x} - \hat{x})^T \bar{H}^T \bar{H}(\bar{x} - \hat{x}) \le R_{CD}^2 \quad (19)$$

The above said sphere centre is $\hat{x}$. In the above said example we are having 4 vectors inside the sphere but all are placed at different lengths.

If we find the point which is closest to the center then we can determine new radius of sphere. After that there is only one vector inside the sphere with modified radius and that is the solution.

The above equ. Can be expressed as

$(\bar{x} - \hat{x})^T \bar{H}^T \bar{H}(\bar{x} - \hat{x}) = (\bar{x} - \hat{x})^T R^T R(\bar{x} -$ *x=||Rx−x||2* (20)

Where R is calculated from QR decomposition method and $\bar{H} = QR$.

$$\left|\left|R(\bar{x} - \hat{x})\right|\right|^2 = \left|\left|\begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} \\ 0 & r_{22} & r_{23} & r_{24} \\ 0 & 0 & r_{33} & r_{34} \\ 0 & 0 & 0 & r_{44} \end{bmatrix}\begin{bmatrix} \bar{x}_1 - \widehat{x_1} \\ \bar{x}_2 - \widehat{x_2} \\ \bar{x}_3 - \widehat{x_3} \\ \bar{x}_4 - \widehat{x_4} \end{bmatrix}\right|\right|^2$$

$$= \left|r_{44}\overline{(x_4} - \widehat{x_4)}\right|^2 + \left|r_{33}\overline{(x_3} - \widehat{x_3)}\right|^2 + \left|r_{34}\overline{(x_4} - \widehat{x_4)}\right|^2 + \left|r_{22}\overline{(x_2} - \widehat{x_2)}\right|^2 + \left|r_{23}\overline{(x_3} - \widehat{x_3)}\right|^2 + \left|r_{24}\overline{(x_4} - \widehat{x_4)}\right|^2 + \left|r_{11}\overline{(x_1} - \widehat{x_1)}\right|^2 + \left|r_{12}\overline{(x_2} - \widehat{x_2)}\right|^2 + \left|r_{13}\overline{(x_3} - \widehat{x_3)}\right|^2 + \left|r_{14}\overline{(x_4} - \widehat{x_4)}\right|^2$$

i.e.,

$$\left|r_{44}\overline{(x_4} - \widehat{x_4)}\right|^2 + \left|r_{33}\overline{(x_3} - \widehat{x_3)}\right|^2 + \left|r_{34}\overline{(x_4} - \widehat{x_4)}\right|^2 + \left|r_{22}\overline{(x_2} - \widehat{x_2)}\right|^2 + \left|r_{23}\overline{(x_3} - \widehat{x_3)}\right|^2 + \left|r_{24}\overline{(x_4} - \widehat{x_4)}\right|^2 + \left|r_{11}\overline{(x_1} - \widehat{x_1)}\right|^2 + \left|r_{12}\overline{(x_2} - \widehat{x_2)}\right|^2 + \left|r_{13}\overline{(x_3} - \widehat{x_3)}\right|^2 + \left|r_{14}\overline{(x_4} - \widehat{x_4)}\right|^2 \le R_{CD}^2$$

Using the above equation we can describe circular decoding in following steps.

STEP-1 : Referring the above equation ,we first choose the value for $\bar{x}_4$ in its dimension ,i.e., we will choose an arbitrary value from the points in sphere $|r_{44}(\bar{x}_4 - \hat{x}_4)|^2 \le R_{CD}^2$

In other way ,we have to choose the point in the following range.

$$\hat{x}_4 - \frac{R_{CD}}{r_{44}} \le \bar{x}_4 \le \hat{x}_4 + \frac{R_{CD}}{r_{44}}$$

If any point is not satisfying above inequality, then we will increase radius of sphere R_{CD} and we will choose $\bar{x}_4$ as per above equation. Let us consider $\tilde{\bar{x}}_4$ is chosen point in step1.

Step-2: Again refer the equation () and choose a value to $\bar{x}_3$. The value of $\bar{x}_3$ is chosen from the below sphere equation.

$$|r_{44}(\tilde{\bar{x}}_4 - \hat{x}_4)|^2 + |r_{33}(\bar{x}_3 - \hat{x}_3)|^2 + |r_{34}(\tilde{\bar{x}}_4 - \hat{x}_4)|^2 \le R_{CD}^2$$

We can simplify and write

$$\hat{x}_3 - \frac{\sqrt{R_{CD}^2 - |r_{44}(\tilde{\bar{x}}_4 - \hat{x}_4)|^2} - r_{34}(\tilde{\bar{x}}_4 - \hat{x}_4)}{r_{33}} \le \bar{x}_3 \le \hat{x}_3 + \frac{\sqrt{R_{CD}^2 - |r_{44}(\tilde{\bar{x}}_4 - \hat{x}_4)|^2} - r_{34}(\tilde{\bar{x}}_4 - \hat{x}_4)}{r_{33}}$$

$\tilde{\bar{x}}_4$ value is already chosen in step-1. If there exists no value for $\bar{x}_3$ such that step-2 equation is not satisfied, then go to step-1 and choose another value for $\tilde{\bar{x}}_4$ .Again choose value for $\bar{x}_3$. If there does not exist any value for $\bar{x}_3$ for all possible values of $\tilde{\bar{x}}_4$, then the radius of sphere is increased. After increasing the radius of sphere, $\tilde{\bar{x}}_4$ and $\bar{x}_3$ are chosen according to step1 & 2. The final values after step1 and step 2 are $\tilde{\bar{x}}_4$ and $\tilde{\bar{x}}_3$ respectively.

STEP-3 : For given values for $\tilde{\bar{x}}_4$ and $\tilde{\bar{x}}_3$, $\bar{x}_2$ is chosen according to the below equation.

$$\begin{aligned} &|r_{44}(\tilde{\bar{x}}_4 - \hat{x}_4)|^2 + |r_{33}(\tilde{\bar{x}}_3 - \hat{x}_3)|^2 \\ &+ |r_{34}(\tilde{\bar{x}}_4 - \hat{x}_4)|^2 \\ &+ |r_{22}(\bar{x}_2 - \hat{x}_2)|^2 \\ &+ |r_{23}(\tilde{\bar{x}}_3 - \hat{x}_3)|^2 \\ &+ |r_{24}(\tilde{\bar{x}}_4 - \hat{x}_4)|^2 \le R_{CD}^2 \end{aligned}$$

We will choose the value $\bar{x}_2$ according to above equation. If there exists no value for $\bar{x}_2$ such that above equation is satisfied, then go to step2 & choose other value for $\tilde{\bar{x}}_3$. If there exists no value for $\bar{x}_2$, for all possible values of $\tilde{\bar{x}}_3$, then go to step1 & choose the value for $\tilde{\bar{x}}_4$. If there exists no value for $\bar{x}_2$, for all possible values of $\tilde{\bar{x}}_3$ and $\tilde{\bar{x}}_4$ then increase radius of sphere R_{CD} and choose $\bar{x}_2$.

The final values chosen from step1 to 3 are $\tilde{\bar{x}}_4$, $\tilde{\bar{x}}_3$ and $\tilde{\bar{x}}_2$ respectively.

Step -4: For given values for $\tilde{\bar{x}}_4$, $\tilde{\bar{x}}_3$ and $\tilde{\bar{x}}_2$, $\bar{x}_1$ is chosen according to the below equation.

$$\begin{aligned} &|r_{44}(\tilde{\bar{x}}_4 - \hat{x}_4)|^2 + |r_{33}(\tilde{\bar{x}}_3 - \hat{x}_3)|^2 \\ &+ |r_{34}(\tilde{\bar{x}}_4 - \hat{x}_4)|^2 \\ &+ |r_{22}(\bar{x}_2 - \hat{x}_2)|^2 \\ &+ |r_{23}(\tilde{\bar{x}}_3 - \hat{x}_3)|^2 \\ &+ |r_{24}(\tilde{\bar{x}}_4 - \hat{x}_4)|^2 \\ &+ |r_{11}(\bar{x}_1 - \hat{x}_1)|^2 \\ &+ |r_{12}(\tilde{\bar{x}}_2 - \hat{x}_2)|^2 \\ &+ |r_{13}(\tilde{\bar{x}}_3 - \hat{x}_3)|^2 \\ &+ |r_{14}(\tilde{\bar{x}}_4 - \hat{x}_4)|^2 \le R_{CD}^2 \end{aligned}$$

We will choose the value $\bar{x}_1$ according to above equation. If there exists no value for $\bar{x}_1$ such that above equation is satisfied, then go to step3 & choose other value for $\tilde{\bar{x}}_2$. If there exists no value for $\bar{x}_1$, for all possible values of $\tilde{\bar{x}}_2$ then go to step2 & choose the value for $\tilde{\bar{x}}_3$. If there exists no value for $\bar{x}_1$, for all possible values of $\tilde{\bar{x}}_3$ and $\tilde{\bar{x}}_2$ then go to step1 & choose the value for $\tilde{\bar{x}}_4$. If there exists no value for $\bar{x}_1$, for all possible values of $\tilde{\bar{x}}_4$, $\tilde{\bar{x}}_3$ and $\tilde{\bar{x}}_2$, then increase radius of sphere R_{CD} and choose $\bar{x}_1$. The final values chosen from step1 to 4 are $\tilde{\bar{x}}_4$, $\tilde{\bar{x}}_3$,$\tilde{\bar{x}}_2$ and $\tilde{\bar{x}}_1$ respectively. With the help of these points we will calculate the radius of sphere using equation.

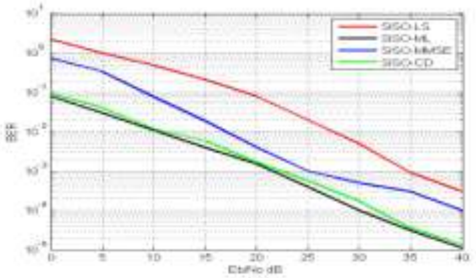

Fig. 6 BER vs SNR with SISO for various channel estimation techniques.

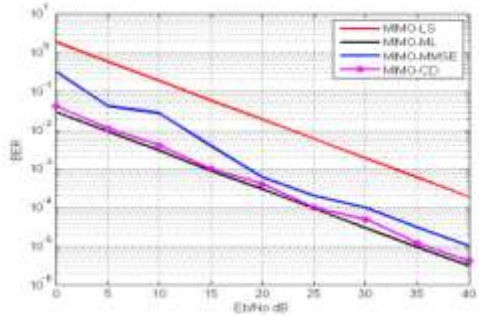

Fig.7 BER vs SNR with MIMO for various channel

IV. TYPES OF CHANNEL ESTIMATIONS

4.1 TRAINING BASED CHANNEL ESTIMATION

This estimation schemes take advantage of the potential of training symbols on the receiver and spacing of those training symbols or pilot tones are decided across time and frequency depending [10]. By the nature of the channel ,the addition of those pilot tones reduces the overall data rates Fig. 7 represents block type pilot arrangement .The estimation is performed making use of Least Square and Minimum Mean Square Error constraints to correct the distortion within the subsequent symbols [11]. The other type of pilot tones are comb type pilots which are used in fast fading channels as shown in Fig. 8 in which pilots are transmitted with even spacing on the sub carriers. To estimate the channel at the data subcarrier the channel estimates are interpolated. Despite the fact that more than a few upgrades are brought in channel estimation for growing the accuracy due to wastage of channel BW and delay induced in the receiver to estimate long training sequences .TBCE is hardly ever desired for time limited wireless systems [12] .Unresolved mistakes arise on this estimation approach, because the estimation is fully elegant on only pilot symbols ,where as interpolation is used to estimated data points. Even though various improvements are brought in channel estimation for increasing the accuracy due to wastage of channel BW and delay induced in the receiver to estimate long training sequences .TBCE is rarely preferred for time constrained wireless systems .unresolved errors occur in this estimation process ,because the estimation is completely dependent on only pilot symbols ,where as interpolation is used to estimated data points.

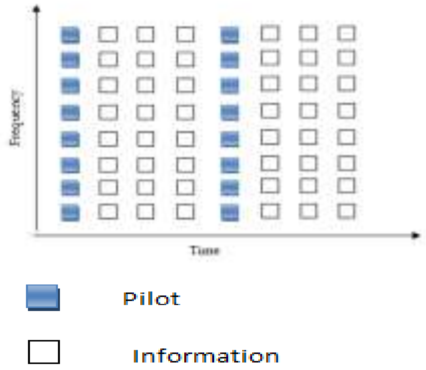

Fig 7 Block Type Pilot

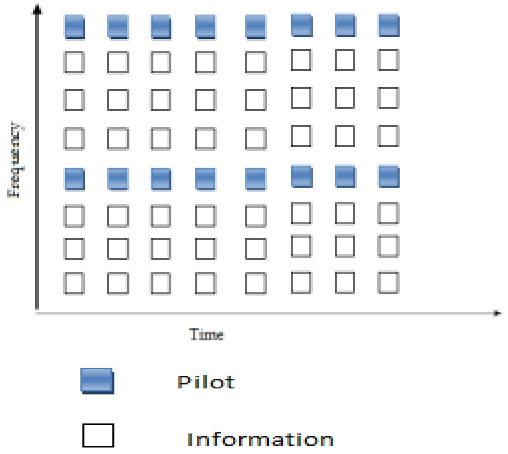

Fig. 8 Comb Type Pilot

4.2 BLIND CHANNEL ESTIMATION

Blind Channel Estimation (BCE) on the other hand require no training sequences. They utilize certain underlying mathematical information about the kind of data being transmitted . These methods might be bandwidth efficient but still have their own drawbacks[13]. The other drawbacks are that these methods are extremely computationally intensive and hence are impractical to implement in real-time systems. They also do not have the portability of training sequence-based methods. One algorithm that works for a particular system may not work with another due to the fact they send different types of information over the channel..Blind Channel Estimation is classified into Statistical and Deterministic estimation techniques. In Statistical estimation technique the estimation of channel is based on cyclic statistic properties where as in the deterministic technique cyclic statistic properties are not used but deterministic qualities are considered. it is very fast compared to statistical method. The complexity of deterministic estimation technique is increased if modulation order increased.

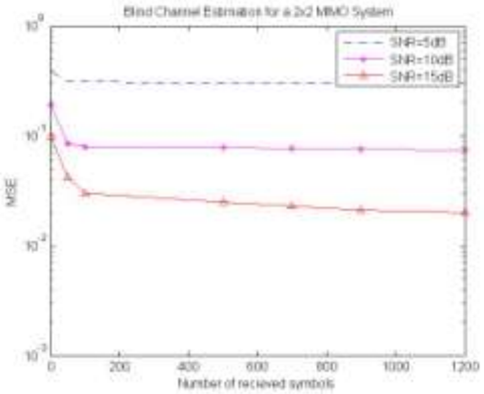

Fig. 9 Blind Channel Estimation for 2*2 MIMO system

4.3. SEMI BLIND CHANNEL ESTIMATION

In semi blind channel estimation (SBCE) is the combination of training based channel estimation and blind channel estimation. For the channel estimation inherent information within the acquired received signals and the information about the known training symbols are used. Depends on order statistics of the channel the tremendous imposed periodic pilot sequences are used to estimate the channel coefficients. The SBCE makes use of very much less computation time on the receiver.

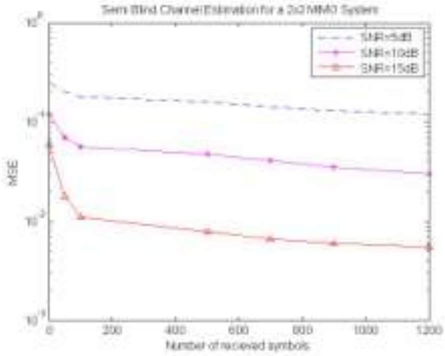

Fig. 10 Semi Blind Channel Estimation for 2*2 MIMO system

In MIMO technology the additional bandwidth is not required to make significant increase in data throughput and link range. The perfect channel state information can be obtained by

MIMO. To get benefits from MIMO technology it is necessary to utilize coding in the channels as the data is separated from the different paths. By this additional channel robustness/ data throughput capacity can be increased. In MIMO the co-evaluation effects per unit of diversity. This can be avoided if Multi user MIMO comes into existence. MU-MIMO system is an extension of Space-Division Multiple Access (SDMA). This technology supports multiple connections on a single conventional channel where different users are identified by spatial signatures. SDMA uses spatial multiplexing and enables for higher data rate. This could be achieved by using multiple paths as different channels for carrying data. Another benefit of using the SDMA technique in cellular networks is to mitigate the effect of interference coming from adjacent cells. Traditional communication MIMO systems are usually referred as single-user MIMO systems (SU-MIMOs) or also point-to-point MIMO. Case of MIMO systems, the access point communicates with only one mobile terminal (the user). Both the access point and the mobile terminal are equipped with multiple antennas. In contrast to the single-user case, the access point is able to communicate with several mobile terminals. SU-MIMO and MU-MIMO systems are two possible configurations for multi-user communication systems. In contrast to MU-MIMO systems where one base station could communicate with multiple users, base station only communicate with a single user in the case of SU-MIMO systems

In addition, MU-MIMO systems are intended to employ multiple receivers so that to improve the rate of communication while keeping the same level of reliability. These systems are able to achieve the overall multiplexing gain obtained as the minimum value between the number of antennas at base stations and the number of antennas at users. The fact that multiple users could simultaneously communicate over the same spectrum improves the system performance. Nevertheless, MU-MIMO networks are exposed to strong co-channel interference which is not the case for SU-MIMO ones. In order to solve the problem of interference in MU-MIMO systems, several approaches have been proposed for interference management .Some of these approaches are based on beam forming technique. Moreover, in contrast to SU-MIMO systems, MU-MIMO systems require perfect CSI in order to achieve high throughput and to improve the multiplexing gain. Finally, the performances of MU-MIMO and SU-MIMO systems in terms of throughput depend on the SNR level. In fact, at low SNRs, SU-MIMO performs better. However, at high SNRs level, MU-MIMO provides better performances.

TABLE 1:

Feature	MU – MIMO	SU – MIMO
Main aspect	Bs communicates with multiple users	Bs communicates with single users
Purpose	MIMO capacity gain	Data rate increasing for single user
Advantage	Multiplexing gain	No interference
CSI	Perfect CSI is required	No CSI
Throughput	Higher throughput at high SNR	Higher throughput at low SNR

TABLE 2: SIMULATION RESULTS

Bandwidth	5MHz
Data stream	2048
Mobility	1km
No of recivers	2
No of reciver antennas	2
Thermal noise	-108dB
Variance	0.2574
Channel mode	AWGN ,rayleigh
Transimitted power	27 dBm
TTI	2ms

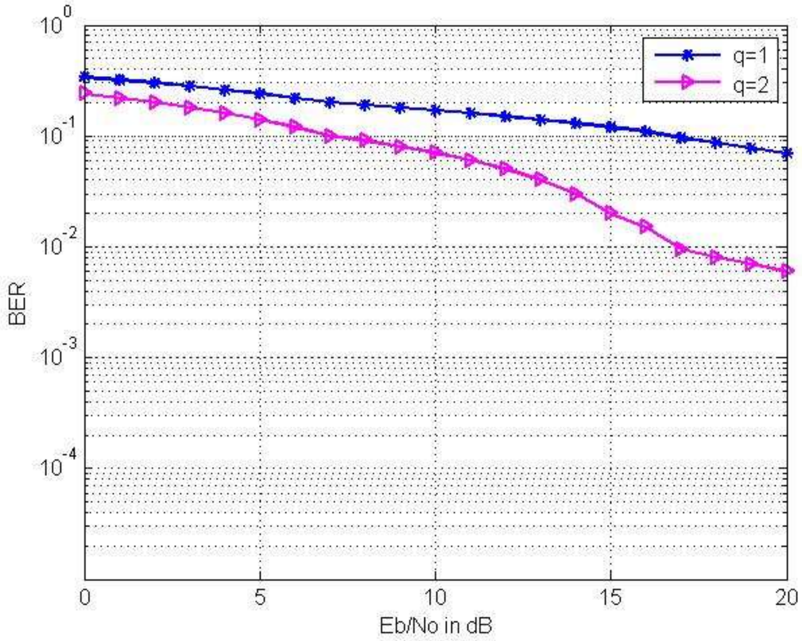

Fig. 11 BER performance for mu-mimo with number of iterations

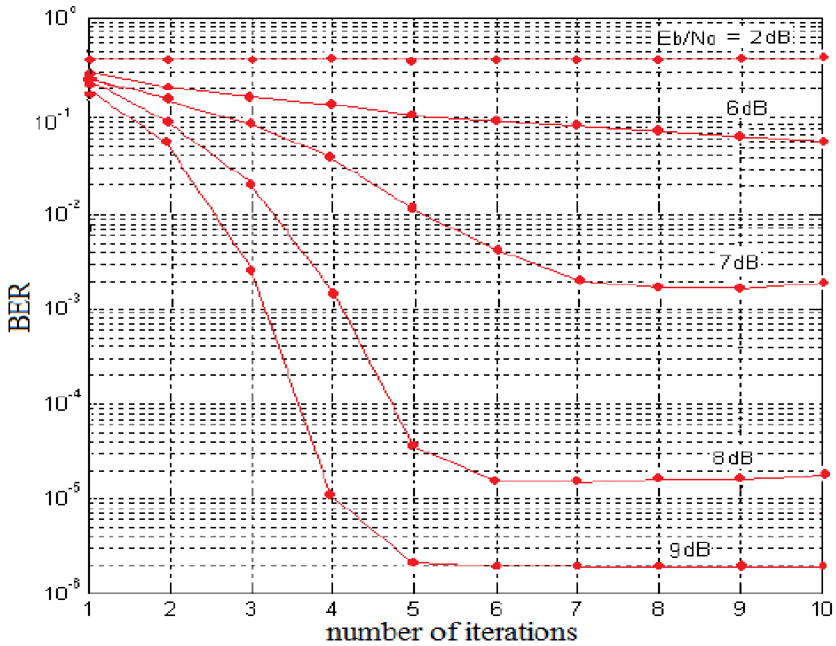

Fig 12 BER Performance of MIMO -IDMA system with number of iterations

V. CONCLUSION

In this paper performance of SISO and MIMO systems in terms of through put is analyzed in capacity In section II various estimations techniques are compared in which ML method is better Complexity is more in calculation to overcome this new Circular decoding technique is explained in fig 4 and 5.In section-III channel is estimated by partial training symbols(SBCE) and without training symbols(BCE).the performance of SBCE is better than BCE. The performance of MIMO and MU-MIMO is compared for single user MIMO for 2 iteration SNR value 8db and BER is 10-1 Were as MU-MIMO for 2 iterations SNR value is 8db and BER is converging at 10^{-1}

REFERENCES

[1] M. Schubert and H. Boche, Solution of the multiuser downlink beamforming problem with individual SINR constraints, *IEEE Trans. on Veh. Technol.*, vol. 53, no. 1, pp. 18–28, Jan. 2004.

[2] L. Dai, Distributed antenna system: Performance analysis in multi-user scenario, *Conference on Information Sciences and Systems*, March 2008, pp. 85–89.

[3] B. Song, R. L. Cruz, and B. D. Rao, Downlink optimization of indoor wireless networks using multiple antenna systems, *INFOCOM*, vol. 4, Mar. 7–11, 2004, pp. 2778–2789.

[4] T. Wu and P. Hosein, "Radio resource management strategies for distributed antenna systems," *IEEE Wireless Communications and Networking Conference*, Apr. 2010, pp. 1 –6.

[5] P. Marsch, S. Khattak, and G. Fettweis, A framework for determining realistic capacity bounds for distributed antenna systems, *Information Theory Workshop*, Oct 2006, pp. 571 – 575.

[6] J. Zhang, R. Chen, J. G. Andrews, A. Ghosh, and R. W. Heath, Jr., Networked MIMO with clustered linear precoding, *IEEE Trans. Wireless Commun.*, vol. 8, no. 4, pp. 1910–1921, 2009.

[7] A. H. Feiverson and F. C. Delaney, The distribution and properties of a weighted sum of chi squares, *NASA*, *Tech. Rep. Tech. Rep*. TN D-4575, 1968.

[8] K. K. Wong, R. S.-K. Cheng, K. B. Letaief, and R. D. Murch, Adaptive antennas at the mobile and base stations in an OFDM/TDMA system, *IEEE Trans. Commun.*, vol. 49, pp. 195–206, Jan. 2001.

[9] J. Fuhl and A. F. Molisch, Capacity enhancement and BER in a combined SDMA/TDMA system, in *Proc. IEEE Vehicle Technology Conf.*, vol. 3, New York, NY, 1996, pp. 1481–1485.

[10] F. R. Farrokhi, K. J. R. Liu, and L. Tassiulas, Transmit beamforming and power control for cellular wireless systems, *IEEE J. Select. Areas Commun.*, vol. 16, pp. 1437–1450, Oct. 1998.

[11] R. Schmalenberger and J. J. Blanz, Multiantenna C/I balancing in the downlinkofdigitalcellularmobileradiosystems, *Proc.IEEEVehicle Technology Conf., Phoenix*, AZ, May 4–7, 1997, pp. 607–611.

[12] W. S. Au, R. D. Murch, and C. T. Lea, Comparison of the spectrum efficiency between SDMA systems and sectorized systems, *Wireless Commun*., to be published.

[13] L. F. Chang and J. C.-I. Chuang, Diversity selection using coding in a portable radio communications channel with frequency-selective fading, *IEEE J. Select. Areas Commun.*, vol. 7, pp. 89–97, Jan. 1989.

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M. Shashidhar "Performance Analysis of MIMO In Comparison with MU-MIMO Under Non Data Aided Technique." International Journal of Engineering Research and Applications (IJERA) , vol. 7, no. 12, 2017, pp. 27-35.