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Simultaneous Antenna Selection in BI-Directional Full Duplex MIMO System

Ganga Gopinath
M. Tech ECE, Department of ECE
Sree Narayana Gurukulam College of Engineering,
Kadayiruppu, Kerala, India

Shiji Abraham
Professor, ECE Dept.
SNGCE, Kadayiruppu, Kerala
India

Abstract:- **This paper is to examine about approximate antenna selection (AS) strategies for bi-directional full duplex Multiple Input multiple Output(MIMO) structures in which the antenna node can be decided on both to transmit or to receive. The technique used here is finding the best antenna set solution from all the available antennas primarily by analysing the average sum rate of optimal AS. This result provide which all antennas from the receiver side to the transmitter side configuration gains the average sum rate of the performance. This is followed by the introduction of a new AS algorithm with optimal rate of average sum that is near to the AS scheme but with reduce complexity.**

Keywords:- *MIMO systems, AS scheme.*

I. INTRODUCTION

Wireless communique procedure have superior considerably in the past years and played an extremely vital role in our society. The demand for communique among humans is growing rapidly, requiring greater connection, extra uses and high excellent..Many new stringent technical requirements have to be faced when considering the designs of further wireless systems. a few of the extraordinary aspects that should be taken into regard, the subsequent ones can be noted. (i) boom of variety of human beings demanding wireless communique server.(ii) growth of the require for broader coverage regions.(iii) increase of the call for for higher pleasant services and therefore, better bit rates

Trying to improve all previous aspects simultaneously is extremely difficult. One possible solution is diversity. Which consists in sending several copies of the signals, thus introducing reliability in transmission. Multiple Input Multiple Output may be called the communique channel created with a couple of transmitter and receivers of an antenna to enhance communication overall performance. MIMO has been achieved space measurements to enhance wireless system’s functionality, range and reliability. It offers growth inside the facts through and link range with none extra bandwidth or transmitting power. MIMO antenna technology had achieved this objective by spreading the identical overall transmit power over the antenna to perform an array gain that recovers the spectral efficiency or obtain a range benefit that will increase the link reliability or reduce the fading.

A multiple-input-multiple-output (MIMO) system currently turns into one of the superior future techniques for the destiny use as it proposes an intensive development over traditional smart aerial systems in both quality of service (QoS) and the transfer rate. the usage of a couple of antenna requires a couple of radio frequency (RF) chains which desires amplifiers, up and down converters, digital to analog convertors, are typically very pricey A promising method for reducing charge at the identical time as retaining a reasonably large fraction of the immoderate ability data rate of an MIMO technique is to appoint a few form of antenna choice.

II. LITERATURE SURVEY

Many researchers have introduced various techniques for Antenna Selection (AS).The study of currently related work is grouped as describing the system model for MIMO system with bi-directional full duplex, performance analysis of the optimal antenna selection strategy and reduces the antenna searching complexity.

Melissa Duarte and Ashutosh sabharwal [1] discussed about simultaneous bi-directional communication system and full duplex communication on a same band. The amount of self-interference is proportional with the transmitted power. In order to make feasible full duplex wireless communication, the self-interference can be cancelled sufficiently. With same resources, full duplex system can achieve higher rate the that of half duplex system

Brian P. Day, Daniel W. Bliss, Adam R. Margetts and Philip Schniter [2] gives brief knowledge about the issues between a pair of modems, each with couple of transmitter and multiple receive antenna in full duplex bidirectional wireless communication. To perform interference cancellation, transmit beamforming and receive beamforming consider the system with pilot aided channel estimation

Albert and Inkyu [3] provide an explanation for approximately a brand new complexity reduced sphere decoder for multiple antenna system to achieve close to most- chance overall performance with low complexity.

In [5] [9]saids about flat-fading MIMO channels with a spatial multiplexingscheme significantly reduces the processing complexity at both transmitter and receiver as well as the remarks overhead. In [6] suggest a quick antenna choice set of rules for multiple-input more than one-output structures. Some set of guidelines achieves nearly the same outage capability because the most appropriate choice method at the same time as having lower computational complexity than the present almost most suitable antenna choice techniques. Here shows the antenna subset selection approach relies upon on the rank residences of this matrix undefined.

In [10], [15] targeted on the overall duplex two-way communication, in which the two nodes have information for each other and transmit and obtain concurrently within the same frequency band.

In this paper is following sections arranged as . In section III the system model along with the mode of operation is presented. The system is thoroughly analyzed. In section IV, the proposed framework is compared with the simulation results. Finally in section V, the paper is concluded with following references.

III. PROPOSED METHODOLOGY

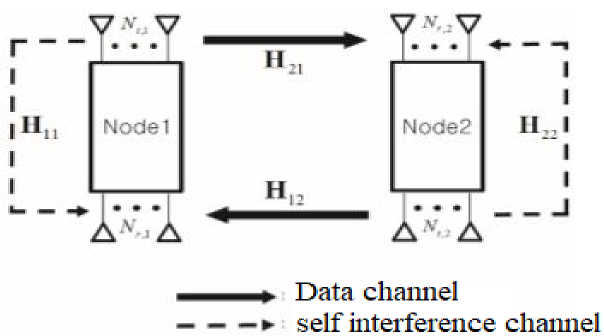

Fig 1:- MIMO system model

Fig1: provides two junctions FD communiqué system with a transmit and a get hold of antenna at every junction. Junctions can simultaneously transmit and get hold of the signals at the identical frequency and same time gap, which results in immoderate self-interference because of the signal discharge from the transmute RF unit to get hold of RF unit, as verified in Fig. 1. One way to nullify the self-interference is via antenna cancellation, and there are numerous analog and virtual signal technique strategies evolved recently for SI cancellation. Relying on the gap the various transmit and acquire antennas, the self-interference can be massive than the acquired signal.As a result the signal acquired at every node is dominated by way of way of the self-opposition. This can weigh down the AD/DA alteration manner duetoits restricted dynamic variety. Consequently, the effectual bits for the acquired signal is lesser and the following SINR is down. Consequently, the self-oppositionwishes to be alleviate in earlier than the ADC in analog circuit. After the analog self-interference cancelation, final opposition maybe in addition decreased through the energeti c digital cancelation.

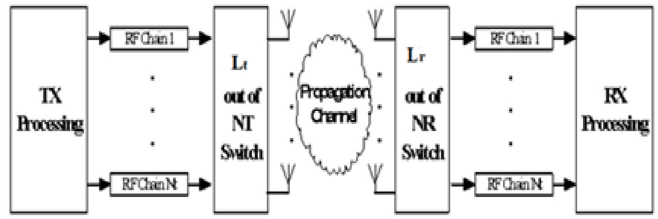

Fig 2:- MIMO system with antenna selection

A bit stream is despatched thru a encoder and modulator. This encoder transforms one-bit flow into Lt similar flow of symbols. These flow could have all the identical data or can all have independent symbol streams. With in the give up, a combiner switches the modulated sign to the best pleasant Lt out of Nt to be had antenna branches can be recognize from fig 2. The signal is send via the channel.

The input and output relation of MIMO communication system model is commonly represented by the vector notation

$$y = Hx + n \qquad (1)$$

$$H = \begin{bmatrix} h_{11}h_{12} & \cdots & h_{1N_t} \\ \vdots & .... & \vdots \\ h_{N_r1}h_{N_r2} & \cdots & h_{N_rN_t} \end{bmatrix} \qquad (2)$$

Equation (2) denote the Nr ×Nt matrix of the channel as H. The access with $H_{K,M}$ denotes the attenuation among the M th transmute and the Kth receiving aerial. The result of the channel is polluted thru AWGN, which is believed to be impartial in any respect receiving aerial component. At the receiver, the perfect Lr of the available Nr aerial factors are preferred, and down transformed for further. assume within the following that

A. The fading upon the special antenna factors is still believed to be anindependent equivalently allotted fading. That is accomplished if the hints of the multipath part on the sender and acceptor are approximately uniform, and the component in aerial are spaced a long way aside from one another.

B. We expect that the recipient as ideal expertise of the channel. For the sender study each instances in which the transmitter has no channel statistics, and in which it has best channel facts and partial channel statistics

➢ *Antenna Selection*

No matter the use as variety or spatial multiplexing device, the primary disadvantage of any MIMO device is the elevated difficulty, and accordingly expense. at the equal time extra antenna factors are normally inexpensive, and the further digital processing becomes ever inexpensive, the RF factors are highly priced. Nt transmute and Nr recipient antenna of MIMO system require Nt (Nr) complete RF chains at the sender, and the acceptor, severally which incorporates low nose amplifier, down converter and ADC. because to this motive, the "top " L out of N antenna indicators are chosen, down transformed, and processed. This reduces the quantity of required RF chains from N to L, and for this reason leads to significant economic financial savings.

The simplest procedure for a superior choice of the antenna factors is an exhaustive seek of all possible combos for the one that gives the excellent SNR or potential. This require a few $\binom{N_t}{L_t}\binom{N_r}{L_r}$ computations of determinants for every channel awareness, which speedy becomes impractical. Because of that, extraordinary preference set of rules has been advised. Most of them are supposed for device in which the choice is accomplished at only one link give up.

A. Receiver Antenna Selection

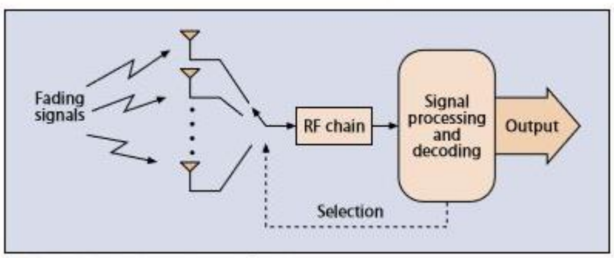

Fig 3:- Selection of antenna in receiver part

In Fig. 3 represents the utility of choice combining to get hold of antenna choice, in which a single acquire antenna is chosen from among all antennas. The excellent one RF part is to be to be had, as a cease end result we want to recognize all of the path SNRs for optimum choice, but how can we understand all SNRs concurrently. One may use a signal in a preface to transmitted facts. during this preface, the receiver examines the antennas, well-known shows the antenna with the highest channel benefit, and selects it for receiving the subsequent information. there are various realistic problems in antenna desire. for example, the best first-rate choice need to be primarily based at the acquired signal's SNR, but in sensible it's far less complicated to apply an envelope detector and Pick the path with largest SNR.

B. Transmit Antenna selection

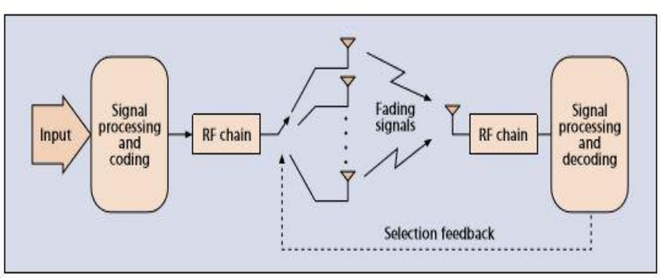

Fig 4:- Antenna selection in transmitter side

In fig 4 explains the transmit antenna preference, not like acquire choice, calls for a feedback direction from the acceptor to the sender. This feedback direction is alternatively less, in particular for sign antenna choice. Other than that distinction, but, sender antenna choice may be very much like acquire antenna choice; the antenna is chosen that gives the quality equal obtained SNR. To examine more than one sender antenna selection, expect that there are Lt RF chains and Mt antennas (Mt > Lt) on the transmute, and one antenna at the acceptor. Then we are faced with the task of choosing the most suitable Lt out of Mt antennas from the sender. Then the phase and magnitude of the transmit signs want to be such that their superposition at the receiver effects in maximal receive SNR. In this case, one need to choose the Lt transmit antennas with the exceptional channel advantage.

➢ *Design Procedure*

Let us specify a set of aerial at node i (i = 1,2) as Ni = {1,2,⋯ ,Ni}, where Ni represents the total figure of antennas at node i. The sets of sender and acceptor antennas at node i are denoted as Ti⊂Ni &Ri⊂Ni, respectively, also the figure of sender and acceptor antennas at node i are represented by Nt,i and Nr,i, respectively, with Nt,i+Nr,i = Ni. Further, we use the notation S = {T1, T2,R1,R2} to indicate a certain antenna set selection suitor and denote A to represent the group of all available antenna set candidates S.

The signals obtained at each node are a mixture of the signal send by the alternative supply, the RSI, and the noise at node i

$$y_i(s) = \sqrt{p_i}H_{i\bar{\imath}}(s)X_{\bar{\imath}}(s) + \sqrt{P_i}H_{ii}(s)X_i(s) + n_i(s) \quad (3)$$

Where the p_i stands for the transmit power at node i, $H_{i\bar{\imath}}$impliesthe communication path from node $\bar{\imath}$ to node i , H_{ii} represents the interference channel at node i, n_i indicates noise term.

Achievable rate at the node i for a given antenna set candidate S can be

$$R_i(\text{s})=\log_2 |I_{N_{r,i}} + \gamma_i H_{I\bar{I}}(\text{s})H_{I\bar{I}}(S)^H * (\sigma^2 I_N+\gamma_i H_{ii}(\text{S})H_{ii}(s)^H)^{-1}| \quad (4)$$

Where $I_{Nr,}$ is the identity matrix of N_rxN_r. and the signal to noise ratio γ_i become

$$\gamma_i \triangleq \frac{P_i}{N_{t,i}}(5)$$

White Gaussian noise with covariance become

$$E\{n_i(s)n_i(s)^H\} = \sigma_n^2 I_{N_{r,i}} \quad (6)$$

Here antenna set S that design to extend the sum rate become

$$R(S) \triangleq R_1(S) + R_2(S)(7)$$

The most reliable preference of antennas requires expertise of the entire channel matrix. This will appear to necessitate using Nr RF chains, that can not be given as true with the purpose of decreasing the number of RF chains in a low-complication machine. But, in a adequately gradually converting surroundings, the aerial can be multiplexed to the Lr RF chains at a few stage within the bits

$$S^* = \arg max_{S \in A}\ R(s) \qquad (8)$$

It is realize that the most quality antenna choice solution S^* can be acquired via manner of an exhaustive inquiry that look at all the aerial group candidate. The inquiry intricacy of the high quality antenna choice scheme is calculated as

$$\widehat{N}_c \triangleq |A| \qquad (9)$$

$$\widehat{N}_C = \sum_{N_{t,1}=1}^{N_1-1}\sum_{N_{t,2}=1}^{N_2-1}\binom{N_1}{N_{t,1}}\binom{N_2}{N_{t,2}} \qquad (10)$$

$$\widehat{N}_C = (2^{N_i}-2)(2^{N_i}-2) \qquad (11)$$

From the equation (11) intricacy expand exponentially as N_1 and N_2 ie, total count of antenna at node 1 and node 2 respectively develops. Because of this introduce a dynamic AS technique which reduce the inquiry intricacy of the optimal AS scheme.

A. Performance Evaluation of the Optimal AS Strategy

We consider the moderate sum rate of the optimal AS strategyR_{opt} .For symbolic conveniences, let us define$S_j \in A$ as the j[th] component of A for j = 1,2,⋯ $\widehat{N}_C$. Then, the average worth amount of the optimal AS Strategy may be expressed.

$$\widehat{R}_{opt} = E\left[{}_{j=1,2,\ldots,\widehat{N}_c}^{max} R(S_j)\right] \qquad (12)$$

$$\approx E[\ log_2 \textstyle\sum_{j=1}^{\widehat{N}_r} 2^{R(S_j)}\ ](13)$$

$$= E\left[log_2 \textstyle\sum_{j=1}^{\widehat{N}_c}\prod_{i=1}^{2} D_i\left(S_j\right)\right](14)$$

Where (13) comes from the max-log estimation, which is close inside the excessive SNR regime

$$D_i(S_j) \triangleq |I_{N_{r,i}} + \gamma_i H_{I\bar{I}}(S_j) H_{I\bar{I}}(S_j)^H\ *(\sigma^2 I_N + \gamma_i H_{ii}(S_j) H_{ii}(S_j)^H)^{-1}|(15)$$

Since equation (15) still has a complicated form, it is hard to collect any insight upon the optimal choice AS scheme. Due to this reason, through making use of the relation amidst the mathematics and geometric manner to (15), we further derive

$$\bar{R}_{opt} \approx \log_2 \widehat{N}_C + E\left[\frac{1}{\widehat{N}_c}\sum_{j=1}^{\widehat{N}_c}\log_2\prod_{i=1}^{2} D_i\ (S)_j\right]$$

$$= \log_2 \widehat{N}_C\ + E\left[\frac{1}{N_c}\sum_{j=1}^{\widehat{N}_c}\{R_1(S_j) + R_2(S_j)\}\right]$$

$$= \log_2 \widehat{N}_c\ +\ \bar{R}_{conv}\ (16)$$

Where the sum rate of the conventional Bi-directional full duplex systems can be represented as $\bar{R}_{conv}$

$$\bar{R}_{conv} = E\left[\frac{1}{N_c}\sum_{j=1}^{\widehat{N}_c}\{R_1(S_j) + R_2(S_j)\}\right] \qquad (17)$$

From equation (17) , the optimal aerial choice scheme provide an mean sum rate performance benefit of $\log_2 \widehat{N}_c$ compare to conventional Bi-directional full duplex system systems. The mean sum rate gain is sovereign of the self-interference power and boost the count of N_i increases.

While the number of transmit and receive antenna is given by ie, $N_{t,i}$ and $N_{r,i}$respectively

$$\bar{R}_{opt}\left(N_{t,i}, N_{r,i}\right) \approx \log_2 N_c(N_{t,i}, N_{r,i)} + \bar{R}_{conv}(N_{t,i}, N_{r,i}) \qquad (19)$$

The count of antenna set can be represented as $N_c(N_{t,i},N_{r,i)}$.

$$\text{Nc}\left(N_{t,i}, N_{r,i}\right) = \binom{N_{t,1}+N_{r,1}}{N_{t,1}}\binom{N_{t,2}+N_{r,2}}{N_{t.2}}$$

From (19), we are able to see that the operation of the AS scheme can be improved via maximizing the count of antenna set candidates $N_c(N_{t,i},N_{r,i})$. making use of Pascal's triangle [14], it can be shown that $N_{t,i}$ and $N_{r,i}$ maximizing $N_c(N_{t,i},N_{r,i})$below the antenna constraint $N_{t,i} + N_{r,i} = Ni$ (i = 1,2) are obtained as

$$\{N_{t.i}^*, N_{r,i}^*\} = \begin{cases}\left\{\frac{N_i}{2}, \frac{N_i}{2}\right\} & if, N_i\ is\ even \\ \left\{\frac{N_{i\pm1}}{2}. \frac{N_{i\mp1}}{2}\right\} & if, N_i\ is\ odd\end{cases} (21)$$

it is notice that if the wide variety of transmit and acquire antennas is ready consistent with (21). We can not simplest improve the operation of BD FD systems as compared to traditional BD FD systems, however also lessen the inquiry quantity of the best AS scheme to $\binom{N_1}{\frac{N_1}{2}}\binom{N_2}{\frac{N_2}{2}}$for even N1 and N2.consequently, at the idea of the outcomes in (21), we recommend a low-complexity antenna selection manner inside the coming section.

B. Low Complexity AS Algorithm

On this phase, introduce a brand new AS set of rules which lower the search intricacy. As noted inside the previous segment, we guess that the transmit and collect antenna structure satisfies [21]. To lessen the intricacy, right here observe a greedy seek concept to BD FD structures. The greedy seek set of rules has been extensively completed to the AS problem in traditional HD

MIMO systems to lower the are looking for complexity [9] [21]. However, the strategies in [9] [21] can't be right now implemented to BD FD structures due to the SI term in (4). viain view of those problems, we endorse an effective AS set of rules for BD FD structures in accordance with greedy inquiry.

First, allow us to specify 'n'as the new loop index and $\bar{S}^{(n)} = \left\{\bar{T}_1^{(n)}\bar{T}_2^{(n)}\bar{R}_1^{(n)}\bar{R}_2^{(n)}\right\}$ as the antenna set determined at the n[th] step. In the proposed AS algorithm, we$\bar{T}_{\bar{\imath}}^{0} = \bar{R}_i^0 = \emptyset$, $\bar{R}_{\bar{\imath}}^{(0)} = N_{\bar{\imath}}$ and $\bar{T}_{\bar{\imath}}^{(n)} = N_i$. On the n[th] loop, one transmute and one obtain antenna that maximize the sum rate R($\bar{S}$) are brought to $\bar{T}_{\bar{\imath}}^{(n)}$ and $\bar{R}_i^{(n)}$, at the same time as they're eliminated from $\bar{R}_{\bar{\imath}}^{(n)}$and $\bar{T}_i^{(n)}$, respectively. That is due to the fact in BD FD structures$\bar{R}_{\bar{\imath}}^{(n)}$and $\bar{T}_i^{(n)}$, may be directly received as$\left(\bar{T}_i^{(n)}\right)^c = \bar{R}_i^{(n)}$, wherein $(.)^c$ represent a complementary set. We repeat this process until the aerial set $\bar{S}$satisfies the form in (21). The suggested AS procedure is summarized as set of rules 1 for N1 = N2. The set of rules may be described in a like way while N_1 isn't same to N_2.

We evaluate the complicated of the designed AS procedures with that of the optimal AS scheme. whilst and both Ni and are even, the search difficult of the suggested AS algorithm is computed as

$$\widehat{N}_c = \sum_{k=1}^{\frac{N_i}{2}} \left(N_i - (k -)\right)\left(N_{\bar{\imath}} - (K-1)\right) + \sum_{K=\frac{N_i}{2}+2}^{\frac{N_i}{2}} (N_{\bar{\imath}} - (k - 1)) \qquad (22)$$

this is given by means of using a polynomial of the count of aerial Ni.

IV. RESULT AND ANALYSIS

This section is deals with the performance analysis of the optimal selection method and proposed selection method in the MATLAB software in terms of performance gain of the optimal selection method, Average sum rate for various variance, Average sum rate as the function of SNR in the perfect and imperfect case, complexity calculation.

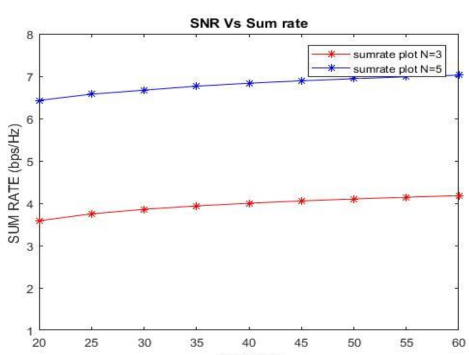

Fig 5:- Optimum AS scheme with gain

In Fig 5 shows the graphical result drawn between sum rate and signal to noise ratio. From this graphs, we can understand that gain grows as the count of aerial at each node grows. But the number of antenna rises the complexity of the optimal selection scheme increases.

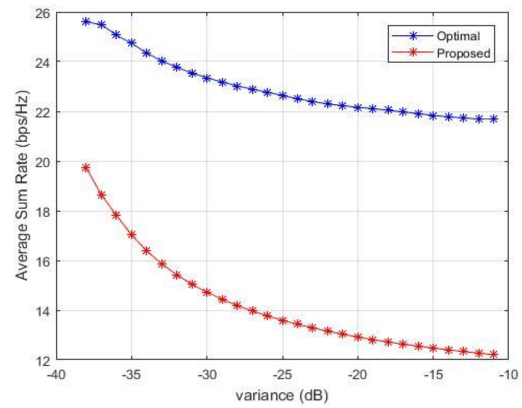

Fig 6 :- Average sum rate for various variance

In fig 6 present the average sum rate of the bi-directional full duplex systems with respect to σ^2_{SI}. The suggested AS procedure exhibits performance almost to the optimal AS scheme.

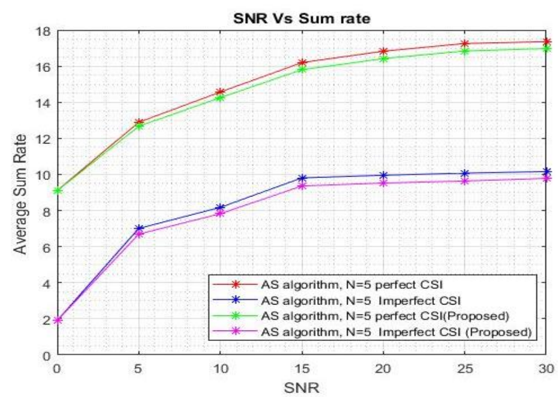

Fig 7:- Average sum rate as a function of SNR in the perfect and imperfect CSI case

Fig 7 gives the average sum rate performance of the optimal AS scheme and the suggested set of regulation with ideal and imperfect CSI. here, we employ the additive Gaussian channel estimation error model [20], i.e., the estimated channel $\widehat{H}_{i\bar{\imath}}$and the SI channel $\widehat{H}_{ii}$ are given by and $\widehat{H}_{ii}$= Hii+Eii, respectively, wherein the factors of $E_{i\bar{\imath}}$ and Eii are i.i.d. complex Gaussian random variables with zero mean and variance σ2 . In the ideal CSI case, we take a look at that the proposed AS algorithm almost nearly performance with much decreased difficulty as relate to the optimal AS scheme we are able to see that the proposed AS algorithm shows suitable performance as associate to the optimal AS scheme for the imperfect

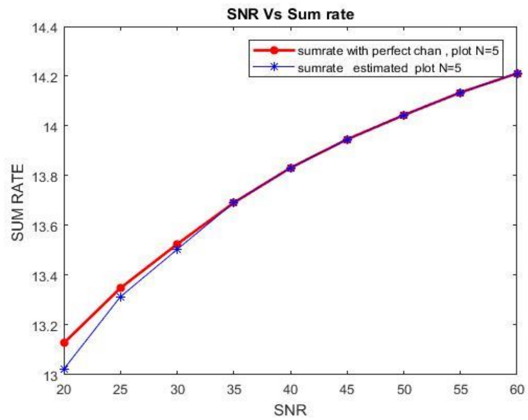

Fig 8:- Sum rate as a function of SNR with no CSI in optimal method

From Fig 8. presents the sum rate as the function of SNR in the optimal AS scheme with no channel state information and perfect channel state information. In case of no CSI, the transmitter does not have any knowledge of any parameter concerning the channel and interference statistics at the receiver so we need to estimate the channel. Sum rate with perfect CSI and estimated channel gives similar performance gain.

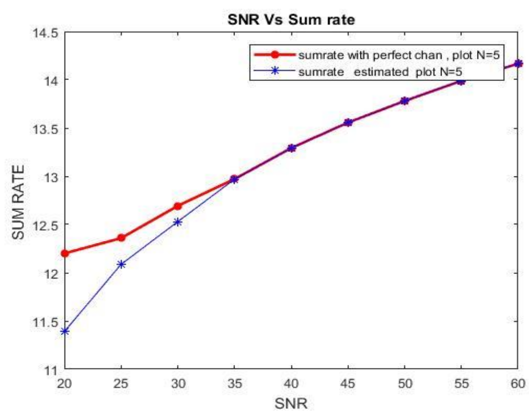

Fig 9:- Sum rate as a function of SNR with no CSI

Fig 9. gives the sum rate performance of proposed AS scheme with perfect channel state information and no CSI .In case perfect CSI ,the transmitter has full knowledge of the channel and interference statistics at the receiver. Perfect CSI exhibit significant performance than the estimated channel state information. Comparing Fig 8and Fig 9 both optimal AS and proposed AS method have nearly same performance.

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Complexity of optimal method:
   961

Complexity of proposed method:
    35
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Fig 10:- complexity calculation

From the Fig 10, shows that the expected AS algorithm achieves a important intricacy cutback compared to the optimal AS scheme. From the above results we can confirm that the recommended AS procedure provides act almost identical to that of the optimal AS Scheme with much reduced complexity

V. CONCLUSION

Inside the advocated a low-convoluted AS expertness for BD FD MIMO structures. Initially analyzed the overall concert of BD FD MIMO structures with the top-quality AS scheme. By way of the usage of this end result, an efficient AS algorithm has been furnished which makes use of the grasping search method. From the numerical simulations, we've demonstrated that the analytical result has the same opinion well with the simulation effects. also, we've confirmed that BD FD structures the use of the suggested AS set of rules outperform conventional BD FD systems and show off near-greatest sum rate performance with an awful lot reduced complexity

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