ISSN(Online): 2319 - 8753
ISSN (Print) :2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

Improvement of BER Performance Using Transmit Antenna Selection in Multiple Antenna Systems

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ABSTRACT: In this paper, we implement transmit antenna selection to enhance the energy efficiency of large scale multiple antenna systems. Two easy but effective antenna selection algorithms, Sequential Search Algorithm (SSA) and Binary Search Algorithm (BSA) are proposed to obtain the maximal energy efficiency. In addition, BER performance is determined using non-linear receivers which integrate minimum mean-square error equalization with successive interference cancellation. The simulation results show MMSE-SIC detection technique exhibit 40% better BER performance than ZF-SIC and MRC-SIC.

KEYWORDS: Large scale multiple antenna system, transmit antenna selection, energy efficiency, selection algorithms, successive interference cancellation

I. INTRODUCTION

In the recent years, ―Multiple antenna wireless systems have attracted more scrutiny as it improves system performance by increasing the count of transmit and receive antennas at the price of higher hardware costs and computational burden. To overcome the hardware complexity, antenna selection scheme have been approached [3]–[4]. The disadvantage of employing more antennas lead to complexity as separate radio frequency (RF) chains are attached to each antenna. It in turn hikes up the implementation cost. From [4], Fast algorithms are proposed to select optimal no of transmit antennas to reduce complexity and parameters such as capacity are taken into consideration .In other case, from [3], antenna subset selection has been accounted by criteria such as maximum mutual information, bounds on error rate in a noisy channel.

The growing demand for energy efficiency has been studied more in power related applications. In accordance with transmit antenna selection in large scale multiple antenna systems, energy efficiency have been widely discussed in [1].This paper analyzes the concept of channel hardening and various scenarios where 1)transmit power is dominates circuit power when it is smaller or negligible and 2)high circuit power for low transmit power. Taking into account the above conditions, two simple algorithms are proposed to achieve maximum energy efficiency.

In this paper, we focus on the two energy efficient antenna selection algorithm, Sequential Search Algorithm (SSA) and Binary Search Algorithm (BSA) to achieve maximum energy efficiency. In extension to that, the bit error rate (BER) performance of the energy efficient system is calculated using minimum mean square error and successive interference cancellation (MMSE-SIC) detection .The simulation results of BER performance compared with other equalizers enhances the point that MMSE-SIC detection is more desirable.

The rest of the paper is arranged as follows. Section II presents the system model In Section III, energy efficiency and two selection schemes are discussed. Simulation results are given in Section IV. Section V summarizes the paper.

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II.SYSTEM MODEL

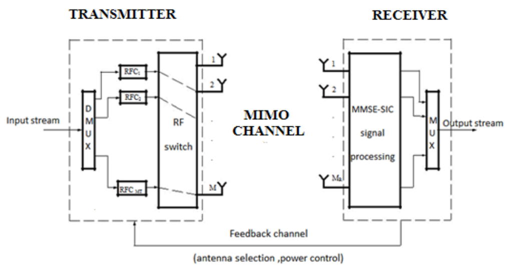

FIG 1 TRANSMIT ANTENNA SELECTION SCENARIO

We consider the downlink of a point-to-point MIMO system. Considering the transmitter antenna as N and receiver antenna as M, the energy efficiency for the closed –form expression was derived to improve it. By assumptions, the received signal can be written as [1]

$$y = h^T x + n$$

where h is the channel matrix and the channel used here is Rayleigh fading channel. The vector $h=[h_1,h_2,....,h_N]^T$, where h_i is the fading coefficient amid the i^{th} transmitter and receiver; x is the transmitted vector; n is the additive white zero-mean Gaussian noise.

To attain high rate, it is impractical to use all antennas due to expensive implementation cost and high intricacy. To utilize every antenna in MIMO system brings about high complexity and each antenna apply independent RF Chain. Hence, Transmit antenna selection is implemented to choose the best L antennas from all the available ones. CSI is assumed perfect at the transmitter.

Across the antennas there is the total power constraint (ρ). The transmit antenna selection in this system I_{sel} is given by [1]

$$I_{sel} = \log_2(1 + \rho \sum_{i=1}^{L} |h_i|^2)\ bits/s/Hz$$

where $|h_1|^2>|h_2|^2>...>|h_N|^2$.

At the transmitter, the data streams are encoded using modulation format QPSK. Exact CSI is assumed at the receiver. Ordered successive interference cancellation is carried out in combination with MMSE equalization to compute the BER performance.

II.ENERGY EFFICIENCY AND SELECTION ALORITHMS

A) ENERGY EFFICIENCY

The energy efficiency is defined as the spectral efficiency divided by the total power consumed. It is written from [1] as

$$\eta = \frac{E[I]}{P_{total}}$$

where E indicates the expectation, I is the mutual information and P_{total} is the total power consumption.

For every used antenna, a separate RF chains is attached. The circuit power consumption model is considered from [10]. It is given as

$$P_C \approx N_t(P_{DAC}+P_{mix}+P_{filt})+2P_{syn}+N_r(P_{LNA}+P_{mix}+P_{IFA}+P_{filr}+P_{ADC})$$

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where N_t and N_r are the numbers of transmitter and receiver antennas. The power consumption values for the DAC, mixer, active filters at transmitter side, frequency synthesizer, low noise amplifier, intermediate frequency amplifier, active filters at receiver side and ADC are represented as P_{DAC},P_{mix},P_{filt},P_{LNA},P_{mix},P_{IFA}, P_{filr} and P_{ADC}.

To remove the complexities, we symbolize that P_1=2 P_{syn}+P_{DAC}+P_{filt}+P_{LNA}+P_{mix}+P_{IFA}+P_{filr} + P_{ADC} and P_2=P_{DAC}+P_{filt} + P_{mix}. Hence P_c=P_1+LP_2 evidently with $P_1>P_2$. Thus the closed-form statement of the energy efficiency from [1] is

$$\eta = \frac{\log_2\left[1+\left(1+\ln\frac{N}{L}\right)\rho L\right]}{\rho + P_1 + LP_2}$$

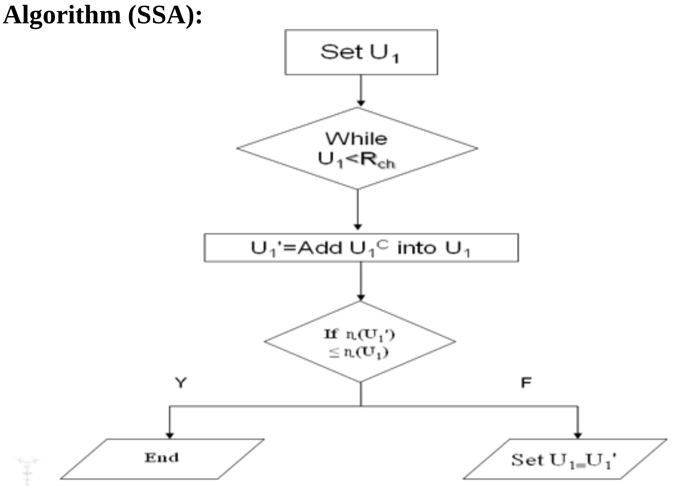
By letting P_1= P_2=0, the energy efficiency equation from [1] is modified as

$$\eta = \frac{\log_2\left[1+\left(1+\ln\frac{N}{L}\right)\rho L\right]}{\rho}$$

B) SELECTION ALGORITHM

As is stated in section I, many fast algorithms have been proposed to reduce the complexity [3]–[4] with the RF chains attached. From [1] we know that for a fixed transmit power, it is not necessary to employ all the available RF chains. Based on the above conclusions, the two efficient selection algorithms concentrates on the number of employed antennas and the antenna subset is stated below. We assume perfect CSI at the transmitter throughout the implementation of both algorithms.

1) Sequential Search Algorithm (SSA):



a) SSA FLOWCHART

The sequential search is a method for finding a particular value in a list that checks each element in sequence until the desired element is found. Here the sequential search is used to find the ideal antenna subset. After every loop, the current ideal subset is represented as U_1.The antennas with best channel conditions are added to the ideal subset and updated after each comparison. If R_{ch} chain constraint is equal or more than the no of elements in ideal antenna subset (U_1),then the algorithm terminates. If R_{ch} constraint satisfied, then at every loop, a best antenna is selected from the complimentary set of U_1 , U_1^C to create a new set U_1'.A If condition is added to check whether the efficiency of U_1' is smaller than or equals to the efficiency of U_1 . The condition satisfies means, set U_1=U_1' or else the search stops and

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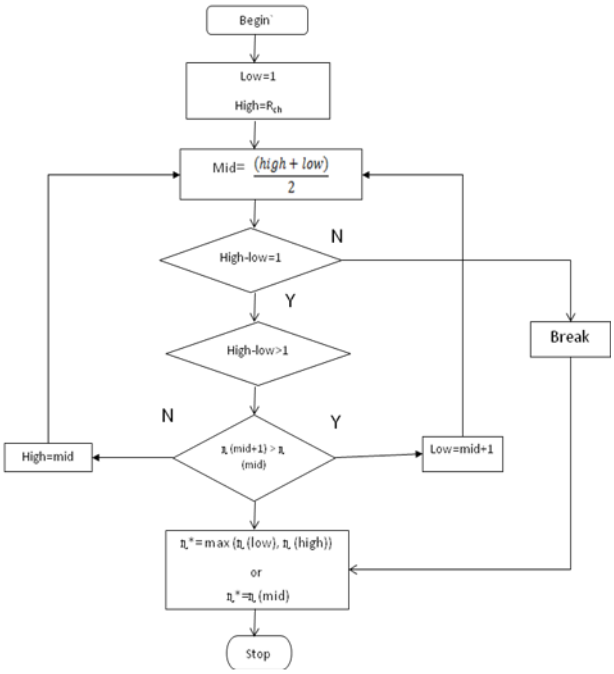
ideal antenna subset is taken as U_1.

2) Binary Search Algorithm (BSA):



b) BSA FLOWCHART

The BSA is used to determine the position of a specified value within a sorted array. This algorithm requires far fewer comparisons than a linear search especially for large arrays. The location of the maximum value is taken from the middle value.

The low value, high value and mid value stands for lower constraint of antennas, higher constraint of antennas and midpoint of lower constraint and upper constraint of antennas respectively. Set opening value of low value and high value as 1 and R_{ch}. The mid value is calculated by taking average of both high and low value. To find the subset in which the maximum value location is, the efficiency of (mid value+1) is compared with the efficiency of mid value. If ɳ(mid value+1) is more; the location is in lower constraint of antennas, set high value=mid value to check lower subset. Otherwise the location will be in upper constraint of antennas, set low value=mid value +1 to check upper subset. The mid value is updated after every loop. If the condition (high value - low value=1) is satisfied, then the maximum value location is in the mid value constraint of antennas.

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IV. SIMULATION RESULTS

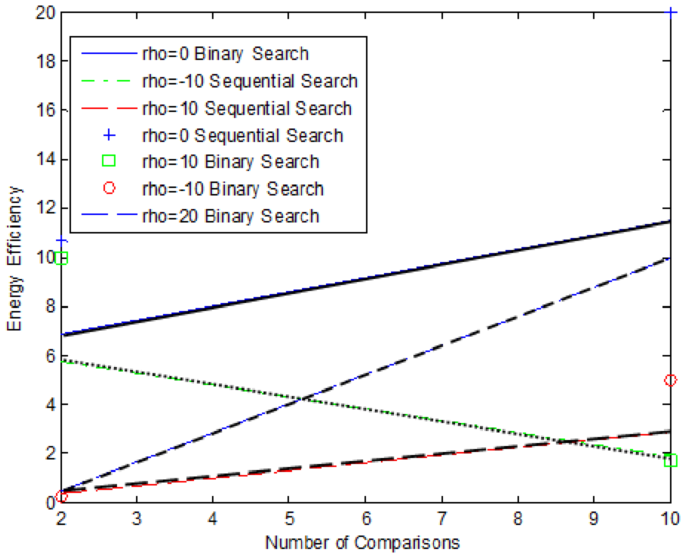

FIG 2 ENERGY EFFICIENCY VS NO OF COMPARISONS AT L=2

From the 10 antennas at the transmitter side, only 2 best antennas are selected. In Figure [2], both selection algorithms BSA and SSA are compared for selected L antennas in terms of energy efficiency and no of loop comparisons. From [2], we select different number of antennas to boost up the energy efficiency. SSA outperforms BSA in some cases and vice-versa. But SSA is more sensitive to no of ideal antennas selected.

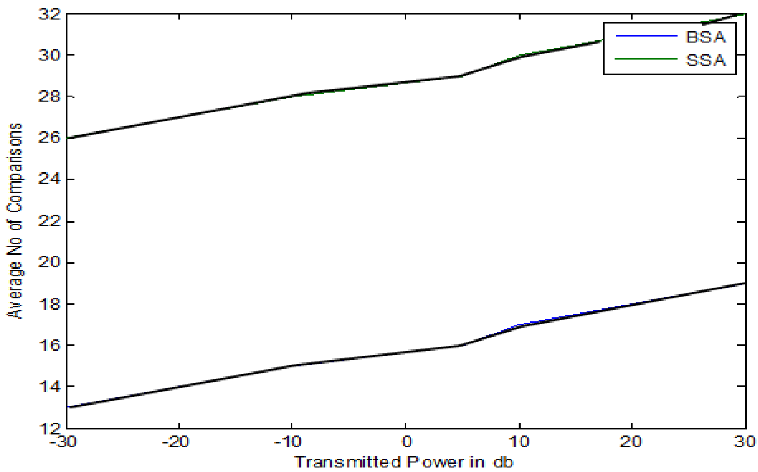

FIG 3. AVG NO OF COMPARISONS VS TRANSMIT POWER FOR L=2 ANTENNAS

The figure [3] shows the relationship between the average no of comparisons and transmitted power for fixed R_{ch} chains in ideal selected antennas

From the figure [3], we can observe that SSA takes more no of loop comparisons to determine the ideal antennas than BSA. the complexity of SSA is proportional to the ideal number of selected antennas. Such complexities of SSA are intolerable by large arrays. Hence BSA is the most preferred algorithm.

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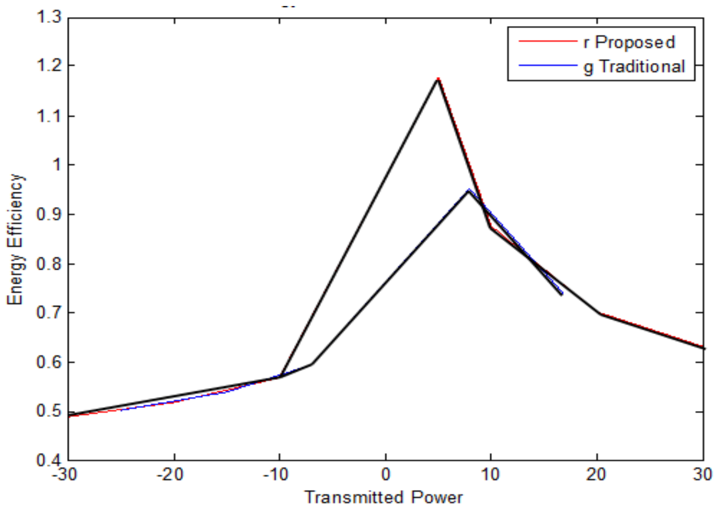

FIG 4 ENERGY EFFICIENCY Vs TRANSMIT POWER

From the figure [4], we can observe the energy efficiency of proposed system using only optimal no of antennas (L=2) is better than the traditional system using all the available no of transmitter antennas. The overlap of both systems is because; at certain transmit power all RF chain must be used to attain maximum energy efficiency.

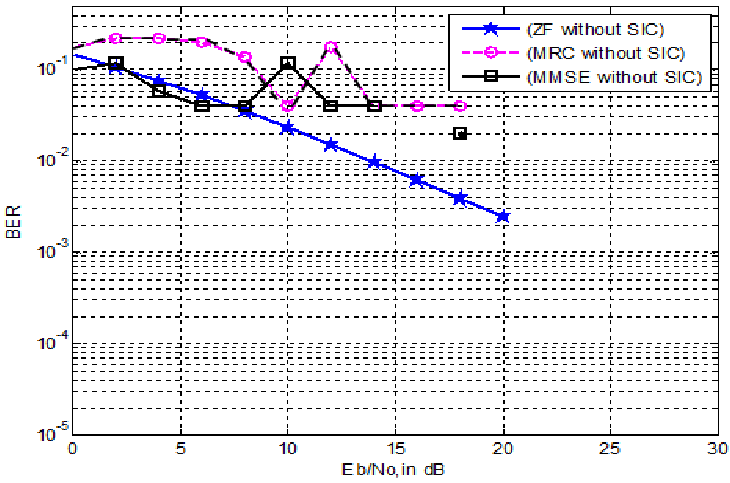

Fig 5 BER Vs SNR without SIC FOR L=2 SELECTED ANTENNAS

From fig [5], different detection techniques' BER performance is plotted in Rayleigh channel at receiver side for QPSK modulated optimal no of selected antennas L=2 at the transmitter. As perfect CSI is considered, Zero forcing has better BER performance than typical MMSE, MRC detectors.

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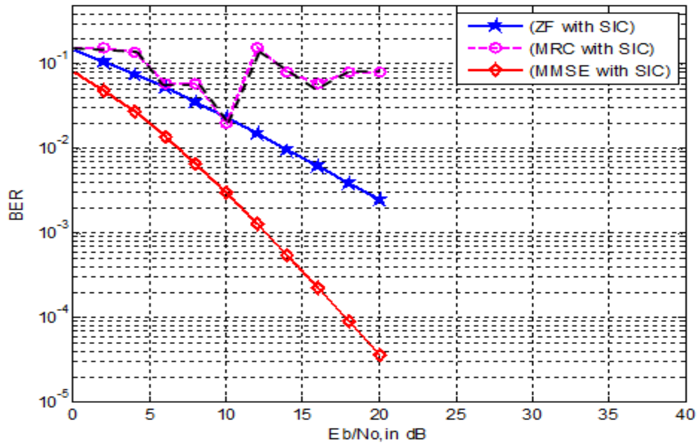

FIG 6 BER VS SNR WITH SIC FOR L=2 SELECTED ANTENNAS

From figure [6], we can perceive that conventional MMSE combined with successive interference cancellation has better BER performance than other detectors (ZF, MRC) using successive interference cancellation (MMSE-SIC). From the fig [5] and fig [6] ,we can examine that MMSE-SIC reduces error rate of MRC, MMSE and ZF by 25%,16% and 40% respectively and ZF-SIC and MRC-SIC by 40% at a constant SNR of 10 db.

V.CONCLUSION

By using Transmit Antenna Selection, an energy efficient large scale antenna system has been developed. In extension to that, BER was determined using MMSE-SIC detection. From the simulation results, we can observe MMSE-SIC outperforms than MRC-SIC and ZF-SIC by 40% and MRC, MMSE and ZF by 25%, 16% and 40% respectively. Hence we can conclude that antenna selection and MMSE-SIC detection can be a good choice to constitute energy efficient and more reliable MIMO system.

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