Review on MIMO System using Transmit Diversity and Relay Selection Algorithm

Sanjeevani Jenekar[1], M. K. Demde[2]

[1]Department of ETC, PCE,
Nagpur, Maharashtra, India
manujenekar.435@gmail.com

[2]Department of ETC, PCE,
Nagpur, Maharashtra, India
manoj_demde@yahoo.co.in

Abstract: ***MIMO for wireless communication is an antenna based technology where multiple antennas at each end are used to minimize the errors, optimize speed and data integrity also it meant for improvement of the efficiency and reliability of a system. Conventional technology which use single antenna at both source and destination results in problems such as fading, cut-off, intermittent reception. To extend coverage area, data rate, quality of service etc. several systems have been come up with goal of low complexity and having high gain. We present here a comprehensive review of MIMO System Using Transmit Diversity and Relay Selection Algorithm where Transit Diversity technique used to improve the wireless link performance and received signal quality whereas Relay Selection are used for interference suppression. MIMO system enables to increased spectral efficiency and by using MMSE estimator it results in minimization of mean square error.***

Keywords: Minimum mean square errors (MMSE), multiple-input–multiple-output (MIMO), relay selection (RS), transmit diversity (TD), filter

1. Introduction

Explosive growth in the number of user drives the explosive growth in the amount of data consumed per subscriber. To support this growth providing sufficient and pervasive network, adequate spectrum as well as maximum spectrum efficiency [1]. In conventional technology, single antenna use at both source and destination. But due to the multipath effect, electromagnetic field bounces off hills, canyons, buildings. Hence, signal reaching at the receiving antenna multiple times having different angle and cause problem such as fading, cut-off, intermittent reception. It causes a reduction in data rate and increased in number of error. Hence multiple antennas at both ends take advantageous effect. MIMO for wireless communication is an antenna technology in which multiple antennas at each terminal. The multiple antenna at each end is use to minimize the errors and optimize speed and data integrity. MIMO system enables to increased spectral efficiency for a given total transmit power. Multiple antennas at the both end of the system called multiple inputs and multiple outputs. Basically use to improve the efficiency and reliability of a system as compared to single input and single output system [2], [3]. In conventional method require to provide larger bandwidth and having introduced with higher modulation types. MIMO technique having multiple numbers of antennas at both transmitter and receiver to improve the communication performance and higher data rate [4]. Diversity technique used to improve the wireless link performance and received signal quality. There are various types of diversity such as time diversity, frequency diversity, space diversity, angle diversity, path diversity, polarisation diversity, transmits diversity. Referring to the Fig 1 of MIMO system having m transmit antenna and n receive antenna. At the receiver side, every antenna receives the direct component intended for it as well as indirect component intended for the other antennas.

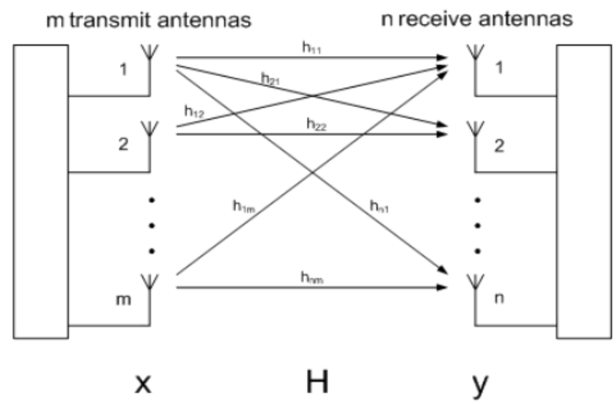


Figure 1. MIMO system

Referring to the Fig 1 the H matrix below is represented as follows, a direct component from antenna 1 to 1 is specified with h_{11} and indirect connection from 1 to 3 is cross component h_{31}. The transmission matrix H with dimension n*m. The following transmission formula y = Hx + n where y is receive vector, x is transmit vector and x is transmit vector and n is noise

$$H = \begin{bmatrix} h_{11} & h_{12} & h_{..} & h_{1m} \\ h_{21} & h_{22} & h_{..} & h_{2m} \\ h_{..} & h_{..} & h_{..} & h_{.m} \\ h_{n1} & h_{n2} & h_{n.} & h_{nm} \end{bmatrix}$$

This paper focuses on use of MIMO system and familiarizing the reader with techniques that are more progressively used in MIMO. To make this paper manageable, we concentrate here on SNR, BER, capacity, interference suppression.

The remainder of the paper is organized as follows. A review of prior approaches on MIMO is presented in Section II to analyze the underlying approaches. This section focuses on use of MIMO systems based on filters, MMSE and relay selection. In Section III, conclusion, scope and future prospects of MIMO are provided.

2. Prior Approaches on MIMO

As the number of user in mobile communication ever increasing, it is the major concern of mobile network. To extend coverage area, data rate, quality of service etc. is a major problem of mobile network. Many project system discuss circumvent the need for exhaustive searching and increases the speed of convergence having low complexity and having high gain. Near-far problem is common in wireless communication systems. MIMO system enable to increased spectral efficiency.

2.1 MIMO using filter

Johnson and Zulch *et al.* develop a system used for array processing using the concept of reduced rank linear filtering giving the accurate estimation of small amount data [5], [6]. Reduced rank filtering uses equalisation technique which is mainly use for the purpose of interference suppression [7]. Basically in this purpose system they use code-division multiple access technique. Michael L. Honig *et al.* develop a system for the suppression of interference using multistage wiener filter (MSWF) [8]. The access technique is direct sequence CDMA and MSWF. The system is applicable for small observed data, error rate is low due to which use for radar application problem with the MWF approach. It is less complex than the full-rank solution, but implementation result produced considerable computational burden and numerical problems. Result plot between the error rate and the number of dimension for reduced rank with 200 symbols. Compare the Eigen decomposition of MSWF, CS, and PC with GSC structure matched filter and also compare the three partial de-spreading methods compare with adaptive MSWF.

To minimize that computation burden Rodrigo C. de Lamare *et al.* uses finite impulse response filter with DS-CDMA system MMSE and Constrained minimum-variance (CMV) [9]. Basically used to reduce the complexity of the system, steady state performance, and minimum bit error rate provided result is flexible for low complexity and having high performance. In these consider an interpolated finite impulse response (IFIR) for the reduced rank interference suppression having simplicity, flexibility, low complexity and is favorable for wiener filter. Complexity parameter compare on the basis of arithmetic operation versus the number of received sample for both supervised and blind recursive algorithm. Graph shows the representation of BER performance of trained RLS algorithm versus $Eb/N0$ and BER performance verses number of users. Also SINR performance on the basis of number of received symbol.

2.2 MIMO Using MMSE Technique

Mean squared error of an estimator is the difference between values implied by an estimator and the true values of the quantity being estimated. MMSE estimator is the approach which minimizes the mean square error. Nadia Khaled *et al.* consider joint transmit and receive optimization, Rayleigh flat-fading MIMO channels, spatial multiplexing (ref. Fig 2) and considering assumption that channel is slowly varying [10]. The mode selection is one of the parameter in the system in which total average power and rate is fixed. The computational result of system considering spectral efficiency is 18 bits/sec/Hz required SNR gain of 2.1db and observed BER is 10^{-3}. It increases BER performance with minimizing SNR using minimum mean square error technique. This system provides less complexity and also compares joint MMSE with the different number of stream on the basis of BER performance and rate for mode selection.

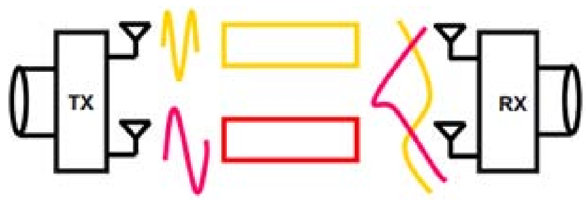


Figure 2. Spatial Multiplexing

R. Lamare *et al.* uses minimum Mean Squared Error (MMSE), Decision Feedback (DF) receivers, Direct Sequence-Code Division Multiple Access (DS-CDMA) systems, convolution code, turbo detector and MMSE using shadow area constraints (SAC) [11]. SAC basically used to reduce the complexity .This is done by avoiding redundant processing taking reliable decisions. It increases the capacity and the performance of system having CDMA but if increase the number of user get increases complexity also get increases. This system having poor performance is for voice services. Same author uses direct sequences code division multiple access technique for decision feedback receiver with convolution code at a encoded system and viterbi and turbo at the decoding system considering the perfect and imperfect feedback considering minimum mean squared error design criteria [12]. System suppressed the multi access interference and increases the capacity and performance of the CDMA system. Outputs is expressed by covariance matrix and from the all possible group of undetected users select the one having smallest mean squared error and having the better performance but the problem is that if the user increases, complexity increases and practical implementation is impractical.

Joung *et al.* develop a system having MIMO, spatial beam forcing ,minimum mean square error, two way relay and power control multiuser, SDMA [13]. There is consideration of two way relay through the two phases that is first phase is receive phase and second is transmit phase. Zero forcing system considering local and global power control. System eliminates both co-channel interference and self interference. Angel Lozano *et al.* consider spatial multiplexing and transmit diversity and multipath fading of wireless channel, wideband channelization, time and frequency domain scheduling for low-velocity user, powerful channel codes, link adaptation and specifically rate control via variable modulation and coding, automatic repeat request [14]. Comparison of MMSE-SIC spatial multiplexing with transmits diversity. It also evaluates the transmission behavior and reception technique.

2.3 MIMO using Relay Selection

Source transmitter transmits multiple signals to increase efficiency then at relay node analysed all signal using DF and AF protocol. From relay node transmit signal further to the receiver. Amplify and forward (AF) in which first amplify the received signal from the source node and forward it to the destination station. Decode and forward (DF) in which first decode the received signal from the source node and forward it to the destination station. RS improves the performance of conventional TDS referring Fig 3 as shown below.

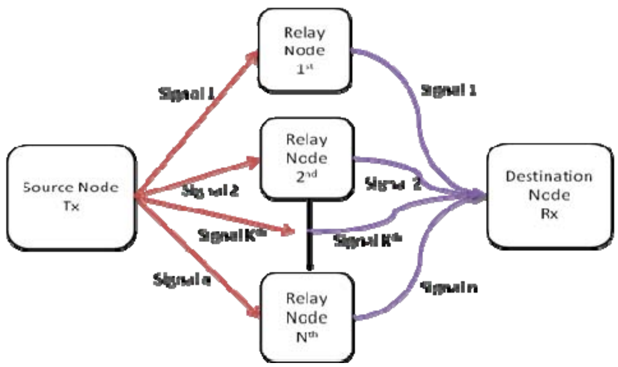


Figure 3. MIMO using relay selection

Yi zhao *et al.* design system using wireless cooperative networks, relay selection using amplify and forward protocol [14]. Selection AF (S-AF) is use especially when the number of relay nodes is in more number. The selection of algorithm is basically implemented at the destination end. Using relay gain of the system increases having low SNR. Orthogonal transmission of signal basically uses time or frequency division technique. The modulation technique use in these is 4-QAM. The Computational result of design is when number of relay is 10 then gain is 3.32db. Zheng Fang *et al.* consider a non-regenerative MIMO relay system with relay selection. The destination, source, relay are all having multiple antennas [15]. The relay does not decode the packets but performs a multidimensional amplify-and-forward function. The relay transmits and receives in two orthogonal channels (i.e. half duplex). System compare the naïve scheme with the PDF, PDF of capacity gain of the relay, PDF of capacity gain of the joint scheme, PDF of gain of the joint scheme over the relay only Computational result of above system is the capacity gain optimize when the SNR at the relay is low.

Yijia Fan *et al.* develop MIMO system of forward channel state information relay, spatial multiplexing, and selection diversity algorithm [3]. The source and destination are having large number of antenna. Channel state information at the relay. The distance between source and relay is 0.5 and relay to destination is 0.5. There is consideration of three type of relay i.e. analogue Relaying, digital relaying, hybrid relaying. Increasing the number of antenna at the relay increases efficiency of the system. Channel state information increases the network capacity. SNR value at the receiver is low. S. W. Peters *et al.* develop system having Antenna selection, diversity methods of MIMO systems [16]. Relay channel is half duplex and have an ability to decode the source code. Suboptimal form of beam forcing is used for beam selection. The bit error rate at both source and relay is calculated by optimal antenna selection. The achieve diversity and small SNR compare with the Grassmannian codebooks. Extended in [17] develop a system for limited feedback results achieving full diversity of the non regenerative MIMO relay channel using practical approaches for it. To develop practical strategies for the development of MIMO relay considering infinite SNR and half duplex relay channel having diversity multiplexing. It results in giving the output optimal in compress and forward relay channel. In both [18] and [19] considered spatial multiplexing, non-regenerating linear relay for mutual information giving the result that high SNR. Beam forcing requires greater feedback than the antenna selection.

Torabi *et al.* develop a system in which consideration of a source and destination pair having equal number of antenna and apply zero forcing algorithms at the source and destination [20]. To recover the data multi-user beam-forming technique is use. Relay selection on the basis of semi-orthogonality selection criteria. It results in decrease the amount of feedback and having less complexity, consume less power but decrease the distributed array gain. Zhang *et al.* uses Multiple feedback successive interference cancellation (MF-SIC) strategy and achieves high detection diversity and also The MB(multi branch) processing is incorporated into the MF-SIC to achieve a higher detection diversity order and to yield a close to optimal performance and point to point channel [21]. An iterative detection and decoding (IDD) receiver is introduced to approach the MAI (multiple access interference) free performance in coded systems. The system decreases SNR but complexity get increased. S. Chen *et al.* uses flat Rayleigh fading channel where source and destination communicate with each other with a single antenna [22]. Consider cumulative distribution function (CDF) and probability density function (PDF) to calculate overall SNR, on that basis calculate symbol error rate (SER). The antenna selection at the receiver provides a good performance and having low cost and complexity. R. C. Lamare et al. uses CDMA interference technique based on time varying algorithm [23]. Consider the modified version of set-membership normalised mean square, affine projection technique estimate dependency, and inter-symbol interference which is used for direct sequence CDMA. It results in decreases the overall complexity of the system and increases the significant convergence and tracking performance. P. Clarke *et al.* use MIMO system having multi-relay but there is no direct connection between transmitter and receiver [24]. At the transmitter, consideration of transmit diversity selection algorithms. For that purpose uses discrete stochastic optimization algorithm evaluate bit error rate and complexity comparison. It exceeds the performance of systems which lack transmits diversity selection. Destination node does not have any knowledge about the forward channel. It is complex and having maximum SNR and BER performance. For that purpose require additional feedback. Basically system is used for mobile applications. Peng Li et. al. consider a low-complexity multiple feedback Successive interference cancellation (MF-SIC) strategy for the uplink and MF-SIC algorithm with shadow area constraints (SAC), multiuser multiple-input multiple-output (MU-MIMO) systems[25]. The complexity of MF-SIC require little additional complexity than conventional SIC result in developed interference suppression by introducing multiple constellation points. The multi-branch processing scheme enhanced the performance of the MF proceeding.

Amarasuriya *et al.* uses MIMO system relay network having channelled assisted amplify and forward to avoid Rayleigh fading [26]. With the use of moment generating function to give efficient and accurate closed form and it also evaluation of outage probability. These systems calculate average SER accurately. Using transmit antenna selection in MIMO AF relaying giving significant performance gains can be achieved. In (L. Cao)[27], MIMO having dual hop amplify and forward co-operative relay network is provided with Transmit antenna selection using full diversity technique, but the computational result of TAS strategy having high complexity. The uses of two suboptimal TAS result in low complexity using Monte-Carlo simulation (L. Cao)[27]. MIMO having dual hop amplify and forward relay which analyse source to destination pair and single antenna relay (Muller)[28] and [29]. TAS and MRC analysed source-to-relay and relay-to-destination transmission, in (Muller) [28] consideration three strategies and having decode-and-forward relay. Gayan *et al.* consider channel assisted amplify and forward network of MIMO, three TAS strategies where one is optimal and two is sub-optimal TAS strategy [29]. Consider Nakagami-m fading where m is an integer. It is use to derive cumulative distribution function and moment generating function. Diversity order and array gain are the design parameter. The direct path from transmitter to receiver is ignored. The performance of channel state information on the TAS is studied. Using the feedback delays, the reduction of diversity order and array gain. Monte Carlo simulation analyse the system performance and accuracy.

Zeng *et al.* consider multi relay network. The transmitter transmit signal to relay node in the first slot and then at the relay using decode and forward algorithm send the signal to the destination in the second slot, also consideration of multipath fading [30]. Channel state information is available at the receiver but not at the transmitter, using transmit antenna selection algorithm maximise the network capacity. At the relay node sorted list of antenna is generated with decrease number of source to relay capacities and maximise relay to destination capacities. Both the network capacity and average capacity is achieved and also significant performance gain with low complexity and high power efficiency. Batu Krishna Chalise *et al.* consider co-operative network having selection beam forming [31]. Multiple antenna at the source, destination, two amplify and forward relay. At the source and destination antenna, beam-forcing technique is applied at the transmitting and receiving antenna. Consider channel state information from the source to relay but no channel state information from the relay to destination. Consider asymptotic analysis of partial relay selection which gives better routing the information from source to relay and Rayleigh fading technique. It also derives the overall diversity gain. The partial relay selection does not consider global CSI where as antenna configuration is used. In antenna configuration no need to feedback any CSI from relay to destination to achieve the full diversity.

Erdem *et al.* consider wireless relay interference network and consideration of any number of transmitter, relay, and receivers [32]. In between the transmitter and relay there is a short term power constraints. Using quantised beam-forming network analysed both amplify and forward and decode and forward relay strategies use channel state information to minimize the probability. Decode and forward strategies use to minimize the interference. The system having first-order diversity and also incorporate the second order diversity. Second order diversity concern with transmitting power depends on logarithmic term. Basically system design having special distributed quantizer called localisation. Results analysed AF and DF use quantised network having beam-forming protocol. Haiyang Ding *et al.* consider selection relaying for transmit beam-forming assume variable gain and fixed gain and having two distributed relay selection [33]. These two distributed relay selection consist of distributed link selection and success/fail signalling feedback between terminals. Mobile station having single antenna , base station having multiple antennas and relay station having single antenna half duplex. Distributed link selection is considered either direct link or dual hop relay for each information transmission. Both the fixed gain selection and distributed relay selection compared with optimal scenario, both scheme reduces the channel state information feedback. From these achieve full diversity validated by comprehensive Monte Carlo simulation.

3. Conclusion & Future Prospects of MIMO

This paper presents a comprehensive review on MIMO which is an antenna based technology where multiple antennas at each end are used to minimize the errors, optimize speed and data integrity also it meant for improvement of the efficiency and reliability of a system. Several approaches of MIMO using filter and relay selection mechanism results in interference suppression. The use of MMSE results in capacity and performance improvement and also it minimize the mean square error. Co-operative MIMO have received significant attention due to low power, spatial diversity gain, robustness and high capacity and having desirable characteristic suited for future network application for increased data rate, quality of service, extended coverage

3.1 Multi Antenna Schemes

- The main possible multiantenna techniques:
  - – Adaptive antennas and beamforming
    - space–division multiple–access
  - – Spatial diversity
  - – Spatial multiplexing
- MIMO
- Potential for significant information theoretic capacity increase.

Scope: Cellular System Evolution

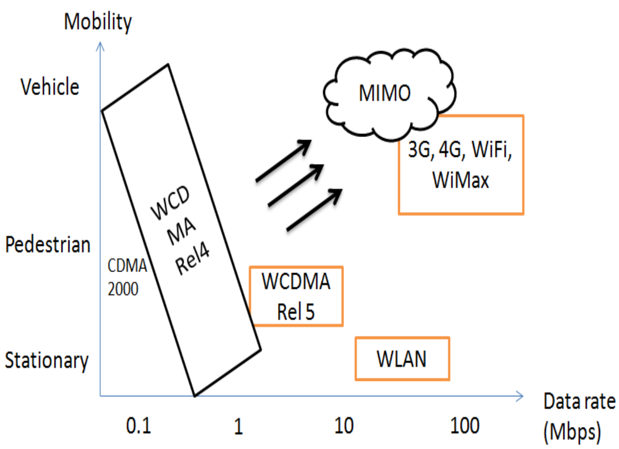


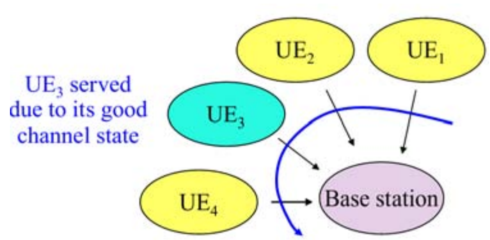
Figure 4. Cellular System Evolution

3.2 High-Speed Packet Access with MIMO:

- Receiver feeds back the channel state information
- Adaptive modulation & coding schemes (MSC)
  -adaptive radio link using feedback information
- Hybrid ARQ --> operating point at 10%-50% BLER
- Packet scheduler has a crucial role --> system level evaluation
  – Multi-user diversity
  – Intelligent transmit power management
  – Multi-codes
- No soft handover probably applied (cell selection)
- HSDPA with MIMO scheduled for WCDMA rel. 6: Target 10-20 Mbit/s
- HSUPA with MIMO still uncertain

3.3 MIMO Prospects:

- MIMO has prospect in high data rate packet access
  – Scheduler ensures good channel
  – Multi-user diversity (fat pipe) gives trunking gain
  – Receive diversity is efficient
  – Due to HARQ operating point at 10% -50% BLER
  – UEs with highest data rates close to BTS (high G-value)
- Improved system level throughput possible!



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