A New Rapid Broadcast Antenna Selection Algorithm for MIMO System

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Abstract— Orthogonal frequency division multiplexing (OFDM) and multiple-input multi-output (MIMO) are key techniques for high speed wireless communication. The problem of transmit antenna selection for massive multiple-input multiple-output systems by maximizing the determinant modulus of the selected channel matrix. Based on the maximum-volume sub matrix finding method, it proposes a new rapid broadcast antenna selection algorithm with low memory cost and low computational complexity. The convergence of the proposed algorithm is proved and the performance of it is evaluated via numerical simulations. It compared to the real-time antenna-by-antenna iterative swapping enhancement (RAISE) transmit antenna selection algorithm, A new rapid broadcast antenna can achieve near optimal capacity performance while the computational complexity and the memory cost are significantly reduced. By introducing pilot check system in the same antenna selection RAISE methodology an improved selection system can be achieved for minimum BER w.r.t minimum SNR.

Index Terms—Electronic Communication System (ECS), Orthogonal Frequency Division Multiplexing (OFDM), Multiple-Input Multi-Output (MIMO), Pilot, Matlab.

1 Introduction

Electronics communication system has revolutionized the face of the world. Communication with someone a mere century back was only possible by physical mode. But now that can be done just by clicking a switch on the telephone pad or by just a click of the mouse. Even live television report, live games telecast could not be possible without wireless communication.

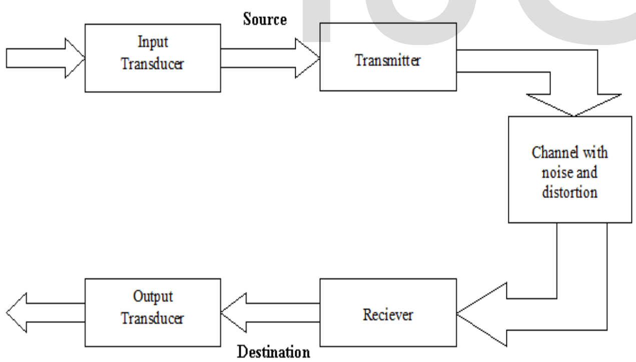

Figure 1: Electronic Communication System.

A simple communication system consists of a transmitter end which sends the data and a receiver end at which the data is received [2]. Usually there received data is not the same as the data sent. Because of the noise present in the medium the signal gets affected and distortion is observed in the signal. Various modulation techniques are under taken in order to ensure that the signal sent is safely available at the receiver end.

2 MIMO OFDM

MIMO-OFDM is a late wireless or remote innovation and is considered in number of creating remote guidelines. Data transmitted through a correspondence channel dependably experiences variables creating different disabilities, subsequently mistakes get incited. Current advanced transmission frameworks handle huge measure of information and such impedances can bring about undetected and uncorrected mistakes subsequently corrupting frameworks BER execution. To experience the same, mistake control codes are utilized in the framework involving recognition and revision of blunders. Grouped exploration difficulties and configuration parameters of the MIMO-OFDM system or framework have been tended to and investigated by numerous. MATLAB reenactment programming has been generally used to break down framework's BER execution by fusing highlights given by the stage. MIMO stands for Multiple Input and Multiple Output that means we use multiple antennas at the transmitter and receiver, by doing so we are increasing the channel capacity as we can accommodate more number of subscribers in wireless communication system [3].

Figure 2: MIMO.

If increase the number of antenna we are increasing the degree of freedom of channel, improving its performance or flexibility and even the gain also improves. The price for MIMO is more because of the hardware used, its complexity and energy consumption for signal processing at both ends. In a point-to-point communication complexity at the receiver is more important but in multiuser communication the complexity at the transmitter along with the receiver is also important because advances coding schemes are used for transmitting data simultaneously to more than one user and maintaining the interference. One more challenge to MIMO system is that we

ISSN 2229-5518

require physical space to accommodate the antennas including the rent. There are four basic types of MIMO system based on the number of transmitter and receiver antennas used.

2.1 MIMO-SISO (Single Input Single Output)

The advantage of SISO system is that it is simple and requires less processing. But it is limited in performance due to interference and fading [9].

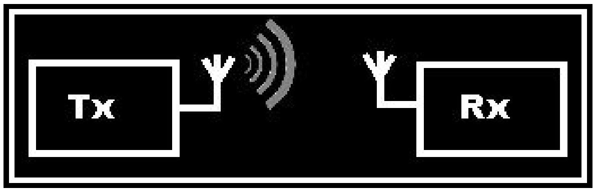

Figure 3: SISO.

2.2 MIMO-SIMO (Single Input Multiple Output)

This system is relatively easy to implement, but as there is multiple antennas at the receiver we require some processing at the receiver [9].

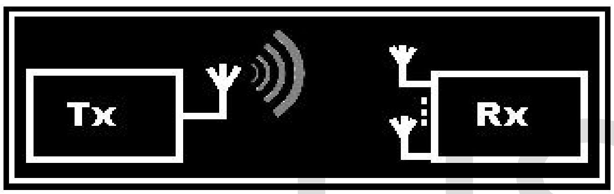

Figure 4: SIMO.

2.3 MIMO-MISO (Single Input Multiple Output)

The advantage here is that the processing is at the transmitter than at the receiver. The receiver can be handheld device with limited power as the processing is reduced the life time of battery is improved [9].

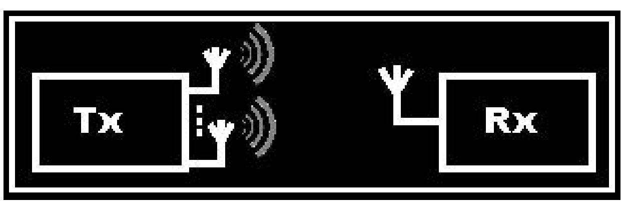

Figure 5: MISO.

2.4 MIMO (Multiple Input Multiple Output)

As we have multiple antennas at the receiver and transmitter we have processing at both the ends but we are increasing the number of user, the data rate is increased and good quality of service [9].

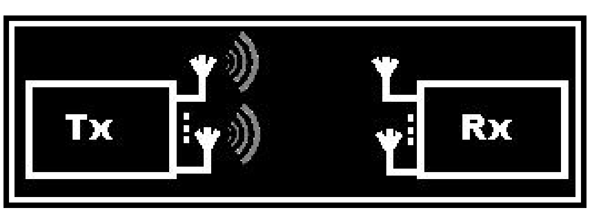

Figure 6: MIMO.

In Massive MIMO or larger MIMO there are going to be more than 100 antennas. But not all the antennas will work at the same time; a limited number of antennas will be operating at a time because of limitation to acquire channel state information. Massive MIMO technology can be made possible by combining the conventional TDMA, FDMA and OFDM multiplexing technology. Future prediction is that the Massive MIMO technology will use very low power in the order of milliwatts. The major challenges are multiuser multiplexing gains, error in channel state information and interference. The power consumption at the base stations is a growing concern. Massive MIMO system will be designed in such a way that it will be robust to the failure of the antenna [1].

3 Single User MIMO System

Multiple-Input Multiple-Output (MIMO) wireless systems are known to provide remarkable benefits in scenarios with rich scattering as the multi-path fading is exploited in a beneficial way. More specifically, the key concept is that MIMO systems take advantage of multi-path fading to send several streams in parallel. Then, the link reliability of the system can be improved by sending replicas of the same symbol or the data-rate can be increased by sending independent symbols in parallel. This section is devoted to provide the reader with some background on MIMO wireless schemes. We first present some of the fundamental limits obtained in the study of MIMO wireless systems from an information theory viewpoint. After that, we describe some practical schemes according to the purpose for which MIMO techniques are considered: spatial diversity or spatial multiplexing. Finally, since the main topic of this thesis is the study of antenna selection techniques from a cross-layer perspective, we conclude this section with a complete overview of algorithms and some classical results related with antenna selection mechanisms.

4 Antenna Selection

In a MIMO system, adding complete Radio Frequency (RF) chains may result in increased complexity, size and cost. These negative effects can be drastically reduced by using antenna selection. This is because antenna elements and digital signal processing is considerably cheaper than introducing complete RF chains. In addition, many of the benefits of MIMO schemes can still be obtained. Besides, perfect CSI is not required at the transmitter as the antenna selection command can be computed at the receiver and reported to the transmitter by means of a low-rate feedback channel. In Figure 7, we show a typical MIMO wireless system with antenna selection capabilities at both transmit and the receive sides. The system is equipped with M transmit and N receive antennas, whereas a lower number of RF chains has been considered (($L_M < M$ and $L_N < N$ at the transmitter and receiver, respectively). In accordance with the selection criterion, the best sub-set of L_M transmit and L_N receive antennas are selected. In order to convey the antenna selection command to the transmitter, a feedback channel is needed but this can be done with a low-rate feedback as only (LL_M^M) bits are required. Originally, antenna selection algorithms were born with the purpose of improving link reliability by exploiting spatial diversity. More precisely, a reduced complexity system with antenna selection can achieve the same diversity order as the system with all antennas in use. However, as MIMO schemes gained popularity, antenna selection algorithms began to be adopted in spatial multiplexing schemes aimed at increasing the system capacity. A brief review of the state of the art is presented below, where different methodologies are classified according to the context: spatial diversity or spatial multiplexing.

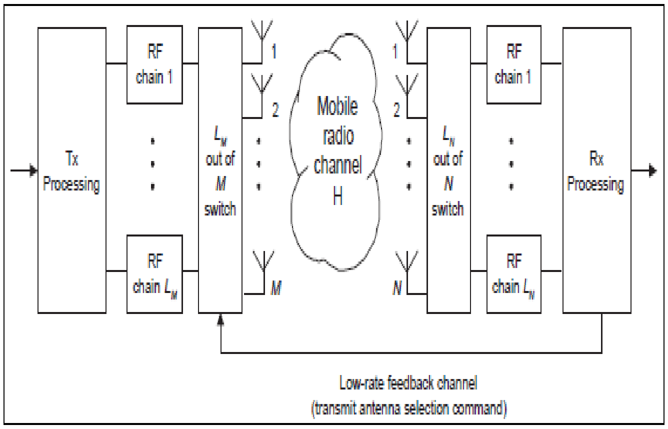

Figure 7: MIMO scheme with Tx/Rx antenna selection.

5 Multi User MIMO System

So far we have discussed the benefits obtained with MIMO systems in a single-user scenario. In multi-user systems, however, multi-antenna capabilities play a different role. Apart from exploiting spatial diversity and multiplexing gains, multi-antenna capabilities can also be exploited to send (receive) information to (from) several users simultaneously. As previously explained, the interests of this thesis are oriented towards the study of broadcast channels. For that reason, in this section we give some insight on the model considered in the downlink of a wireless multi-user system, i.e., the MIMO Gaussian Broadcast Channel. We start the discussion by exploring the fundamental limits and, after that, we present some practical schemes. In particular, we present a scheme known as orthogonal random beamforming which requires a low amount of information in the feedback channel and, due to its applicability in wireless networks, is studied.

6 MIMO Gaussian Broadcast Channel System

Consider the downlink of a wireless system with one Base Station (BS) equipped with M antennas and K Mobile Stations (MS) with N1,...,NK receive antennas, respectively (see Figure 8). The received signal for user k can be modeled as:

$$r_k = H_k s + n_k$$

Where $H_k \in C^{N_k \times M}$ is the channel matrix gain between the BS and the kth MS, $s \in C^{M \times 1}$ is the symbol vector broadcasted from the BS and $n_k \in C^{N_k \times 1}$ stands for an additive Gaussian noise vector of complex, random variables with zero mean and unit variance, $n_k \sim CN(0, I_{Nk})$. For the case that $N_k = M = 1$, this model falls into the category of degraded broadcast channel, which capacity region is widely known for the case with perfect CSI at the transmitter. The average cell throughput can be increased when in each time-slot the user with the best channel conditions is scheduled. However, in the multiple antenna case (i.e., in the MIMO Gaussian Broadcast Channel setup) the problem is more complicated since the channel is in general non-degraded.

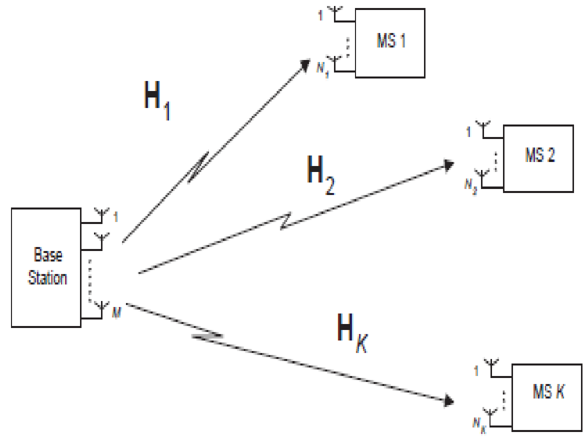

Figure 8: MIMO Broadcast Wireless System.

Roughly speaking, the ordering among users is lost. Indeed, for the general non-degraded broadcast channel the capacity region is still unknown. Fortunately, the capacity region of the MIMO Gaussian Broadcast Channel has been recently solved in where the authors proved that Dirty Paper Coding (DPC) is the capacity-achieving strategy. In order to obtain that result, some previous steps were done, which are briefly overviewed in the next paragraphs. It showed that in a Gaussian scalar channel with Gaussian interference non-causally known at the transmitter, the same capacity can be obtained as that achieved without interference. To do so, Costa proposed a technique called writing on dirty paper (or dirty paper coding) consisting in the exploitation of the interference knowledge at the transmitter when the transmitted signal is constructed. In particular, an interference pre subtraction technique was used to completely remove the interference component. This strategy was considered in order to obtain an achievable region for the MIMO Gaussian Broadcast Channel.

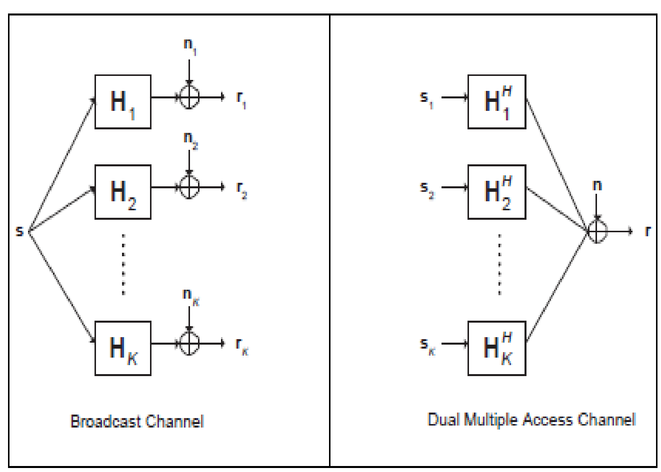

Figure 9: Broadcast and Multiple Access Channels.

ISSN 2229-5518

In particular, the authors obtained a closed-form expression for scenarios with two transmit antennas and two single-antenna receivers. Besides, they proved that the maximum sum-rate achievable with the DPC strategy is in fact the sum-rate capacity of the MIMO Gaussian Broadcast Channel. The extension of that work to an arbitrary number of transmit antennas was derived and the generalization to a scenario with multiple antennas at both the transmit and the receivers. The problem was considerably simplified due to the use of the duality principle between the uplink and downlink channels. This is because the concept of duality for the scalar Gaussian Broadcast Channel facilitates the computation of the DPC achievable region. Figure 9 shows the block diagram of broadcast and multiple access channels.

7 Pilot Based Channel Estimation OFDM System

OFDM signals can be demodulated either coherently or differentially coherent manners. The most important advantage of differential demodulation is not requiring channel information, and the receiver is relatively simple. However, compared with coherent demodulation, system performance will be degraded from 3 to 4 dB [11]. Moreover, differential demodulation cannot be applied in multi-level modulation. So coherent demodulation is preferred to achieve higher data rates, spectrum efficiency and good performance. Since coherent demodulation depends on the change of phase and amplitude of carrier signal, an accurate estimation of the channel is needed [12]. In OFDM systems, it is very important to know how to get the best channel estimation.

OFDM system channel estimation method can be divided into two ways, pilot-based channel estimation and blind channel estimation. The pilot channel estimation methods are based on the pilot channel and pilot symbol. However, due to two-dimensional time-frequency structure of OFDM system, pilot symbol assisted modulation (PSAM) is more flexible [14]. PSAM is the method doing channel estimation by using pilot sequence and symbol, which are inserted into some fixed positions of signals sent by transmitter. The pilot symbol sent by transmitter makes spectral efficiency and power utilization lower with the trade-off of quick response to the channel variation. Blind channel estimation is focusing on the correlation between the data sent and received, without knowing the information of the transmitted data. Although it yields higher spectral and power efficiencies by using blind channel estimation, it needs more data to analyze. Hence it is suitable for slow varying channel [19]. This thesis is concentrated on PSAM. For pilot based channel estimation of OFDM system, following three are required. Firstly, suitable pilot pattern needs to be considered. Secondly, pilot-based channel estimation algorithm with low complexity should be identified. Thirdly, proper demodulation method toward effective channel estimation has to be developed.

8 Simulated Results

In this section, the proposed algorithm is evaluated via computer simulation using MATLAB simulator. All simulation results are obtained with a random start and no antenna ordering techniques are used. The parameter of the algorithm in [7] is set to be K = N_r in this paper (K should be larger than N_r in [7]).Figure 10 show the order of memory requirement for transmit antenna selection versus the number of receive antennas (N_r) when the number of transmit antennas is fixed at (N_T = 200).

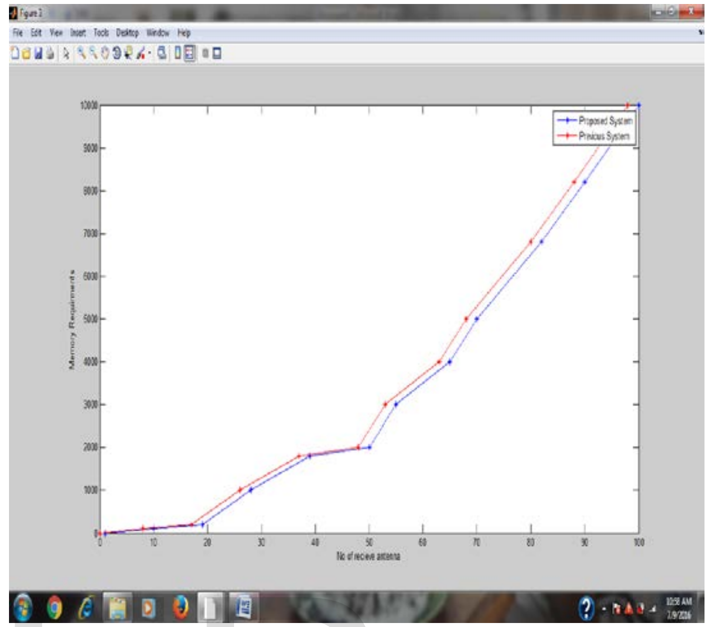

Figure 10: Comparative Analysis on basis of receiver antenna versus memory requirements.

Figure 11 show the comparative analysis of proposed system with previous system on the basis of cumulative distribution function versus capacity.

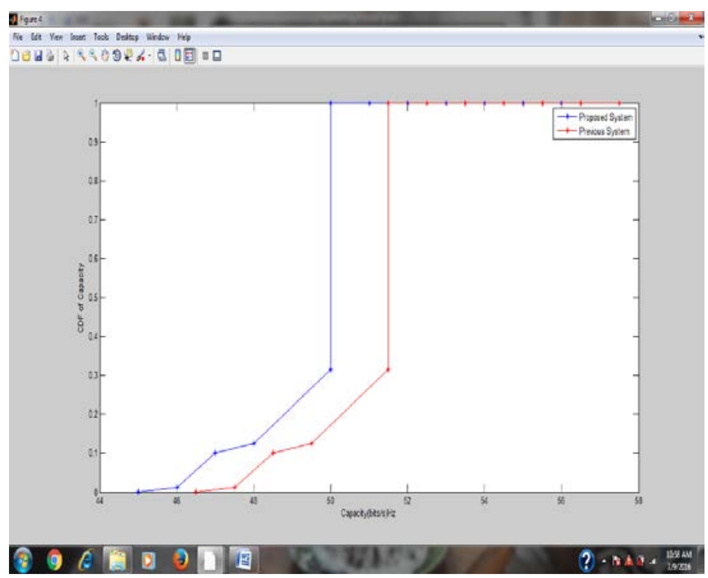

Figure 11: Comparative Analysis on the basis of CDF versus capacity.

Figure 12 show the comparative analysis of proposed system with previous system on the basis of Ergodic Capacities versus SNR.

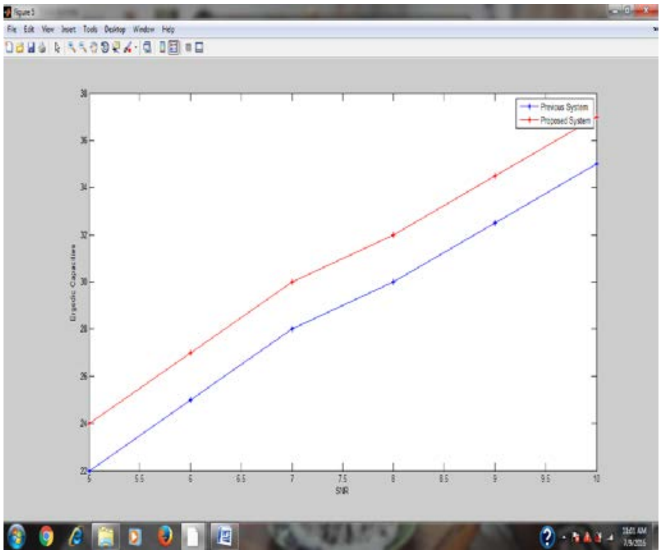

Figure 12: Comparative Analysis on the basis of Ergodic Capacities versus SNR.

7 Conclusion

Multicasting routing or efficient utilization of channel, an adaptive method is proposed for best antenna selection. An antenna selection algorithms have been further enhanced by allowing adaptive modulation schemes to be included in the optimization procedure. With the proposed cross-layer design, the integration of an adaptive modulation scheme with the antenna selection strategy comes in a very natural way, since both concepts are directly taken into account in the throughput expression. The proposed new rapid broadcast antenna selection algorithm is proved and the performance of it is evaluated via numerical simulations. It compared to the real-time antenna-by-antenna iterative swapping enhancement (RAISE) transmit antenna selection algorithm. By introducing pilot based adaptation system in the same antenna selection RAISE methodology an improved selection system can be achieved for minimum BER w.r.t minimum SNR. For further extent of this work, instead of RAISE algorithm a new artificial intelligence can be utilized for better selection of the antenna.

References

[1] Vahid Tarokh, Hamid Jafarkhani, A. Robert Calder bank, "Space–Time Block Coding for Wireless Communications: Performance Results", Published in IEEE Journal on Selected Areas in Communications, Volume 17, Issue 3, PP 451 – 460, March 1999.

[2] M.-S. Alouini, and A.J. Goldsmith, "Capacity of Rayleigh Fading Channels under Different Adaptive Transmission and Diversity-Combining Techniques", IEEE Transaction on Vehicular Technology, vol. 48, no. 4, pp. 1165–1181, July 1999.

[3] D. Gore, R. Nabar, and A. Paulraj, "Selecting an optimal set of transmit antennas in wireless systems", in Proc. ICASSP, 2000.

[4] S. Cautreaux, P.F. Driessen, and L.J. Greensteins, "Data throughputs using multiple-input multiple-output (MIMO) techniques in a noise-limited cellular environment", IEEE Trans. on Wireless Communications, vol. 1, no. 2, pp. 226–234, April 2002.

[5] D. A. Gore, and A. J. Paulraj, "MIMO antenna subset selection with space-time coding", IEEE Trans. on Signal Processing, Oct. 2002.

[6] D.A. Gore, R.W. Heath Jr., and A.J. Paulraj, "Transmit selection in spatial multiplexing systems", IEEE Communications Letters, Nov. 2002.

[7] Gorokhov, "Antenna selection algorithms for MEA transmission systems", in Processing ICASSP, vol. 3, pp. 2857–2860, May 2002.

[8] L. Zheng, and D. Tse, "Diversity and multiplexing: a fundamental trade-off in multiple antenna channels", IEEE Trans. on Inform. Theory, May 2003.

[9] X. N. Zeng, and A. Ghrayeb, "Performance bounds for space-time block codes with receive antenna selection", IEEE Transactions on Information Theory, vol. 50, no. 9, pp. 2130–2137, Sept. 2004.

[10] S. Zhou, and G. B. Giannakis, "MIMO Communications with Partial Channel State Information", A. B. Gershman, N. D. Sidiropoulos (eds.), Space-Time Processing for MIMO Communications (to appear), John Wiley & Sons, 2005.

[11] Zagami, "Beamforming and bit-loading strategies for multi-user MIMO systems", Master Thesis, Universitat Politecnica de Catalunya and Politecnico di Torino, June 2006.

[12] Bolcskei Helmut, "MIMO-OFDM wireless systems: basics, perspectives, and challenges," Published in Wireless Communications, IEEE Journal on Selected Areas in Communications, Volume 13, Issue 4, pp. 31-37, 2006.

[13] G. Caire, S. Shamai, Y. Steinberg, and H. Weingarten, "On information-theoretic aspects of MIMO broadcast channels", H. Boelcskei, D. Gesbert, C. Papadias, A. J. van der Veen (eds.), Space-Time Wireless Systems: From Array Processing to MIMO Communications, Cambridge University Press, 2006.

[14] Wang, B. H., Hui, H. T., & Leong, M. S. (2010). Global and fast receiver antenna selection for MIMO systems. IEEE Transactions on Communications, 58(9), 2505–2510.

[15] Dong, K., Prasad, N., Wang, X., & Zhu, S. (2011). Adaptive antenna selection and Tx/Rx beamforming for large-scale MIMO systems in 60 GHz channels. EURASIP Journal on Wireless Communications and Networking, 2011(1), 1–14.

[16] S. P. Premnath, J. R. Jenifer, C. Arunachalaperumal," Performance enhancement of MIMO systems using antenna selection algorithm", International Journal of Emerging Technology and Advanced Engineering, Jan 2013.

[17] Bing Fang, ZupingQian, Wei Shao, Wei Zhong, "RAISE: A New Fast Transmit Antenna SelectionAlgorithm for Massive MIMO Systems", Springer Science+Business,Media New York, 2014.

[18] P.Sunil Kumar and M.G.Sumithra, "Performance Analysis for Differential STBC and SFBC MIMO- OFDM Systems Under Different Modulation Schemes in a Rayleigh Channel," IEEE International Conference on Electronics and Communication System (ICECS), pp. 1 – 5, Feb. 2014.

[19] Kavita.Trivedi and Anshu Khare, "BER Performance of OFDM with Discrete Wavelet Transform for Time Dispersive Channel," International Journal of Research in Engineering and Technology (IJRET), volume: 03, pp. 152-155, June 2014.

[20] Sameer A.Dawood, F. Malek and M. S. Anuar, "Comparison the Performance of OFDM System Based on Multiwavelet Transform with Different Modulation Schemes," IEEE International Conference on Computer, Communication, and Control Technology, Langkawi, Kedah, Malaysia pp. 403- 406, September 2014.