ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 4, Issue 1, February 2014

An Extensive Review on Spatial Diversity Techniques in Wireless Communication

Pooja Patil
M. Tech. Scholar
Department of ECE
Sagar Institute of Science and Technology, Bhopal

Prof. Nitin Muchhal
Associate Professor
Department of ECE
Sagar Institute of Science and Technology, Bhopal

Dr. Ravi Shankar Mishra
Head of Department
Department of ECE
Sagar Institute of Science and Technology, Bhopal

***Abstract*-Wireless engineers are usually well-known with the benefits to be gained of using antenna diversity in wireless base stations, though they are implemented as an overlay to the system and not part of the basic standard. Antenna diversity has been used in wireless communication systems for countless years. One of the most general problems faced by design engineers of wireless communication systems is the spatiotemporal changes in the wireless channel which occur mainly due to the fact of multipath fading which is predictable in scattering environments that are subject to changes over time. A ample variety of pre/post processing techniques have been used to moderate the degrading effects of such channels, but with limited improvements in performance. This review provides an assessment of the concept of Spatial Diversity (SD), applied to multi-antenna systems that require modifications at the physical and soft level - the use of multiple antennas at the transmitter and/or the receiver.**

Keywords - Spatial Diversity, MIMO, OFDM, AWGN.

I. INTRODUCTION

The spatial properties of wireless communication channels are more important in determining the performance of the systems. Thus, there has been great interest in the application of beam forming and latest spatial diversity methods (or Multi-antenna systems) since they can offer a wide range of ways to improve performance of wireless systems. For a while, diversity techniques such as multiple-input single-output (MISO), single-input multiple-output (SIMO) and multiple-input multiple-output (MIMO) can increase the capacity, coverage, and quality and energy efficiency of wireless systems [1]. The challenges of wireless communication systems face is reliably conveying information to the receiver in the presence of signal fading. A diversity scheme refers to a method for improving the reliability of a message signal by using two or more communication channels with different characteristics. MIMO has drawn valuable attention of researchers in the field of wireless communication.

Spatial multiplexing is requiring MIMO antenna configuration. In this type of multiplexing a high rate signal is split into two low rate streams, each stream transmitted from different antenna in the same frequency channel. The receiver can divide these streams into parallel channel. It deals with two key requirements for recent wireless systems: - High bit rates and small error rates. Diversity Coding techniques are used when there is no channel information at the transmitter. Multiple-input and multiple-output, or MIMO is the use of multiple antennas at both the transmitter and receiver to improve the performance of communication. There parameters on which performance depends such as SNR, number of transmit and receive antennas, the transmission scheme used, the combining scheme used at receiver, channel model modulation scheme, etc. Spatial multiplexing is a very effective technique for increasing channel capacity at higher signal-to-noise ratios (SNR).

Another recently popular technique to improve the signal to noise ratio of the long range transmission is to use some form of spatial multi antenna diversity system. In this chapter, we employ modern diversity techniques which have gained great interest in the past decade or so. These are: multiple-input single-output (MISO), single-input multiple-output (SIMO) and multiple-input multiple-output (MIMO) antenna systems. Multiple transmit and receive antenna systems allow increased data rates and enhanced link reliability of wireless communication systems while reducing the transmission power requirements. In the following analysis of these diversity techniques, we will assume a perfect knowledge of the propagation channel [1].

Multiple Input Multiple Output System:

MIMO refers as multiple input multiple output systems**.** MIMO is the use of multiple antennas at both the transmitter and receiver to improve communication performance.

ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 4, Issue 1, February 2014

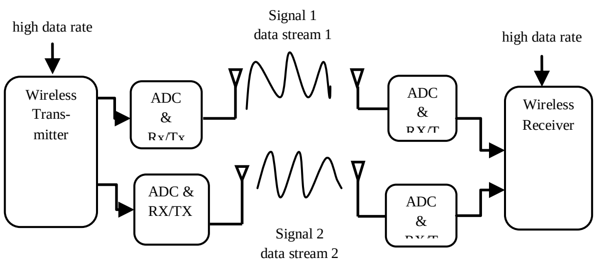

Fig. 1.1 Multiple Input Multiple Output System

MIMO can be separated into three main terms [1]-

(1) Precoding
(2) Spatial multiplexing SM
(3) Diversity coding

Precoding: is multi-stream, beam forming it is considered to be all spatial processing that occurs at the transmitter. The benefits of beam forming are to increase the received signal gain, by making signals emitted from different antennas add up constructively, and to reduce the multipath fading effect.

Spatial Multiplexing(SM): It requires MIMO antenna configuration. In spatial multiplexing, a high rate signal is divided into multiple lower rate streams. Each stream is transmitted from a different transmit antenna in the same frequency channel.

Diversity Coding: can be combined with spatial multiplexing when some information about the channel is available at the transmitter.

II. Spatial Diversity Techniques

A diversity scheme refers to a method for improving the reliability of a message signal by using two or more communication channels with different characteristics.

Diversity plays an important role in combating fading and co-channel Interference and avoiding error bursts[6].

Transmit/Receive diversity uses two separate, collocated antennas for transmit and receive functions. Such a configuration eliminates the need for a duplexer and can protect sensitive receiver components from the high power used in transmit. Different type of combining techniques are used in receive diversity .Spatial Diversity can be achieved with the help of multiple transmit antenna (transmit diversity) or multiple receive antenna (Receive diversity) with sufficient spacing between the antennas. The figure represents a typical multiple input multiple output arrangements.

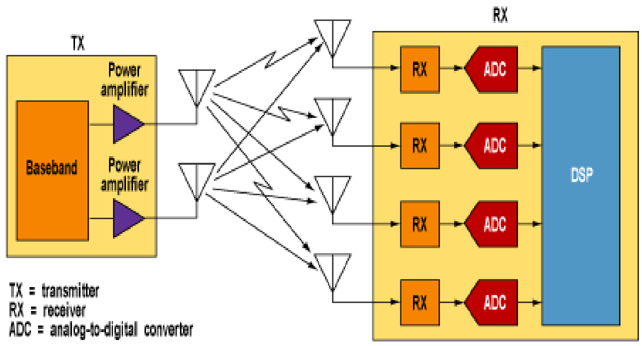

Fig. 3.1 Typical Arrangement of MIMO System

Spatial diversity handling multiple antennas usually with the same characteristics and sufficient spacing from one another. Depending upon the expected incidence of the incoming signal, sometimes a space on the order of a wavelength is sufficient. Other times much larger distances are needed. Sectorization or Cellularization for example, is a spatial diversity scheme that can have antennas or base stations miles apart. This is especially beneficial for the mobile communication industry since it allows multiple users to share a limited communication spectrum and avoid co-channel interference.

Different types of combining techniques are used in receive diversity. Here we are using the maximal ratio combining because MRC is the best combining techniques for combating fading in smart antenna system. In the complexities of implementation are much less.

Methodology: The performance of Spatial Diversity techniques is evaluated through Bit Error Rate (BER) Vs SNR plot under various conditions and parameters. The various parameters used are Number of transmit and receive antenna, modulation technique, Eb/No ratio (energy per bit to noise power spectral density ratio), It is a normalized signal to noise ratio (SNR) measure, also known as the "SNR per bit". Bit error rate, Channel type.

The methodology used for simulation is as follows:

In this process firstly generates data then Modulate the data into symbols. in this Encode the symbols according to the MIMO system. Demultiplex the Encoded data and transmit on different antenna. Then we simulate the Channel and pass the transmitted symbols through it .Add noise as per required Eb/No ratio Process the received symbols according to the MIMO system. Demodulate the symbols and recover the data Compare recovered data with original data to compute BER (Bit Error rate) revise above steps for different Eb/No ratios and plot the graph[7].

ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 4, Issue 1, February 2014

Modulation: Modulation is the process of varying one or more properties of a periodic waveform, called the carrier signal, with a modulating signal which typically contains information to be transmitted. Modulation is the process of conveying a message signal, for example a digital bit stream or an analog audio signal, inside another signal that can be physically transmitted. Modulation of a sine waveform is used to transform a baseband message signal into a pass band signal. The demodulator which is designed specifically for the symbol-set used by the modulator, determines the phase of the received signal and maps it back to the symbol it represents, thus recovering the original data[3]. This requires the receiver to be able to compare the phase of the received signal to a reference signal such a system is termed coherent.

Detection Techniques: we used different detection techniques for the detection, like MMSE (Mini-Mental State Examination), Altamonte coding. MLE (Maximum likelihood).When applied to a data set and given a statistical model, maximum-likelihood estimation provides estimates for the model's parameters.

III. LITERATURE REVIEW

Wireless communication the area of research among maximum researchers which has the attraction of improvements and capabilities to outperform in communication systems, few of them are discussed below.

In 2013 Nikfar, B.; Vinck, A.J.H. [1] proposed research on "Combining techniques performance analysis in spatially correlated MIMO-PLC systems". Which is a brief introduction to MIMO-PLC as well as the special case of SIMO-PLC. This work explained that in MIMO-PLC channels, a spatial correlation is inevitable and channels are not spatially independent. A physical as well as a mathematical description of the spatial correlation in MIMO-PLC is provided. In addition, two receive diversity techniques, Maximum Ratio Combining (MRC) and Equal Gain Combining (EGC) are studied and numerical results were presented.

In 2012 Kamboj, A. Mallik, R.K. Agrawal, M. Schober, R.[2] done analysis on, "Diversity combining in FSO systems in presence of non-Gaussian noise". In recent years Free-space optics (FSO) communication has received much attention as a reliable and free access technique for high data rate applications. The performance of FSO communication, however, severely suffers from turbulence caused by atmospheric conditions. Multiple photo detectors can be placed at the receiver to moderate the turbulence and exploit the advantages of spatial diversity combining. In this work, they analyzed the bit error rate (BER) performance of an FSO communication system employing binary phase-shift keying with additive non-Gaussian noise over negative exponential distributed atmospheric turbulence and spatial diversity at the receiver. The Laplace distribution is used to model the non-Gaussian impulsive noise. We consider the case when perfect channel state information is available at the receiver for implementation of coherent detection.

In 2010 Rafiq, G. Kontorovich, V. Pätzold, M.[3] analyzed "The influence of severity of fading on the statistical properties of the capacity of Nakagami-m channels with MRC and EGC". In this article, authors have studied the statistical properties of the capacity of Nakagami-m channels when spatial diversity combining, such as maximal ratio combining (MRC) and equal gain combining (EGC), was employed at the receiver. The results provide insight into the statistical properties of the channel capacity under a wide range of fading conditions in wireless links using L-branch diversity combining techniques. They have derived closed-form analytical expressions for the probability density function (PDF), cumulative distribution function (CDF), level-crossing rate (LCR), and average duration of fades (ADF) of the channel capacity. It is observed that increasing the number of diversity branches increases the mean channel capacity, while the variance and ADF of the channel capacity decreases.

In 2007 Lioumpas, A.S.; Karagiannidis, G.K.,[4] presented a "Blind Ratio Combining (BRC): An Optimum Diversity Receiver for Coherent Detection With Unknown Fading Amplitudes". Where author presented an optimum diversity receiver called blind ratio combining (BRC) that minimizes the average symbol error probability or maximizes the average output SNR, where the channels' time delays and the random phases are known, while the fading amplitudes are unknown. In contrast to previous works, where efforts were made to find a posteriori probabilities at the receiver, the BRC simply calculates the optimum weights, which depend on the channel's statistics, avoiding continuous channel estimation, and thus, it significantly reduces the system's complexity. In no identical multipath fading channels with power delay profile (PDP), the BRC receiver performs between maximal ratio combining (MRC) and equal gain combining (EGC), and keeps its performance comparable - and in some cases superior - to that of generalized selection combining, while for large values of the decay factor, it approaches MRC.

ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 4, Issue 1, February 2014

Moreover, in the important practical case of exponential PDP - common in RAKE receivers modeling and adopted for the Universal Mobile Telecommunications System spatial channel modeling by the European Telecommunications Standards Institute-3GPP - the optimum weights can be accurately approximated by simple elementary functions.

In 2005 Chira, L. Palade, T. Dumitrean, R. Puschita, E. [5] has worked on "Performance analysis of spatial diversity schemes on an 802.11a PHY platform". The research performed on an 802.11a a PHY platform have proven the necessity of introducing some spatial diversity schemes on the transmission chain. Basic antenna diversity designs - ThC, SDC, MRC and EGC -have been tested. They clearly improve bit rate and packet error rate performance, and EGC provides higher antenna diversity gain then SDC. MRC realizes the highest antenna diversity gain compared to the other techniques.

IV. Conclusion and Future Scope

In this paper we have studied the spatial diversity concepts and previous work done on this methodology in wireless communication systems which was the key area among the communication system researchers. As we have discussed the various equalization techniques used with spatial diversity techniques make system robust and reliable in all aspects of performance. Some other techniques like Equal gain combining(EGC), maximal ratio combining(MRC) and other techniques are advantageous in the Rayleigh fading, and AWGN channels. So our main area of further research is to work on the modulation as well as the hybrid structure of combining techniques. Using space time coding technique make the most of the transmit diversity without need channel state information at the transmitter and also get better the Bit-Error-Rate performance over conventional un-coded single antenna system. And future direction combine space time coding or space diversity with spatial multiplexing and beam forming improve, however, in order to achieve a good overall performance.

References

[1]. Nikfar, B.; Vinck, A.J.H., "Combining techniques performance analysis in spatially correlated MIMO-PLC systems," *Power Line Communications and Its Applications (ISPLC), 2013 17th IEEE International Symposium on*, vol., no., pp.1,6, 24-27 March 2013.

[2]. Kamboj, A.; Mallik, R.K.; Agrawal, M.; Schober, R., "Diversity combining in FSO systems in presence of non-Gaussian noise," *Signal Processing and Communications (SPCOM), 2012 International Conference on* , vol., no., pp.1,5, 22-25 July 2012.

[3]. Rafiq, G.; Kontorovich, V.; Pätzold, M., "The influence of severity of fading on the statistical properties of the capacity of Nakagami-m channels with MRC and EGC," *Wireless Conference (EW), 2010 European* , vol., no., pp.406,410, 12-15 April 2010.

[4]. Lioumpas, A.S.; Karagiannidis, G.K., "Blind Ratio Combining (BRC): An Optimum Diversity Receiver for Coherent Detection With Unknown Fading Amplitudes," *Communications, IEEE Transactions on* , vol.55, no.9, pp.1725,1735, Sept. 2007.

[5]. Chira, L.; Palade, T.; Dumitrean, R.; Puschita, E., "Performance analysis of spatial diversity schemes on an 802.11a PHY platform," *Telecommunications in Modern Satellite, Cable and Broadcasting Services, 2005. 7th International Conference on* , vol.1, no., pp.101,104 vol. 1, 28-30 Sept. 2005.

[6]. Mr. Jitender Singh, Mrs.Vineeta Khare, "Analysis of Spatial Diversity in MIMO". International Journal of Scientific Engineering and Technology (ISSN : 2277-1581), Volume No.1, Issue No.3, July 2012, pg : 153-156.

[7]. A. J. Paulraj, D. A. Gore, R. U. Nabar, and H Bölcskei "An overview of MIMO Communication-A Key to Gigabit Wireless", Proceedings of the IEEE, Vol. 92, No. 2, PP.198-218(Feb. 2004

[8]. M. Jankiraman, Space time Codes and MIMO systems, published by Artech House, 2004

[9]. L. Zheng and D. Tse, "Diversity and multiplexing: a fundamental tradeoff in multiple antenna channels," *IEEE Trans. Inf. Theory*, vol. 49, pp. 1073–1096, May 2003

[10]. G. J. Foschini, ―Layered space-time architecture for wireless communication in a fading environment when using multi-element antennas,‖ Bell Syst. Tech. J., pp. 41–59, Autumn 1996

[11]. H. Shin and J. H. Lee, "Capacity of multiple-antenna fading channels: spatial fading correlation, double scattering and keyhole," *IEEE Trans. Inf. Theory*, vol. 49, pp. 2636–2647, Oct. 2003.

[12]. Haykin, Simon " *Digital Communications*" Toronto, Canada: John Wiley & Sons, 1988, http://en.wikipedia.org/wiki/Special:BookSources/0-471-62947-2.

[13]. S. M. Alamouti, ―A simple transmit diversity technique for wireless communications,‖ IEEE J. Select. Areas Commun., vol. 16, no. 8, pp. 1451–1458, Oct. 1998.

[14]. Hafeth Hourani "Overview of Diversity Techniques in Wireless Communication Systems Helsinki University of Technology,S-72.333 Postgraduate Course in Radio Communications (2004/2005).

[15]. W H Tranter, K Sam Shanmugam, T S Rappaport, K L Kosbar, Principles of Communication System Simulation with Wireless Applications‖, Pearson Education.

[16]. Andreas Constanttinides, Assaf Shacham "MIMO wireless system, May 14, 2004.

[17]. Tommy Hult, Abbas Mohammed and Zhe Yang (2011). Cooperative Beamforming and Modern Spatial Diversity Techniques for Power Efficient Wireless Sensor Networks, Wireless Sensor Networks, (Ed.), ISBN: 978-953-307-325-5.

[18]. J-F Diouris and J. Zeidler, "Performance Analysis of a Compact Array Receiver for CDMA Cellular Communications," IEEE Military Communications Conference, Oct. 1998, p. 182-186.

[19]. F. Adachi, et al, "Crosscorrelation between the Envelopes of 900 MHz Signals Received at a Mobile Radio Base Station Site," IEE Proceedings-F, Vol. 133, Oct. 1986, p. 506-512.
[20]. W. R. Braun and U. Dersch, "A Physical Mobile Radio channel Model," IEEE Transactions on Vehicular Technology., Vol. 40, May 1991, p. 472-482.
[21]. KwangHyun Jeon; Bing Hui; KyungHi Chang; HyeongSook Park; YounOk Park, "SISO polarized flat fading channel modeling for dual-polarized antenna systems," *Information Networking (ICOIN), 2012 International Conference on* , vol., no., pp.368,373, 1-3 Feb. 2012.
[22]. Kamboj, A.; Mallik, R.K.; Agrawal, M.; Schober, R., "Diversity combining in FSO systems in presence of non-Gaussian noise," *Signal Processing and Communications (SPCOM), 2012 International Conference on* , vol., no., pp.1,5, 22-25 July 2012.
[23]. Faridzadeh, M.; Gholami, A.; Ghassemlooy, Z.; Rajbhandari, S., "Hybrid 2-PPM-BPSK-SIM with the spatial diversity for free space optical communications, "*Communication Systems, Networks & Digital Signal Processing (CSNDSP), 2012 8th International Symposium on* , vol., no., pp.1,5, 18-20 July 2012.
[24]. Michalopoulou, A.; Alexandridis, A.A.; Peppas, K.; Zervos, T.; Lazarakis, F.; Dangakis, K.; Kaklamani, D.I., "Statistical Analysis for On-Body Spatial Diversity Communications at 2.45 GHz," *Antennas and Propagation, IEEE Transactions on* , vol.60, no.8, pp.4014,4019, Aug. 2012.

Author's Profile

Pooja Patil is a research scholar at Sagar Institute of Science and Technology under RGPV, Bhopal. She is pursuing her Master in Technology in Digital Communication. She has keen interest in wireless communication systems and advancement in the performance of MIMO technology.

Prof. Nitin Muchhal is working as an AssO. Prof. at Sagar Institute of Science and Technology under RGPV, Bhopal. He has done his specialization in microwave communication.

Dr. Ravishankar Mishra is HOD, Department of Electronics and Communication Engg. at Sagar Institute of Science and Technology under RGPV, Bhopal.