Survey on Diversity Techniques of MIMO Systems

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Abstract: ***The exploiters of the wireless communication demands for higher data rates, acceptable voice quality with higher network capacity confined due to limited accessibility of radio frequency spectrum, Channel capacity, bandwidth, physical areas and transmission problems caused by different factors like fading and multipath distortion. As in wireless systems it is required to have higher voice quality and high bit rate data services as compared to the present cellular mobile radio standards (up to 2 Mbits/sec). Therefore the key challenge faced by future wireless communication systems is to provide high quality of service (Qos) i.e high data rate wireless access. There are many performance abjection factors in wireless communication channels but FADING problem is the leading worsening problem. In this paper, we studied various transmit diversity techniques in multiple-input multiple-output (MIMO) wireless communication systems. In wireless communication fading of channels is the serious cause of the received degraded signals. Theoretically, the most effective technique to mitigate multipath fading in a wireless channel is that of the transmitter power control. In past receiver diversity was widely used. This was on account of the fact that the receiver diversity was simpler and also the receiving devices were generally passive producing little or no interference. Transmitter diversity was difficult because of the f two reasons: One is multiple signals from the transmitting end would combine to produce only one value of signal level at a given point, resulting in no diversity. Other is the transmitted signals would sometimes produce objectionable nulls in the radiation at some angles.***

Keywords: Wireless Systems, MIMO, Diversity, Fading, Multiple Antennas.

1. Introduction

Digital wireless systems have been arising in popularity, complexity and capabilities over the last few years, and there are now mobile as well as fixed wireless networks, proprietary as well as standardized systems, personal area networks as well as metropolitan area networks. Wireless Network refers to any type of computer network that is not connected by any kind of cable. It is a method through which homes, telecommunications networks and business installations avoid the costly process of introducing cables into the building, or as a connection between different locations of equipment. As in wireless systems it is required to have higher voice quality and high bit rate data services as compared to the present cellular mobile radio standards (up to 2 Mbits/sec). Therefore the key challenge faced by future wireless communication systems is to provide high quality of service (Qos) i.e high data rate wireless access. This growing wireless communication is confined due to the restriction of available frequency resources, channel capacity, bandwidth, complexity, transmission data rate, physical areas and communication channels between transmitter and receiver.

2. Need of MIMO System

MIMO (Multiple Input Multiple Output) technology has pull in attention in wireless communications, as it makes available the probative increase in data throughput and link range without additive bandwidth or enhanced transmit power. It accomplishes this goal by spreading the same total transmits power over the antennas to attain array gain that amend the spectral efficiency to accomplish a diversity gain that amend the link reliability i.e reduce fading. MIMO makes use of multiple antennas at both the transmitter and receiver to improve communication performance. As we know that the communication system includes the transmitter and receiver with different antenna allocation, there are some categories of multi-antenna types:

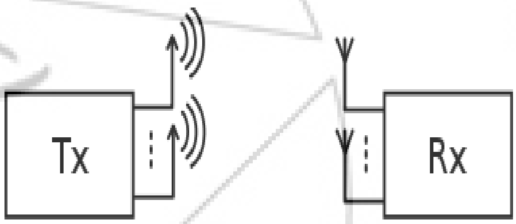

Figure 1: MIMO System

The wireless system before MIMO has been constrained by network capacity which is related with channel quality and coverage. In wireless communication, the propagation channel is characterized by propagation which is multipath due to scattering on different problems. The multipath problem is a common issue in communication system with various time variations and spread. For time variations the channel is fading and caused by the SNR variations. For time spread, it will be important to select the suitable frequency selectivity. In an urban environment, these signals will bounce off trees, buildings, etc. and will go on their way to their destination but all in different directions. With MIMO, the receiving end will be using an algorithm or special signal processing to sort out the many signals and will produce one signal that has the originally transmitted data.

3. Use of Transmit Diversity

Sometimes, a base station has to serve for hundreds of thousands remote units. Therefore, it is cost saving to add the necessary equipments to the base stations instead of the remote units. This is the main reason that transmit diversity is very attractive to the wireless service operators. For example, for covering service area of a base station, one antenna and one transmit chain can be added to that base station to improve the reception quality of all the remote units under the base station. Transmit diversity is more effective than receive diversity for increasing the forwarding

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link that is the bottleneck in broadband asymmetric applications such as browsing internet and downloading files.

4. Diversity Techniques

Diversity technique is used to decrease the fading effect and improve system performance in fading channels. In this method, we obtain L copies of desired signal through M different channels instead of transmitting and receiving the desired signal through one channel. The main idea here is that some of the signals may undergo fading channel but some other signals may not. While some signal might undergo deep fade, we may still be able to obtain enough energy to make right decision on the transmitted symbol from other signals. There are a number of different diversity techniques which can be commonly employed in wireless communication systems. Some of them are following:

4.1 Frequency diversity

It is used to provide the multipath structure in different frequency bands is different. This fact can be exploited to mitigate the effect of fading. But, the positive effects of frequency diversity are limited due to bandwidth limitation. Wireless communication uses the radio spectrum technique which is a resource i.e finite. This limits the number of wireless users and the amount of spectrum available to any user at any moment in time.

4.2 Spatial diversity

It exploits multiple antennas either separated in space or differently polarized in different antennas have a different multipath characteristics or different fading characteristics and this can be used to generate a stronger signal. Spatial diversity techniques do not have the drawbacks associated with time diversity and frequency diversity techniques. The main drawback of spatial diversity is that it involves deployment of multiple antennas at the transmitter and the receiver which is not always feasible.

Table 1: Space Diversity for Channels

Channels	*Spatial Diversity*
Single-input, single-output (SISO)	No spatial diversity
Single-input, multiple-output (SIMO)	Receive diversity
Multiple-input, single-output (MISO)	Transmit diversity
Multiple-input, multiple-output (MIMO)	Combined transmit and receive diversity

4.2.1 No spatial Diversity (SISO)

Single Input Single Output (SISO) is the most wide-eyed form of radio link can be determined in MIMO. This is efficaciously a standard radio channel in which transmitter operates with one antenna as does the receiver. As there is no diversity and no additional processing commanded in SISO. The reward of a SISO system is its simplicity because it requires no processing of the various forms of diversity that may be employed in it. The throughput looks upon the channel bandwidth and the signal to noise ratio therefore SISO channel is confined in its performance as interference and fading will hit the system more than a MIMO system using some form of diversity

4.2.2 Receive diversity (SIMO)

In Single Input, Multiple Output (SIMO), single transmit antenna and multiple receive antennas used.. SIMO is an antenna technology for wireless communications in which multiple antennas are used at the destination (receiver) and the source (transmitter) has only one antenna . The antennas are blended to downplay errors and optimize data speed. SIMO is one of several forms of smart antenna technology, the others being MIMO (multiple input, multiple output) and MISO (multiple input, single output).

4.2.3 Transmit diversity (MISO)

In Multiple Input Single Output (MISO) the same data is transmitted redundantly from the two transmitter antennas.. The receiver is then capable to receive the optimal signal which it can then use to receive extract the expected data. It is also named as transmit diversity. The reward of using MISO is that the multiple antennas and the redundancy coding / processing is moved from the receiver to the transmitter. In cases such as cellphone UEs, this can be a substantial reward in terms of space for the antennas and reducing the level of processing required in the receiver for the redundancy coding.

4.2.4 Diversity on both transmits and receives (MIMO)

In Muliple Input Multiple Output (MIMO) multiple antennas at the transmitter and receiver to alter a variety of signal paths to acquit the data choosing branch paths for each antenna to enable multiple signal paths to be used. It is efficaciously a radio antenna technology as it is found between a transmitter and a receiver; the signal can take many paths. Additionally by moving the antennas even a small distance the paths used will change. The variety of paths available occurs as a result of the number of objects that appear to the side or even in the direct path between the transmitter and receiver.

4.3 Time diversity

It makes use of the fact that fading over different time intervals is different. By using channel coding the effect of bad fading intervals can be mitigated by good fading intervals. However, due to delay constraints time diversity is difficult to exploit.

4.4 .Polarization diversity

It makes the use of transmitted signals having uncorrelated fading statistics in VHF and VHF land mobile radio system when signals should be transmitted through two orthogonally propagations paths. The polarization diversity may obtain in dense scattering environments when there is line of sight (LOS) and non-line of sight (non-LOS) situations..

4.5 Angle diversity

Equal data traffic is used on the both uplink (reverse link) and downlink (forward link) in digital cellular communication but the system requires better reverse link performance because of the limitation of mobile terminal transmit power. There is uplink capacity deployed in CDMA

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system due to synchronize operation on forward link and asynchronies operation on reverse link. If we need to achieve better uplink reliability then we can use space diversity or polarization diversity. On the other hand, there is a huge demand of data applications on downlink capacity comparing to the uplink capacity.

4.6 Antenna diversity

It is a popular and extensively used technique to improve performance in wireless communication systems. This technique reduces fast fading and inter-channel interference effects in the wireless system. In this system, two or many more antennas that are used in this technology are used and are fixed in their respective positions which will provide uncorrelated signals with the same power level. The generated signals are collected and then from those signals an enhanced signal is created. This common method of this diversity is that the antennas experiences different kind of signals because of individual channel conditions and the signals are correlated partially.

5. Related Work

Previous work which had been done on MIMO system and their diversity gain techniques is discussed in this part.

L. Zheng et. al (1999) proposed multiple antennas can be used for increasing the amount of diversity or the number of degrees of freedom in wireless communication systems. In this paper, we propose the point of view that both types of gains can be simultaneously obtained for a given multiple-antenna channel, but there is a fundamental tradeoff between how much of each any coding scheme can get. For the richly scattered Rayleigh-fading channel, we give a simple characterization of the optimal tradeoff curve and use it to evaluate the performance of existing multiple antenna schemes.

T. K. Y. Lo et al, (1999) presents the concept, principles, and analysis of maximum ratio transmission for wireless communications, where multiple antennas are used for both transmission and reception. The principles and analysis are applicable to general cases, including maximum-ratio combining. Simulation results agree with the analysis. The analysis shows that the average overall signal-to-noise ratio (SNR) is proportional to the cross correlation between channel vectors and that error probability decreases inversely with the (L×K)th power of the average SNR.

I. E. Telatar et al, (1999) investigates the use of multiple transmitting and/or receiving antennas for single user communications over the additive Gaussian channel with and without fading. We derive formulas for the capacities and error exponents of such channels, and describe computational procedures to evaluate such formulas. We show that the potential gains of such multi-antenna systems over single-antenna systems are rather large under independence assumptions for the fades and noises at different receiving antennas.

V. Tarokh et. al (2000) present a transmission scheme for exploiting diversity given by two transmit antennas when neither the transmitter nor the receiver has access to channel state information. The new detection scheme can use equal energy constellations and encoding is simple. At the receiver, decoding is achieved with low decoding complexity. The transmission provides full spatial diversity and requires no channel state side information at the receiver. The scheme can be considered as the extension of differential detection schemes to two transmits antennas.

P. Fan et al, (2001) presents a multiple-symbol differential detection method for the differential encoding of MPSK signals by using two transmit antennas. Compared to the conventional detection method proposed by Tarokh and Jafarkhani (see IEEE J. Select. Areas Commun., vol.18, no.7, p.1169-74, 2000), the new detection method retains the advantages such as providing full spatial diversity and no requirement on channel state side information at the receiver etc. Moreover, it can provide a certain coding gain with relatively low complexity. The scheme can be considered as the extension of multiple-symbol differential detection schemes to two transmits antennas.

R. W. Heath Jr. et. al (2002) proposed the Multiple-input multiple-output (MIMO) wireless communication systems provide high capacity due to the plurality of modes available in the channel. Existing signaling techniques for MIMO systems have focused primarily on multiplexing for high data rate or diversity for high link reliability. In this paper, we present a new linear dispersion code design for MIMO Rayleigh fading channels. The proposed design bridges the gap between multiplexing and diversity and yields codes that typically perform well both in terms of ergodic capacity as well as error probability. This is important because, as we show, designs performing well from an ergodic capacity point of view do not necessarily perform well from an error probability point of view. Various techniques are presented for finding codes with good error probability performance. Monte Carlo simulations illustrate performance of some example code designs in terms of ergodic capacity, codeword error probability, and bit error probability

6. Conclusion

In this paper, a comparison of diversity technique for estimating the channel performance of mobile communication signals affected by Rayleigh multipath fading phenomena is discussed. The major features of MIMO links for use in future wireless networks. Information theory reveals the great capacity gains which can be realized from MIMO. Whether we achieve this fully or at least partially in practice depend on a sensible design of transmit and receive signal processing algorithms. It is clear that the success of MIMO algorithm integration into commercial standards such as 3G, WLAN, and beyond will rely on a fine compromise between rate maximization (BLAST type) and diversity (space–time coding) solutions, also including the ability to adapt to the time changing nature of the wireless channel using some form of (at least partial) feedback. To this end more progress in modeling, not only the MIMO channel but its specific dynamics, will be required.

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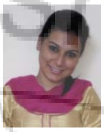

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