Ber Improvement in Rayleigh Fading Channel Using MIMO

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Abstract- *Unlike Wired communication, Wireless communication suffers with multipath propagation of transmitted signal which results in very high Bit-Error-Rate (BER) ultimately poor communication quality. Besides, wireless communication also has the drawback of fading. Both Multipath Propagation and Fading can give rise to complete loss of signal in certain occasions. There's every necessity to combat these two problems. An effective solution to these two is diversity.In wireless communications systems, diversity approaches are generally employed to enhance performance across a fading radio channel. There are different types of diversity techniques. we would like to prefer spatial diversity technique: Multiple Input Multiple Output (MIMO).MIMO is a type of antenna diversity that makes use of many antennas to strengthen RF links and increase signal quality.Equal gain combining, maximal gain combining, and selection combining are the three combining approaches that we have employed. These combing techniques are analysed and compared to get better performance for the fading problem. In this project we observe the bit error rate performance of ZF (Zero Forcing) and MMSE (Minimum Mean Square Error) using MIMO.*

Keywords- Fading, diversity, equal gain combining, maximal gain combining, selection combining, zero Forcing, Minimum Mean Square Error.

I. INTRODUCTION

The early understanding of the magnetic and electric properties observed by the Chinese, Roman, and Greek cultures and experiments laid the foundation for wireless communications carried out in the 17th and 18th centuries. 1g is the first generation in wireless communication. Mobile telecommunications, the first generation of wireless phone technology, was introduced in Japan by NTT in 1979.It makes use of analogue transmissions and permits domestic voice calls. 2g is the second generation in wireless communication. In Finland, the second generation of mobile communications was introduced that year.It allows for the transmission of data such as text messages (SMS, short for short message service) and photographs or photos (MMS, or multimedia messaging service), but not videos.

3g is the third generation in wireless communication.The third generation, or 3G, first appeared in the early 2000s.The speed of data transmission has been doubled to 2Mbits/s, enabling the sending and receiving of huge email messages.4g is the fourth generation in wireless communication. Provide a variety of communication options, such as video calling, in-flight interpreting, and video voicemail. It could deliver speeds between 100 Mbps and 1 GB/s, High QoS (Quality of Service), and High Security.It is related as fifth generation wireless connection which will be possibly deployed by 2020, or perhaps few years before.
In 5G, machine-to-machine communication is conceivable.
There will be considerably faster transmission rate of data to the previous versions. As a result, 5G will have a 1Gbit/s speed.

II. LITERATUREREVIEW

Wireless communication suffers with multipath propagation of transmitted signal which results in very high Bit-Error-Rate (BER) ultimately poor communication quality. Besides, wireless communication also has the drawback of fading. Both Multipath Propagation and Fading can give rise to complete loss of signal in certain occasions.

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'The most common problems in wireless transmission are fading. There are multiple methods to enhance the transmission, as well as various types of fading.In those methods, we'll use variety strategies to get around the fading issue. The variation in signal strength at the receiver is referred to as fading.diverse strategies are employed to find solutions to the issues. Several techniques have the disadvantages too.By examining and contrasting the system's performance, we may decide on the best diversity technique. In order to solve the fading problem as effectively as possible in wireless systems, diversity approaches can occasionally be coupled. Three combining techniques—equal gain combining, maximal gain combining, and selection combining—have been used in this research. The BER performance have been analysed over different techniques. The simulation results reveals that the bit error rate decreases with increases in energy per bit to noise spectral density (E b /N o) and the bit rate is roughly equivalent to a noise spectrum density of 6dB energy per bit.

Wireless communication by Prof. Andrea Goldsmith. Diversity merging of separately fading signal lines is one of the finest methods to reduce the impacts of fading. The limited likelihood of simultaneous deep fades on independent signal routes is taken advantage of by diversity combining. Sending the same data across many fading paths is the concept of diversity. The fading of the combined signal is lessened by combining these distinct routes. Consider a system with two separate fading antennas at the broadcaster or receiver, for instance.It is improbable that both antennas will undergo deep fades at the same time if they are set apart far enough. We get a lot stronger signal than we would if we only had one antenna by choosing the one with the strongest signal—a process known as selection combining.

In a wireless system, independent fading routes can be achieved in a variety of methods. Utilizing an antenna array, often known as numerous transmit or receive antennas, is one technique.

III. METHODOLOGY

Multipath Propagation

Multipath is the propagation phenomena in wireless telecommunications that causes radio signals to travel over two or more routes before arriving at the receiving antenna. Multipath can be brought on by air ducting, ionospheric reflection and refraction, as well as reflection off earthly features like mountains and structures. Time dispersion is another effect of multipath because separate replicas of the transmitted signal travel along transmission pathways with various lengths, arriving at the receiver antenna at various times.

Multipath can be caused by scattering, refraction, and reflection from terrestrial structures like mountains and buildings as well as sea bodies.

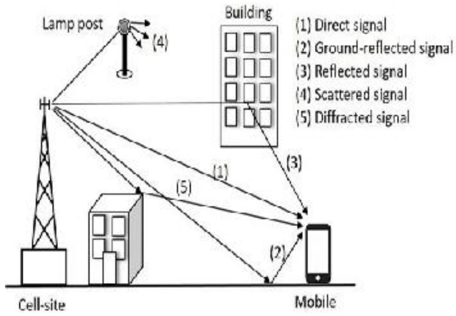

Fig 3.1 multipath propagation

Fading

Due to obstruction from objects in the signal path, a signal carried across a wireless channel will often encounter random variation, leading to random variations of the received strength at a given distance. Modifications to reflecting surfaces and scattering items can also contribute to these variances.

The rate of fading is affected by meteorological factors like rain, lightning, etc.

In a mobile environment, fading is dependent on relative moving impediments in the path. These impediments cause the sent signal to have complicated transmission effects. Wireless communication systems, especially those that operate in high-frequency bands, can suffer greatly from fading.

Diversity

In wireless communications systems, diversity approaches are generally employed to enhance performance across a fading radio channel.

Diversity is a method for compensating for fast fading that is typically used in conjunction with two or more receiving antennas. It is typically used to lessen the depths and lengths of fades that a receiver experiences in a flat fading channel.

Spatial diversity

Multiple receiving antennas are positioned at various spatial positions in space diversity, producing a variety of received signals.

An array of antennas is used to provide redundancy, with a minimum distance of /2 between nearby antennae.

The same signal is replicated and broadcast using a separate antenna. To ensure that channel gain is independent of the signal path, there should be space between adjacent antenna. A path that avoids shadowing and also reduces large-scale fading might be provided via spatial diversity. Different paths are offered by space diversity without increasing transmitter power or bandwidth.

MIMO(Multiple-input, multiple-output)

Multiple-input, multiple-output is what MIMO stands for.

MIMO communication uses many antennas to convey the same data as various signals simultaneously while only using one channel.

An RF link's signal quality and strength are increased using various antennas in this instance of antenna diversity. Geographical Diversity Because MIMO allows for distinguishing transmission across many pathways, it is feasible to encode the signal more effectively when the impact of those paths is taken into account.

- MIMO makes signals stronger. A user device does not need to be in a clear line of sight because it bounces and reflects signals.
- Large amounts of video and other large-scale content can be transmitted through a network. This content is transmitted more quickly thanks to MIMO's higher throughput.
- A variety of data sources enhance visual and aural quality. They lessen the possibility of data packets being lost.

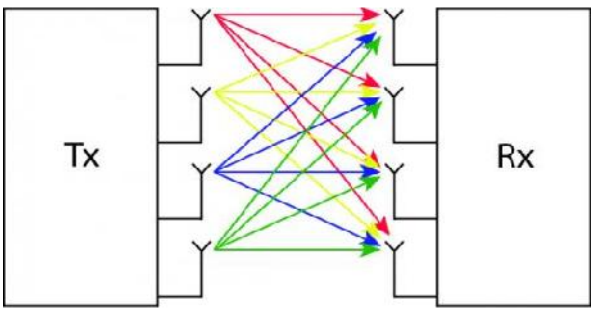

Fig 3.2 MIMO

Combining techniques

Diversity merging of separately fading signal lines is one of the finest methods to reduce the impacts of fading. The limited likelihood of simultaneous deep fades on independent signal routes is taken advantage of by diversity combining. Sending the same data across many fading paths is the concept of diversity. The fading of the combined signal is lessened by combining these distinct routes. Consider a system with two separate fading antennas at the broadcaster or receiver, for instance. It is improbable that both antennas will undergo deep fades at the same time if they are set apart far enough. Selection combining, a method that chooses theantenna with the strongest signal, yields compared to using just one antenna, the signal was significantly better. This chapter focuses on typical techniques for achieving diversity at the transmitter and receiver. Beyond the performance or complexity of these schemes, other diversification techniques may be advantageous.

Selection combining

The signal on the branch with the highest SNR is output by the combiner in selection combining (SC). If the noise power is the same on all branches, doing this is equivalent to picking the branch with the highest SNR. SC frequently only needs one receiver, which is switched into the active antenna branch, because only one branch is used at a time. When using SC, the combiner's path output has an SNR that is equal to the highest SNR of all the branches. Furthermore, co-phasing of several branches is not necessary because only one branch output is employed.

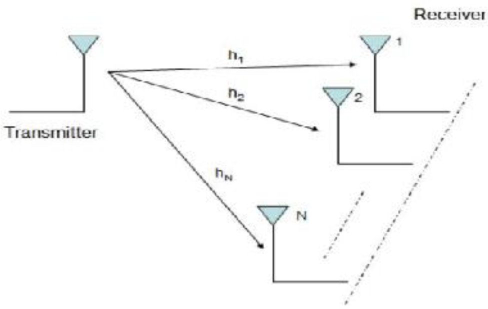

Fig 3.3 Selection Combining

Maximal Ratio Combining

The output of maximal-ratio combining (MRC) is a weighted sum of each branch. The SNR of the combiner output is therefore the total of the SNRs on each branch. Because the average combiner SNR and related array gain rise linearly with the M diversity branches, the high SNR branches should be given more weight than the low SNR branches.

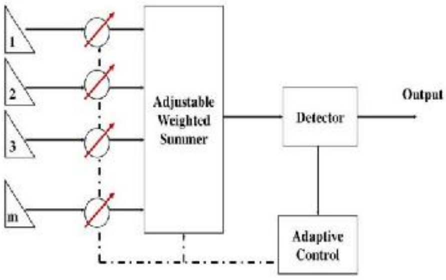

Fig 3.4 Maximal Ratio Combining

Equal gain combining

The time-varying SNR on each branch, which is necessary for maximum-ratio combining, might be challenging to quantify. Equal-gain combining (EGC), a more straightforward method, co-phases the signals on each branch before combining them with equal weighting. EGC's performance is relatively similar to that of MRC, generally showing less than 1 dB of power penalty.

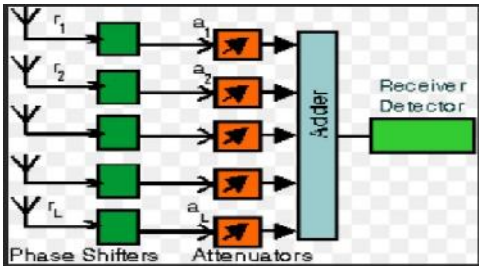

Fig 3.5 Equal Gain Combining

Equalizer

The elimination of inter-symbol interference (ISI) is the aim of equalizers. Due to the dispersive nature of the channel, inter symbol interference (ISI) develops as a transmitted pulse spreads, causing adjacent pulses to overlap.

Two general categories :linear and non linear equalization

There is no feedback path for the equalizer to adapt, thus it is linear.

The equalization is nonlinear since it is fed back in a nonlinear manner to alter the equalizer's future outputs.

Equalizer with zero forcing: The filter taps are changed to push the equalizer output to zero at N sample points on either side.

The filter taps are set to minimise the Mean Square Error (MSE) of the ISI and noise power at the equalizer output.

Zero- forcing equalizer

In a multi-user MIMO wireless communication system, a multiple antenna transmitter can eliminate multiuser interference by using the zero-forcing (also known as null-steering) precoding technique.

When there are many users and the transmitter has perfect knowledge of the downlink channel state information (CSI), ZF-precoding can virtually reach system capacity.

On the other hand, the effectiveness of ZF-precoding declines depending on the accuracy of CSIT when there is little channel state information at the transmitter (CSIT).

MMSE

A popular metric of estimator quality is mean square error (MSE), which is minimized by the minimum mean square error (MMSE) estimator.

Since they are simple to use, simple to calculate, and extremely flexible, linear MMSE estimators are a popular option.

Analysis of the wireless MIMO systems with no fewer receive antennas than send antennas using the zero forcing (ZF) and minimum mean squared error (MMSE) equalizers.

IV. RESULTS

Simulation results

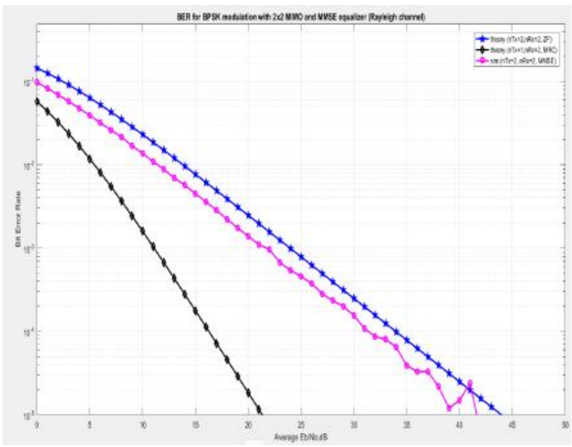

Fig 3.6The simulated performance curves of BER for BPSK Modulation with 2*2 MIMO and MMSE equalizer (Rayleigh channel)

At 10-3 BER point, it can be shown that the Minimum Mean Square Error (MMSE) equalizer produces an improvement of about 3dB over the Zero Forcing equalizer instance**.**

V. CONCLUSION

In this project, we analyze and compare diversity combining techniques (maximal ratio combining, selection combining, equal gain combining) to observe the performance of bit error rate to choose the low bit error rate technique i.e., Maximal ratio combining which has the better bit error rate when compared with selection and equal combining. In spatial diversity we choose, MIMO because, it has the advantages of MIMO offers the ability to distinguish transmission over multiple paths, it is possible to encode the signal more efficiently. From the above plot, Zero Forcing and Minimum Mean square Error Equalizer are compared with Maximal Ratio Combining and bit error rate is observed. The MMSE equalizer transforms into a Zero Forcing equalizer when the noise term is zero. The bit error rate decreases with increases in energy per bit to noise spectral density (E b /N o). When compared to three combining procedures, the bit rate is approximately equal to 14dB of energy per bit in the ideal scenario, while the bit error rate is nearly equal to 6dB energy per bit to noise spectral density. At 10-3 BER point, it can be shown that the Minimum Mean Square Error (MMSE) equalizer produces an improvement of about 3dB over the Zero Forcing equalizer instance.

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