EFFICIENCY EVALUATION OF SPACE DIVERSITY WITH STBC FOR MIMO WIRELESS SYSTEM

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Abstract
Space Time Block Coding (STBC) is a dominant method in wireless communication mainly for MIMO system, due to numerous key benefits. Improved Reliability, Simple Implementation, Compatibility with MIMO Systems, Enhanced Performance in Fading Environments is few advantages of the technique. Evaluating the efficiency of space diversity with Space-Time Block Coding (STBC) in MIMO wireless systems involves analyzing how these techniques improve performance metrics like Signal-to-Noise Ratio (SNR), Bit Error Rate (BER), and overall system capacity. This paper gives the concise overview, structure and results of numerous diversity methods.

I. OVERVIEW

Wireless system involves conveyed data over a remote place without employ the wires, usually using radio waves. The wired networks proves to be expensive when covering a large area because of cabling and do not provide any kind of mobility. Wireless communication proves to be best way of communication around the world. It is essential to different technologies, including mobile phones, Wi-Fi, and satellite communications. Key challenges in wireless communication include:

Multipath Fading: Signals can take multiple paths to reach the receiver, causing interference and signal degradation.

Interference: Signals from different sources can interfere with each other, reducing the quality of communication.

Noise: External noise can corrupt the signal, leading to errors in data transmission.

In other words the wireless systems are supposed to have superior quality and coverage, be more power and bandwidth efficient, and be deployed in diverse environments. However, in most cases, the wireless channel undergoes attenuation because destructive and constructive summation of multipath in the broadcast media and to obstruction from other consumers. Hence makes it hard for the recipient to reliably find out the transmitted signal unless some less attenuated replica of the signal is granted to the receiver. This process is known as diversity, which can be achieved using temporal, frequency, polarization, and spatial resources. Hence severe attenuation in a multipath wireless system makes it really complicated for the receiver to create the transmitted signal unless the recipient is supplied with some form of diversity, i.e., some less-attenuated replica of the transmitted signal is offered to the receiver. Therefore, the receiver diversity has a vital role in wireless communication. Time and frequency diversity are frequently used diversity schemes.

II. MIMO System

In any wireless system, fading in the communication system due to Reflection, Scattering and Diffraction in the communication environment plays a crucial role. Reflection produces when an electromagnetic signal encounters a surface that is large relative to the wavelength of the signal. Diffraction produces at the edge of an impenetrable body that is large enough to the

wavelength of the radio wave. When a radio wave encounters such an edge, the wave propagates in different direction with the edge as the source. Scattering of the signal occurs when the size of the obstacle is of the order of the wavelength of signal or less, the signal is scattered into several weaker outgoing signals.

The effect of this multipath propagation of signal is lowered by utilizing numerous error compensation techniques such as Forward error Correction, Adaptive Equalization and Diversity

Techniques. Diversity Techniques are highly effective in wireless environment. The basic concept of diversity: transmit the signal via several independent diversity branches to get independent signal replica. In communications, a diversity scheme refers to a process for enhancing the reliability of signal by using two or more communication channels with different characteristics. Diversity plays an important role in reducing fading, co-channel interference and avoiding error bursts. The basic principle is that individual channels have different levels of fading and interference. Here, multiple replica of the same signal may be transmitted and/or received and combined in the receiver.

III. Types of Diversity

There are basically three kinds of Diversities namely: Time Diversity, Frequency Diversity and Space Diversity.

(a) Time Diversity

Multiple replica of the identical signal is transmitted at different time instants. Alternatively, a redundant forward error correction code is added and the message is spread in time by means of bit- interleaving before it is transmitted. Thus, error bursts are avoided, which simplifies the error correction.

(b) Frequency Diversity

Frequency diversity is the simultaneous utilize of numerous frequencies to transmit signals. Hence, it is a technique used to combat the effects of multipath fading since the wavelength for unlike frequencies result in dissimilar and un-correlated fading characteristics.

c. Space Diversity

In this process, the signal is transmitted over numerous different propagation paths. In wireless transmission, it can be attained by antenna diversity, which deployed multiple transmitter antennas (transmit diversity) and/or multiple receiving antennas (reception diversity). Therefore, space diversity is one of several wireless diversity schemes that use two or more antennas to improve the quality and reliability of a wireless system. Particularly, in urban and indoor environments, where there is no clear line-of-sight (LOS) between transmitter and receiver. Hence, the signal is reflected along multiple paths before finally being received. These reflected bounces can initiate phase shifts, time delays, attenuations, and distortions that can destructively interfere with one another at the receiving antenna. Therefore, Antenna diversity is mainly efficient at mitigating these multipath situations. This is because multiple antennas offer a receiver several observations of the same signal. Each antenna will experience a different interference environment. Thus, if one antenna is experiencing a deep fade, it is likely that another has a sufficient signal. Collectively such a system can provide a robust link. While this is primarily seen in receiving systems (diversity reception), the analog has also proven valuable for transmitting systems (transmit diversity) as well. So as to achieve this diversity, we use MIMO (Multiple Input and Multiple Output) system.

IV. Space Time Block Code

STC (space time coding) is intended to accomplish transmit diversity and power gain without scarifying any more bandwidth. STC is performed over two axis spatial (space) and temporal (time) axis for multiple antennas at different time. It is assumed that there are N transmit antennas and M receive antennas in a wireless communication system in which STBC is used.

The input source data bits are firstly modulated, and then carried into a space- time block encoder. Mapping from the modulated symbols to a transmission matrix, which is completed by the STBC encoder, is a key step in STBC systems. The input symbols of the encoder are divided into groups of several symbols. The number of symbols in a group is according to the number of transmit antennas. A PxN transmission matrix means there are N transmitting antennas and P time slots. Different symbol columns are transmitted through different antennas separately and different symbol rows in different time slots.

M. Alamouti gives easy methods to attain spatial diversity with two transmit antennas and one receive antenna.

Consider we have a transmission sequence e.g. x1, x2, x3. xn. In normal transmission, we send x1 in first time slot, x2 in second time slot and so on. However, Alamouti suggested that group the symbols into the group of two.

In the first time slot send x1 and x2 from first and second antenna and –x2* and x1* from first and second antenna at second time slot. In third time slot x3 and x4 from first and second antenna and there conjugates in fourth time slot and so on. Now the signal is transmitted through various channels.

The channel experience by each transmit antenna is independent from the channel experienced by another antennas. For i[th] transmitted antenna, the transmitted symbol is multiplied by hi i.e. Rayleigh channel coefficient. The channel experienced between each transmit to receive antenna is randomly varying in time. However the channel is assumed to remain constant over two time slots. G2 represents a code which utilizes two transmit antennas and is defined by:

$$G2=\begin{pmatrix} x_1 & x_2 \\ -x_2^* & x_1^* \end{pmatrix}$$

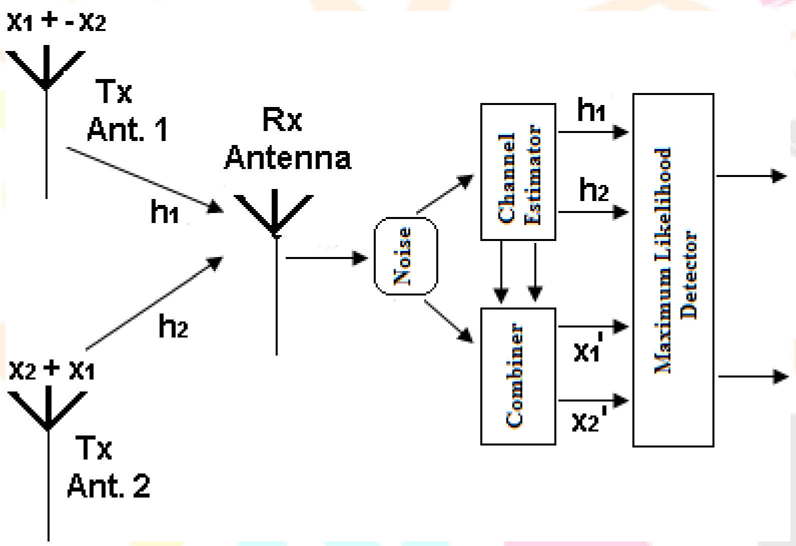

Figure 1: 2Tx and 1Rx diversity method

In the first time slot, the received signal is

$y_1=h_1x_1 + h_2x_2 + n_0$

In second time slot the received signal is

$y_2=-h_1x_2^* + h_2 x_1^*+n_1$

Combining scheme

$X_1'=h_1^* y_1+h_2^*y_2$

$X_2'=h_2^*y_1+h1^*y_2$

These combined signals are then sent to maximum likelihood detector. There are many applications where higher order of diversity is needed and multiple receive antennas at the remote unit is feasible. In such cases, it is possible to provide a diversity order of 2M with two transmit and M receive antenna.

V. RESULTS AND DISCUSSION

In this paper, we implemented and simulated developed model of OFDM system with receiver diversity method. Maximum Ratio Combining (MRC) is a method utilized in wireless communications to enhance signal quality and reliability through diversity combining. It is a technique in which signals recovered from numerous antennas are combined to enhance the signal-to-noise ratio (SNR). Each received signal is weighted proportionally to its SNR before being summed. This ensures that stronger signals are given more importance, while weaker signals contribute less to the final output.

In this paper, we implement one transmitter and numerous receivers. Implementing receiver diversity on OFDM system enhances the performance. It has been clear from figure 2 that adding more antennas at the receiver, there is gradual enhancement in the spectral efficiency of the system.

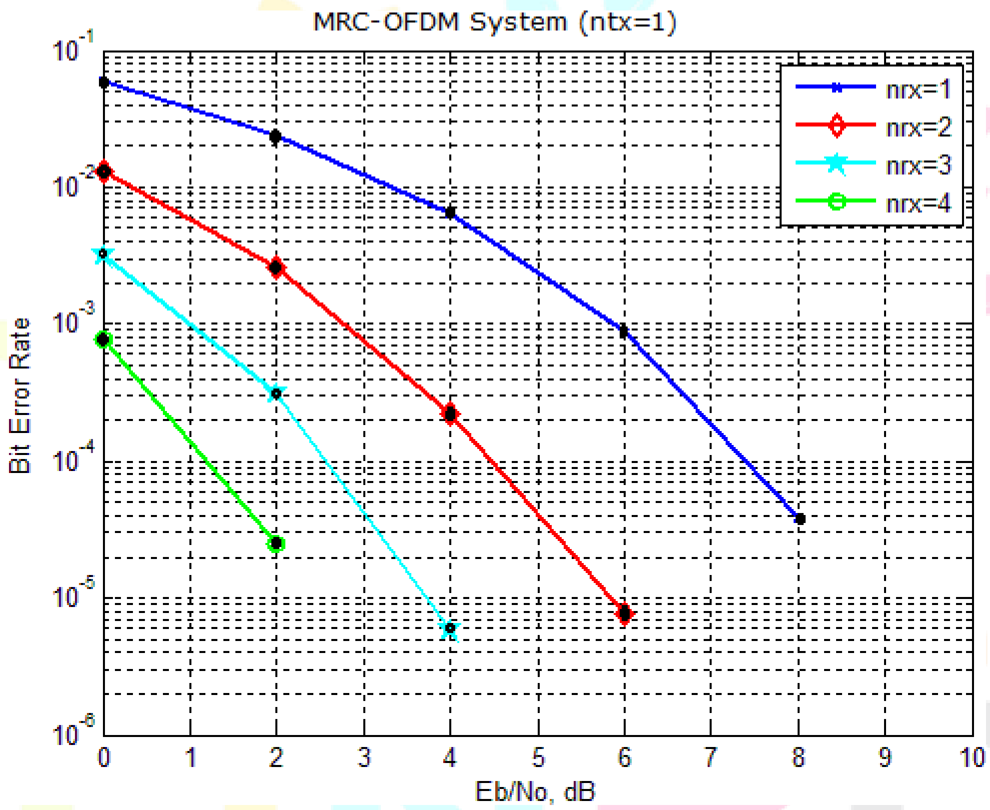

Figure 2: BER of Receiver diversity method

VI. CONCLUSION

This paper developed and simulated OFDM system under diversity technique. The BER performance of implemented system is evaluated. By combining numerous signals, MRC improve the overall signal quality and decreases the impact of fading and interference. It gives superior performance in environments with multipath propagation. With the increase of receiver antennas in developed OFDM structure, the system performance improves.

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