ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 3, Issue 1, April 2016

SPACE TIME BLOCK CODING FOR WIRELESS COMMUNICATION SYSTEM: PRINCIPAL AND TECHNIQUES

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ABSTRACT

Multipath fading is known to arise due to the non-coherent combination of signal arriving at the receiver antenna. Typically, this phenomenon is described as the constructive and destructive interference between signals arriving at the same antenna via different paths, and hence, with different delays and phases, resulting in random fluctuations of the signal level at the receiver. MIMO has drawn significant attention of researchers in the field of wireless communication. The wireless communication channel suffers from much impairment such as Additive White Gaussian Noise (AWGN), the path loss, the shadowing and the fading. This paper describes the basic principle of STBC to combat fading in wireless channel. Various techniques of STBC are discussed.

Keywords— STBC, Spatial Multiplexing, Channels, Almouti.

I. INTRODUCTION

One of the biggest challenges in wireless communication is to operate in a time varying multipath fading environment under restricted power constraints. The problem is the limited accessibility of the frequency range. Future commercial and armed service wireless systems will have to support higher data rates with reliable communication under spectrum limitations and multipath fading environments. Military communication systems must maintain reliable communication under the conditions of hostile jamming and other interference without increasing emitted power or needed larger bandwidth. High speed (data rates), real-time internet protocol (IP) services (including voice) and hours of useful battery-life are the key challenge of wireless and mobile communication.

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International Journal Of Core Engineering & Management (IJCEM)
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Wireless range itself is a valuable resource that also needs should also be conserved. The fundamental variation of wireless communication is the ability to connect on the move. This particular represents both a independence to the end consumer as well as a challenge to the system designer. However in wireless communication, the transmitting information are riding on radio (electromagnetic) waves and hence the information goes through attenuation effects (fading) of radio waves. These damping effects could also fluctuate with time due to user mobility, making Wi-Fi a challenging communication medium.

Multipath Fading is known to occur as a result of non-coherent mixture of signals arriving at the receiver antenna. Typically, this phenomenon is described as the constructive/destructive interference between signals arriving at the same antenna via Different paths, and hence, with different delays and levels, resulting in random changes of the signal level at the receiver. Deep-fades that may occur at a particular point in space, or at a particular time or consistency, cause severe degradation of the quality of signs at the receiver so that it is impossible to find and decode. In the recent years MIMO has attracted significant attention of research workers in the field of wireless communication. Multipath remover is major bottleneck in increasing the info-rate and reliability of transfer of information over wireless port. Channel coding Techniques which are used to improve stability is insufficient to fulfill the requirements of modern multimedia system communications. Diversity is a powerful communication receiver strategy that provides wireless website link improvement at a low cost. Diversity techniques are used in wireless communications to mitigate the effect of fading over a radio station channel. The wireless communication channel is suffering from much incapacity such as Additive Gaussian Noise (AWGN), the path loss, the tailing and the fading. Remover is a major problem and to reduce it, diversity will be used. Hence diversity technique, multiple copies of the same data is transmitted to the receiver via multiple paths or channels and the final decision is made by the device without knowing to the transmitter.

2. FADING

Fading in a typical wireless communication environment, multiple distribution paths exist between transmission device and receiver due to scattering by different things. Thus, copies of the signal following different path can undergo different damping, distortions, delays and phase shifts.

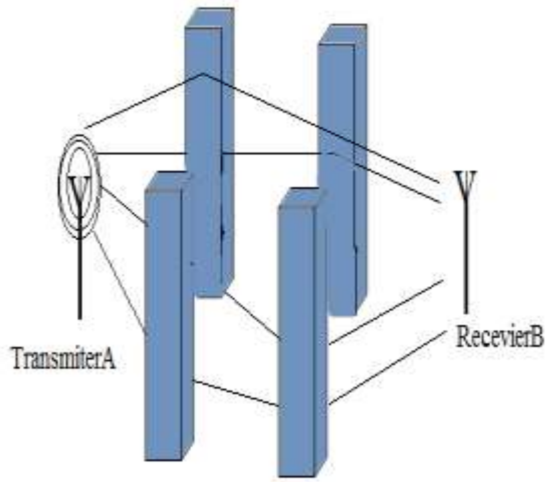

Figure 1.1: Illustration of Multipath Propagation

Constructive and destructive interference can happen at the receiver device. When destructive interference occurs, the signal power can be significantly diminished. This kind of phenomenon is called fading. The fading are of various types and is described as

2.1 FREQUENCY SELECTIVE FADING

The transmitted signal achieving the receiver through multiple distribution paths, having a different relative delay and amplitude. This is called multipath distribution to result in different parts of the sent signal spectrum to be attenuated differently, which is known as frequency-selective falling. In this, the channel spectral response is not flat. It has scoops or fades in the response due to reflections causing cancellation of certain frequencies at the receiver.

2.2 FREQUENCY NON-SELECTIVE OR FLAT FADING

If all the frequency components of the signal would roughly go through the same degree of fading, the channel is then classified as frequency non-selective (also called Flat fading).

2.3 SLOW FADING

Slow fading is a long-term fading effect changing the mean value of the received signal. Slow fading is usually associated with moving away from the transmission device and experiencing the expected reduction in signal power. Slow fading can be caused by events such as shadowing, where a huge obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver.

2.4 FAST FADING

Fast fading is the short term component associated with multipath propagation. It is influenced by the speed of the mobile terminal and the transmission bandwidth of the signal.

3. DIVERSITY

The concept of diversity that is, providing the receiver with multiple copies of the similar message is widely known to work in dealing with channel impairment arising credited to multipath fading. The diversity features various types which are described as:

3.1 FREQUENCY DIVERSITY

Frequency diversity utilizes the fact that in several frequency bands, the multipath structure different. This simple fact can be utilized to combat the effect of fading. In such a case, in the several frequency bands the copies of information signal are transmitted, and the frequency separation is more than channel coherence bandwidth. Although due to bandwidth limits, the positive effects of frequency diversity are constrained.

A finite source that is radio spectrum can be used by wireless communication and by this the amount of wireless users are limited and also the amount of spectrum i.e. provided with each user at any time is also limited

3.2 TIME DIVERSITY

Time diversity utilizes the fact that several time intervals will undergo different amount of fading. Effect of bad channel coding can be reduced by good fading time periods. In this the copies of info signal are sent with time slots which are different. Time slots separating are more than the channel coherence time. The time diversity is difficult to exploit because of delay constraints.

3.3 POLARIZATION OR ANGLE DIVERSITY

In **polarization diversity**, is achieved by utilizing two transmit antennas or two receive antennas with different polarization. The sent waves follow the same path. There are two disadvantages of polarization diversity. First disadvantage is that you can have at most of the two diversity branches, related to the two types of polarization. The second disadvantage is the polarization diversity loses effectively half the power (3 dB) because transmit or receive power is divided involving the two differently polarized antennas

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3.4 SPACE OR SPATIAL DIVERSITY

Spatial Diversity the most common diversity is space or spatial diversity. In this, number of antennas can be used to obtain different copies of the transmitted signal. Using two antennas with a distance between them the level delay makes multi-path signals coming to the antennas differ fading.

Space diversity is nowadays in focus due to higher frequency used for transmission, so that it is possible to apply this type of diversity mechanics in smaller terminals.

3.4.1 TRANSMITTER DIVERSITY

Transmitter diversity (MISO) communication systems utilize multiple antennas (Nt) at the transmitter and a single antenna at the receiver. Fig 2 shows the structure of the system. We assume that perfect channel knowledge is available at the transmitter; it will be possible to achieve transmit-diversity using MRC and EGC at the transmission device.

Applying MRC at the transmitter, also called as beam-forming, requires the use of a filter. The filtered symbol, when sent through all antennas moves to the single receiver antenna.

Combining will take place as the copies travel the through different sub-channels.

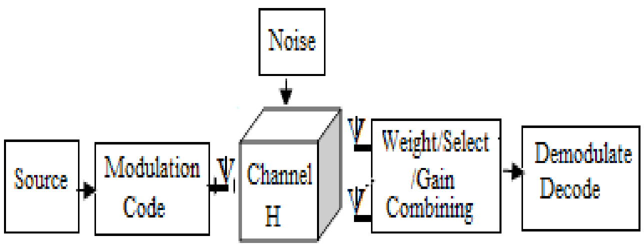

Figure 2: Transmitter Diversity

3.4.2 RECEIVER DIVERSITY

Receiver diversity (SIMO) communication-systems utilize one antenna at the transmitter and multiple antennas at the receiver. Fig 3 shows the structure of transmitted diversity. Thus, any transmitted from the

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only transmit-antenna will arrive at all receiver antennas through different sub-channels. It is assumed that each sub-channel and therefore each channel factor is completely de-correlated.

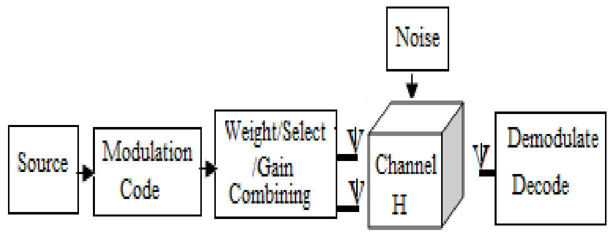

Figure 3: Receiver Diversity

As multiple independent copies of the same signal reach the receiver, it is possible to use the concept of spatial diversity, in such a case receiver-diversity. Assuming that perfect channel information is available at the receiver, it is possible to work with combining techniques at the receiver based structured on the channel state information.

Two combining techniques are being used here: Maximal Ratio Combining (MRC) and Equal Gain Combining (EGC). These two techniques involve conditions matched filter at the receiver to optimally combine the received signals to increase improve the SNR at the output. Suppose Nr system, where Nr denotes the no. of receiver antennas. The transmission of the message symbol c by using a fading channel is simulated as follows:

$$r = h \times c + n$$

where, r denotes the received vector of dimensions Nr ×1, h denotes the channel matrix of dimensions Nr × 1, each factor giving the complex gain between transmitter and each receiver; n denotes an additive noise vector of dimensions Nr ×1; c denotes a transmitted symbol. In the receiver, a matched filter is applied to combine the individual received signals. In the circumstance of MRC, the filtering 'fm' designed as follows;

$$fm = h\ H$$

$$y = fm \times r$$

3.4.3 MANY INPUT & MANY OUTPUT (MIMO) SYSTEM

MIMO systems utilize multiple antennas at both the transmitter and receiver, Fig. 4.

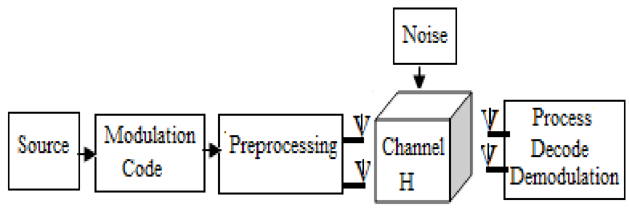

Figure 4: MIMO Diversity

The most common form of diversity used in MIMO systems is space time diversity, taking advantage of both space and time diversity. The Alamouti space time block code is the best of the family of orthogonal space time codes. Along with diversity, MIMO also provides multiplexing capabilities: allowing users to transmit different symbols from different transmit antennas, therefore bettering the throughput of the system.

4. RECEIVER DECODING TECHNIQUES:

Generally the complexity of signal processing at the transmitted side is very low and the main part of the signal processing should be performed at the receiver. The receiver needs to regain the transmitted symbols from the mixed received symbols. Several strategies can be applied at the receiver.

• Maximum Likelihood (ML) Receiver

ML Receiver the best system performance (maximum diversity and lowest bit error ratio (BER) can be obtained), but needs the most complex detection algorithm. The ML receiver calculates all possible quiet receive signals by changing all possible transmit signal by the known MIMO channel transfer matrix. After that the search for the signal is calculated in advance, which reduces the Euclidean distance to the actually received signal. The undisturbed transmit signal that leads to this minimum distance is known as the most likely transmit signals.

• Linear Receivers

Zero Forcing (ZF) receivers and Minimum Mean Error (MMSE) receivers belong to the group of linear receivers. The ZF receiver completely nulls out the influence of the distraction signals coming from other transmit antennas and finds every data stream individually. The disadvantage of this receiver is the receiver due to cancelling the influence of the signal from other transmit antennas, the additive noise may be strongly increased so the performance may break down heavily. Due to the separate decision of each and every data stream, the complexity of this algorithm is much less than in case of an ML receiver. The

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MMSE receiver compromises between noise enhancement and signal interference and minimizes the mean squared error between the transmitted symbol and the detected symbol. As a the results of the MMSE equalization are the transmitted data streams plus some residual interference and noise. After MMSE equalization each data stream is separately detected (quantized) in the same way as in the ZF circumstance

5. CONCLUSIONS

It is concluded that by using diversity, it is possible to effectively mitigate the effects of multipath fading. The scattering of signal severely affects SISO systems therefore techniques are required to avoid it.
The performance of the system is improved by providing the receiver with multiple copies of the data. Thus the introduction of time diversity or space diversity improves the performance of the system. A trade-off can be achieved by sacrificing some of the diversity gain for multiplexing gain, resulting in a significant improvement in data rates without loss of quality.

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