Various Diversity Combining Techniques with LDPC Codes in MIMO-OFDM

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Abstract: OFDM with MIMO is the most efficient and commonly used technology. In MIMO system multiple antennas arrays used across transmitter and receiver side. OFDM with MIMO technology provide reliable communication and efficient manner of signal reception across receiver. In MIMO technology Bit rate error very high due to Multi-path fading effect of channel. In this paper new technique is proposed to reduce Bit rate. The proposed technique uses LDPC filter with OFDM along diversity methods. LDPC filter is used in OFDM to reduce bit rate error and calculate performance in terms of BER for receiver combining technique such as MRC. Since MRC provide excellent reduction in BER as compare to SC and EGC. The proposed technique is implemented in MATLAB and result shows that proposed technique will reduce bit rate error in MIMO-OFDM.

Keywords: Orthogonal frequency division multiplexing (OFDM), m ultipath in put and put multipule out put (MIMO), Low density parity check (LDPC), maximal ration combining (MRC), equal gain combining (EGC), selection combining (SC).

1. Introduction

In the concept of OFDM is subset of frequency division multiplexing which is sing le channel utilizing multiple sub-carriers on a djacent freque ncies. Sub carriers in OFDM system are overlappi ng to maximize spectral efficiency. Overlapping adjacent channels can interfere with one other. OFDM system is precisely or thogonal to one another. OFDM system s are able to maximize s pectral eff iciency without causi ng adjace nt channel interference [6]. In the OFDM communication systems are able to m ore effectively utilize the frequency spectrum. OFDM sub-carrier overlapping sub- carriers. T these sub-ca rriers are able to partially overlapp without interfering with adjacent sub-carriers and maximum power of each sub-carrier corresponds directly with the zero crossing of all channels. OFDM channels are different f rom b and limited FDM channels how th ey ap ply sh aping filter [7]. MIMO communication uses m ultiple antennas a t both transmitter and receiver to exploit the different domains for spatial multiplexing and spatial diversity. In the spatial multiplexing used to increase the capacity of MIMO link by transmitting independent data streams in the same time slot and frecy quency band simultaneously for each t ransmit antenna and differentiating multipath signals. MIMO receiver using th e known transmitted signal and estimate the channel by using CIR (Channel Impulse Response) and is repeated in every tran smission burst. Which enables the receiver to have knowledge of the channel and is used in channel coding for the different enhancement in the system performance. We are trying L DPC channel coding with BPSK modulation scheme with MRC and EGC at the receiver. For multipath signals travelling through different paths have different independent path time delays and independent path phase shifts (change in angle), independent path gain (or loss), independent path frequency offsets. To remove ISI from the signal, various kinds of equalizers can be used. Different techniques are used to handle the changes made by the channel; receiver requires knowledge over CIR (C hannel Impulse Response) to remove ISI (Inter symbol interference), ISI and receive antennas [8]. Wireless channels are multipath fading channels, causing ISI (Inter symbol interference), ISI occurs when a transmission interferes with itself and receiver cannot decode the signal correctly.

2. Literature Review

Satoshi Gounai et al. [1], find result that the SNR thresholds of a regular LDPC codes and the irregular LDPC codes and optimum degree distribution of the irregular LDPC codes for ISM systems with several diversity orders.

Eric Villier [2], derived the performance of optimum combining in the presence of multiple equal power interferers and noise when there is less no. of the interferers than the sum ber of antenna elements. We have desired signal and interferers which use f l at R ayleigh fading a nd there are propagation channels which are independent. The probability density function (PDF) of the output sign al-to-interference-plus-noise ratio (SINR), cumulative distribution
function (CDF) of the SINR and the bit-error rate (BER) of some binary modulations has been derived using the Rayleigh fading.

Mackey et al. [3] proposed that the most powerful error correcting codes LDPC is based on very sparse matrices that give better results than the turbo codes. These results using LDPC codes give results close to Shannon capacity for binary symmetric channel and symmetric stationary ergodic noise.

Brennan [4], in their paper, have used three types of diversity techniques: Selection Diversity, Maximal ratio combining, and Equal Gain combining system. In this paper, we have put forward the quantitative measurement of their performances. We used Rayleigh fading in these diversity techniques. We find out that equal gain combines the term will give performances essentially equivalent to the maximum obtainable from any other system like maximal ratio combining etc. The principal application of the results is to diversity communication systems and the discussion is set in that context, but many of the results are also applicable to certain radar and navigation systems.

Mohamed-Slim Alouini [5], in this paper, find a performance analysis of two hybrids of selective combining/maximal ratio combining (SC/MRC) diversity receivers over Nakagami-m fading channels with a flat multipath intensity profile. Hence numerically compared the conventional SC and MRC schemes. Numerical results for particular cases of interest show that the bit error rate (BER) degradation arising from the use of hybrid SC/MRC instead of MRC is independent of the average signal-to-noise ratio (SNR) regardless of the severity of the fading and that MRC provides a higher rate of improvement than the hybrid SC/MRC as the severity of fading decreases.

3. Spatial Diversity

In spatial diversity, there are multiple receiving antennas placed at different locations, resulting in different (possibly independent) received signals at different times due to the multipath fading available in the channel. The difference between the diversity schemes lies in the fact that in time diversity, there is wastage of bandwidth due to duplication of the information signal to be sent. Thus the problem is alleviated in spatial diversity scheme, but at the cost of increased antenna complexity. Thus the method of transmission or reception, or both, in which the effects of fading are minimized by the simultaneous use of two or more physically separated antennas, ideally separated by one half or more wavelengths.

4. Selection Combining

Selecting the best signal among all the signals received from different branches at the receiving end. Larger the number of available branches, the higher the probability of having a larger signal-to-noise ratio (SNR) at the output. It is seen that among available receive combining techniques at receiver side; SC has worst BER performance [9].

\[ S(t) = \max(s_1(t), s_2(t)) \]

5. Maximal Ratio Combining

Combining all the signals in a co-phased manner so as to have the highest achievable SNR at the receiver at all times. The advantage is that more BER improvements can be achieved with this configuration even when branches are completely correlated. The disadvantage of maximal ratio is that it is little complicated and requires accurate estimates of the instantaneous signal levels and average noise power to establish optimum performance with this combining scheme. Maximal ratio combining will always perform better than either selection diversity or equal gain combining [10].

\[ S(t) = W_1 s_1(t) + W_2 s_2(t) \]

6. Equal Gain Combining

It is the same as that of maximal ratio combining (MRC) except that equal gains are taken in this method. Combining all the signals in a co-phased manner with unity weights for all signal levels so as to have the highest achievable SNR at the receiver at all times [11].

\[ S(t) = s_1(t) + s_2(t) \text{ (having w matrix equal)} \]
7. LPDC Filter

LPDC codes are linear error correcting block codes. These codes are characterized by their very sparse parity check matrix $H$. These codes are generally called capacity approaching codes because the system capacity using these codes is close to Shannon’s capacity limits [12].

So LPDC code is a method of transmitting a message over a noisy transmission channel and is constructed using a sparse bipartite graph. LPDC codes are capacity-approaching codes, which means that practical constructions exist that allow the noise threshold to be set very close to the theoretical maximum (the Shannon limit) for a symmetric memory-less channel. The noise threshold defines an upper bound for the channel noise, up to which the probability of lost information can be made as small as desired. Using iterative belief propagation techniques, LPDC codes can be decoded in time linear to their block length [13]. LPDC codes are defined by a sparse parity-check matrix. This sparse matrix is often randomly generated, subject to the sparsity constraints. These codes were first designed by Gallager in 1962. Below is a graph fragment of an example LPDC code using Forney’s factor graph notation. In this graph, $n$ variable nodes in the top of the graph are connected to $(n-k)$ constraint nodes in the bottom of the graph. This is a popular way of graphically representing an $(n, k)$ LPDC code. The bits of a valid message, when placed on the T’s at the top of the graph, satisfy the graphical constraints. Specifically, all lines connecting to a variable node (box with an ‘+’ sign) have the same value, and all lines connecting to a factor node (box with a ‘*’ sign) must sum, modulo two, to zero (in other words, they must sum to an even number). LPDC encoding algorithm can be represented by a bipartite graph called Tanner graph [14].

8. New Proposed Technique

The new proposed technique is based on the LDPC filter. The multiple split signals received by the receiver are joined together and form the original signal. The bit rate is very high in MIMO-OFDM because of the unique features of OFDM. In this paper, we are proposing the new technique to reduce bit error rate in MIMO-OFDM. The LPDC is used at the receiver side with the multiple signals merged together to form the complete signal. The simulation results show that bit error rate is reduced when LPDC filter is used with the MIMO-OFDM as compared to conventional OFDM. Also, compare the different receive combining techniques across receiver end and observe performance in terms of Bit Error Rate.

9. Conclusion

In this paper, we conclude that MIMO-OFDM is the efficient approach for fast data transmission. Due to the multipath fading effect of the propagation channel, bit error rate is very high in MIMO-OFDM. To reduce the bit error rate, we use LPDC. Also, we conclude MRC gives better error rate performance as compared to other techniques EGC and SC. Simulation results show that more reduction in bit error rate using the proposed technique as compared to previous techniques. Also, compare the different receive combining techniques, which shows MRC is outperforms well in terms of error rate analysis.

References


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