Performance Evaluation of Multilevel Linear Block Codes on Student-t Fading Channel

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Abstract— **In this paper we represent the notion of multilevel linear block codes. These codes are an amalgamation of multilevel multi-input multi-output system with linear block codes. Despite of using a single level linear block code, if we can spread out it and use at multiple levels, then there can be a substantial increase in the spectral efficiency as same bandwidth would be used to transmit more symbols than the ones transmitted with single level linear block coded system. Decoding can be cumbrous in such a multilevel system. However, this problem can be dealt by using multistage decoder that can decrypt a received sequence in multiple stages alike that used at the interval of encoding. Simulation outcomes demonstrate that the planned system significantly outdoes the conventional system.**

Keywords— **Channel Coding, Block Codes, Student-t Fading Channel, Space Time Codes.**

I. INTRODUCTION

In the past few decades the expansion of wireless communication has seen an arduous growth than many other associated fields of communication. The throughput over wireless channels has augmented along with the reliability. Even though, people need more bandwidth day by day. Bandwidth demands are never-ending. Nowadays we required to accomplish reliable wireless systems having high spectral efficiency, good error performance and low complexity outcomes. The exploration in the field of multi-input multi-output systems has assimilated a great interest in recent decade.

Multi-input and multi-output, or MIMO, uses multiple antennas at both the transmitter and receiver to ameliorate communication performance [1]. It attains this goal by distributing the same total transmits power over the antennas to realize an array gain that mends the spectral efficiency or to attain a diversity gain that expands the link reliability. MIMO schemes that adopt the channel knowledge is only accessible at the receiver have in specific engrossed a lot of research consideration [1].

MIMO modulation systems with CSI at receiver only are chiefly of two kinds, spatial multiplexing and diversity systems. space-Time coding or diversity modulation [3] [4] [5], uses codewords intended to exploit the diversity benefit of the transmitted information. Such codes incline to maximize diversity gain at the outlay of some loss in accessible capacity. Bell Labs Layered Space Time (BLAST) or Spatial multiplexing [6] type systems [2], in contrast, transmit sovereign data streams from each transmitting antenna, permitting spectral efficiency to be attained at the outlay of a loss in diversity benefit for a static number of receive antennas [7].

Linear block codes are a category of parity check codes that can be considered by the (n, k) symbolization. The encoder transmutes a block of k message digits i.e. a message vector into an extended block of n codeword digits i.e. a code vector created from a specified alphabet of elements. When the alphabet comprises of two elements 0 and 1, the code is a binarycode consist of binary digits bits.

The k-bit messages form 2^k different message arrangements, stated as k-tuples i.e. arrangements of k digits. The n bit blocks can custom as many as 2^n distinct arrangements, stated to as n tuples. The encoding technique allocates to each of the 2^k message k tuples one out of the $2^n n$ tuples. A block code signifies a one to-one consignment, howbeit, the 2^k message k tuples are distinctively mapped into a novel set of 2^k codeword n tuples; the mapping can be consummate through a look up table. For linear codes, the mapping conversion is, of course linear.

The code rate is the proportion $R = k/n$. For a binary code $R \leq 1$, hence after encoding a k information block or digit message, there are $n - k$ left behind redundant digits in the code word. The redundant digits offer the code words the capability to lessen the effect of channel noise, which could acquaint with errors through the transmission of the message [8].

The Student-T distribution should not be used with small samples from populations that are not approximately normal. Suppose that Z has the standard normal distribution, V has the chi-squared distribution with n degrees of freedom where $n \in (0, \infty)$, and that Z and V are independent. Random variable.

$$T = \frac{Z}{\sqrt{V/n}} \tag{1}$$

has the Student-T distribution with n degree of freedom.

Suppose that T has the Student-T distribution with n degrees of freedom. Then T has a continuous distribution on R with probability density function f given by

$$f(t) = \frac{\Gamma\left[n + \frac{1}{2}\right]}{\sqrt{n\pi}\,\Gamma\left(\frac{n}{2}\right)}\left(1 + \frac{t^2}{n}\right)^{-(n+1)/2} \quad t\epsilon R \tag{2}$$

The proof of this theorem provides a good way of thinking of the Student-T distribution: the distribution arises when the variance of a mean 0 normal distribution is randomized in a certain way.

II. MATERIAL & METHODS

In this section, we deliver a vision of the genuine multilevel linear block code system used in our imitations. The multilevel MIMO system used contains n_T transmit and n_R receive antennas, intended for an fundamental 16-QAM constellation with up to 4 receive and 4 transmit antennas.

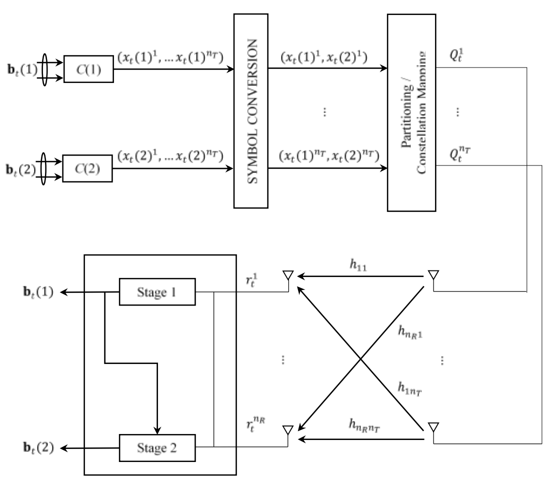

Fig. 1 Used Multilevel MIMO System

We cast-off Linear Block Codes (6, 3) as element codes. We presume Student-t fading channel model which is static over a frame and fluctuates independently between frames. Decoding or Detection of the received symbols is accomplished through multistage decoder as shown in Fig. 1. The system cast-off for simulations uses 2 levels of linear block codes as revealed above.

The symbol transmitted at time $t$at the i^{th}transmit antenna is represented by $Q_{it}, 1 \le i \le n_T$. The channel displays frequency flat Student-t fading over the frame interval. Hence, it remains constant over one frame and independently varies between frames. We presume perfect CSI is existing at the receiver only.

The received signal at time t, by the j^{th} receive antenna is tainted with noisy superposition of independently by the faded versions of Student-t channel n_T transmitted signals and is represented by $r_{jt}, 1 \le j \le n_R$. The discrete complex baseband o/p of the j^{th}receive antenna at time t is specified by,

$$\boldsymbol{r}_t = \boldsymbol{H}_t \boldsymbol{Q}_t + \boldsymbol{\eta}_t$$

where, $\boldsymbol{H}_t$ is the path gain among the i^{th} transmit and j^{th} receive antennas and $\boldsymbol{\eta}_t$ is the noise related with the j^{th}receive antenna at time t. The path gains, $\boldsymbol{H}_t$, are modelled as trials of independent complex Gaussian random variables with variance of ½ per dimension and zero mean. The noise quantities are trials of independent complex Gaussian random variables with variance of $N_0/2$ per dimension and zero mean.

III. RESULTS & DISCUSSIONS

The outcome of error correction on the bit error rate (BER) performance of the code is deliberated in this section. Performance is assessed using two transmit and different number of receive antennas. The BER performance of a system revealed in below Fig. 1 and is displayed in the subsequent figures. The spectral efficiency is 4 bits/sec/Hz and the essential constellation is 16-QAM. Two similar (6, 3) Linear Block Codes were used as element codes. We presumed perfect CSI at the receiver only. Student-t fading channel.

Fig. 2 validates the error performance assessment for two transmit and one receive antenna. It can be realized that with error correction the system is healthier by about 3.5 dB at the BER of 10^{-1}. Fig. 3 determines the error performance comparison for two transmit and two receive antenna. It can be perceived that with error correction the system is improved by about 2.4 dB at the BER of 10^{-2}. Fig. 4 exhibits the error performance comparison for two transmit and four receive antenna. It can be perceived that with error correction the system is ameliorated by about 6.1 dB at the BER of 10^{-2}.

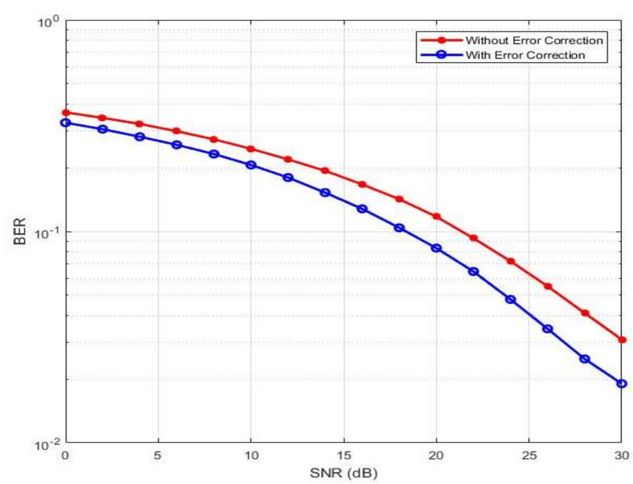

Fig. 2 BER performance for two transmit and one receive antennas.

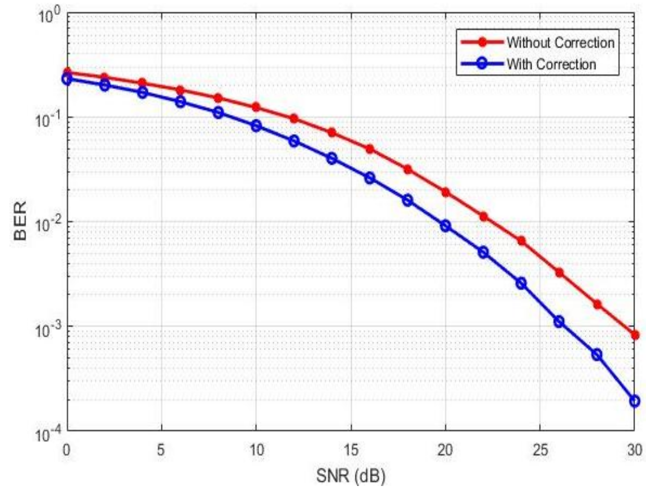

Fig. 3 BER performance for two transmit and two receive antennas.

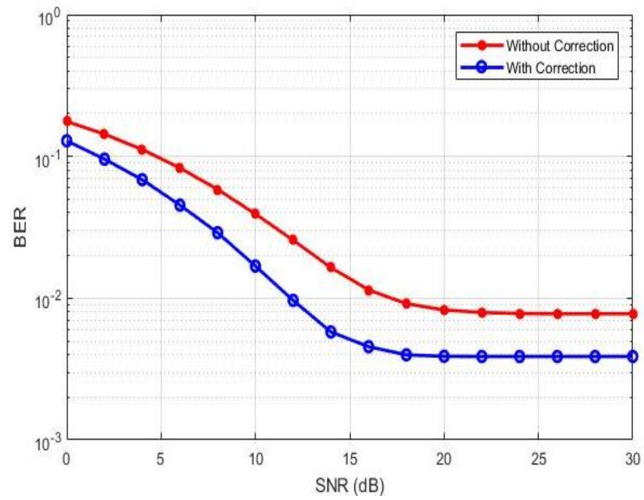

Fig. 4 BER performance for two transmit and four receive antennas.

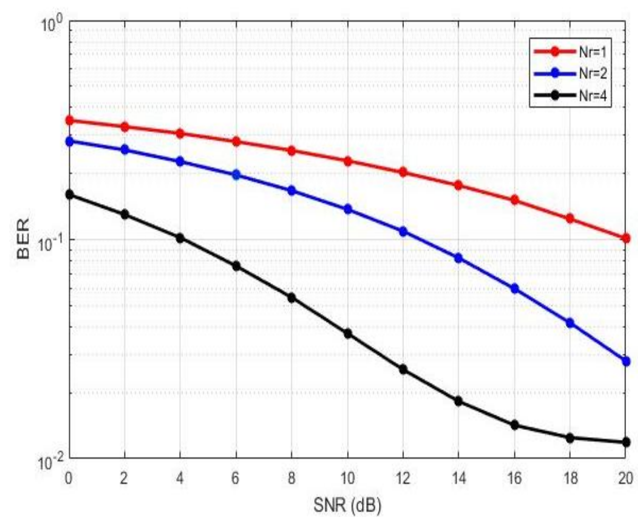

Fig. 5 BER performance for two transmit and different number of receive antennas (Without Error Correction).

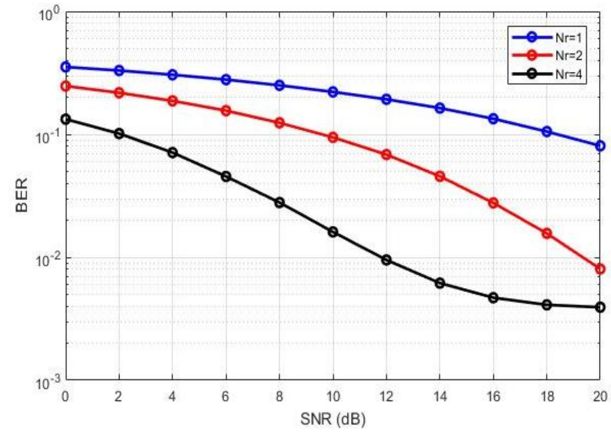

Fig. 6 BER performance for two transmit and different number of receive antennas (With Error Correction).

Now we contemplate the upshot of receive diversity on the bit error rate performance of the code. Performance is calculated using two transmit and different no. of, i.e. 1, 2 and 4 receive antennas. The fundamental system is shown in Fig. 1. The underlying constellation is 16-QAM. Two similar (6, 3) Linear Block Codes were used as element codes. We presumed perfect CSI at the receiver only.

Fig. 6 and Fig. 7 exemplifies the labelled system by means of an underlying QAM modulation. In instance of receiver diversity, liberated fading paths are imparted without a surge in bandwidth or transmit signal power. Coherent relating of the diversity signals primes to a proliferation in SNR at the receiver over the SNR that would be attained with just a single receive antenna. As a result, with intensification in the number of receive antennas, the BER must decline, i.e., the error performance ameliorates with receive diversity. The above shown outcomes imitate the fact that with a rise in the number of receive antennas we get a substantial error performance gain.

IV. CONCLUSIONS

In this paper we reveal a multilevel coding arrangement that termed as Multilevel Linear Block coding, as an addition for the simply Linear Block coding or single level Linear Block coding, without giving up the competency of coding gain, diversity improvement, and bandwidth efficiency with more or less alike decoding complexity, particularly for higher throughputs and largerconstellations. The projected system gained a noteworthy enhancement in the BER performance with error correction. BER performance enhanced more with the use of receive diversity. The scheme with 4 receive antennas accomplished better than the system with one or two receive antennas. Linear Block Codes executed remarkably in case error correction. This ability of error correction of the linear block codes in a multilevel environment assisted in realising higher throughput along with a reliable and a reduced amount of error prone wireless communication, as revealed in our simulated results.

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