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Digital Video Broadcasting in STBC Site Diversity Technique for MC-CDMA System

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ABSTRACT: The combination of multiple antennas and multicarrier code division multiple accesses (MC-CDMA) is a strong candidate for the downlink of future mobile communications. The study of such systems in scenarios that model real life transmissions is an additional step towards an optimized achievement. Nevertheless, when transmitting over fading channel multi-cell interference occurs and this degrades the performance of the system. Site diversity technique is applied to the system to overcome multi-cell interference. Due to non orthogonal of spreading codes, multi-cell interference is not completely eradicated. To overcome this problem, spreading codes are assigned to each base station. Space time trellis code (STTC) site diversity with multiple input multiple output (MIMO) technique was introduced to reduce multi-cell interference further. STTC based space time block code (STBC) site diversity technique is proposed to improve the performance of MC-CDMA system. Simulation result shows that STTC based STBC site diversity outperforms STTC site diversity. MC-CDMA is a promising wireless access method for wideband downlink transmission due to its robustness against the frequency-selectivity of a multipath channel and its high-frequency efficiency.

Keywords: Multiple Input Multiple Output systems (MIMO), Adaptive Channel Estimation (ACE), RLMS, LLMS, LMS, RLS

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) has been accepted as a promising air –interface due to its high spectrum efficiency. High spectrum efficiency is provided due to the fact that in this whole spectrum is shared by all the OFDM sub carriers that are orthogonal to each other. FFT and IFFT operations are used in OFDM due to which the oscillators are not required at the transmitter and receiver side. Thus it reduces the complexity at transmitter and receiver and also they are fast algorithms for implementing DFT and IDFT which decreases the computation complexity as compared to DFT and IDFT. Moreover it provides ISI free communication due to the use of CP (cyclic prefix) which is just the repetition of tail of the symbol at the front part of the symbol. OFDM acts as a standard for many wireless applications like Digital Video Broadcasting (DVB), Digital Audio Broadcasting (DAB) [1] [2], WIMAX, Wireless Local Area Network (WLAN) and ADSLs [1] [5].

If multiple transmit and receive antennas are used then the capacity of the system can be increased. The systems which use multiple antennas at the transmitter and receiver are called MIMO systems [3]. The capacity of the MIMO system can be improved by a factor equal to minimum number of antennas employed at the transmitter and receiver. Transmission rate is increased in case of spatial multiplexing while BER enactment is improved in case of spatial diversity. Therefore, these are widely used in many wireless applications in combination with OFDM forming MIMO-OFDM system. Parallel transmission is done by dividing whole channel into many sub-channels, thus attaining high data rate and increasing symbol duration to battle ISI. STBCs are used to increase the diversity gain in MIMO systems. Channel capacity and multiplexing gain is increased by spatial multiplexing (SM) [5]. The challenging problem for wireless systems is channel estimation. In wireless systems channels are dynamic in nature as compared to guided media.

The signal is received at the receiver after undergoing many adverse effects due to reflection, scattering and diffraction and that too from multi path. Channel response is time variant due to mobility of transmitters, receivers and other obstacles. The signal spreads over the statistics like frequency, time, phase. These statistics define the channel selectivity and has a great impact on received signal. These effects of the channel on its response have to be known which is known as channel estimation or channel state information estimation. For data detection and equalization we need channel State Information (CSI) at the receiver side. Broadly if we classify channel estimation then there are two ways for channel estimation- one is the Training based channel estimation and second one is blind channel estimation. There is also one more of its type called semi blind channel estimation because it employs both of the techniques. It is the combination of the above two. Training based channel estimation uses two types of pilot types i.e. block type and comb type [2]. In comb type the pilots are inserted into certain sub-carriers of each OFDM symbol and not in all the subcarriers while in case of block type the pilots are inserted into all sub-carriers of OFDM symbol within some predefined period. Also comb type is mostly used for fast fading channels while the bock type is used for slow fading channels. Comb type pilot organization outperforms block type pilot organization. Other type is the blind channel estimation which exploits the statistical facts of the symbols that are received at the receiver. But this type of channel estimation can only be used for slow time varying channels. Moreover this type of channel estimation technique increases the complexity at the receiver. Although pilot based channel estimation (CE) consumes bandwidth more than blind type but it is a good candidate for fast time varying channels [5]. Adaptive CE algorithms are gaining more attention these days. Least Mean Square (LMS) [10] [13] is widely used for its simplicity. If complexity is not an issue then Recursive Least Square (RLS) [10] [11] is a good choice. Moreover to use the best part of the above given Adaptive Channel Estimation (ACE) algorithms they can be combined to build the hybrid algorithms. Leaky Least Mean Square (LLMS) [12] algorithm is such an algorithm.

The following notations would be used throughout the paper - (.)* represents the conjugate complex of the vector or variable, E(.) represents the expectation operator and (.)H represents the hermitian or we can say conjugate transpose. All the variables used are vectors as here we are dealing with MIMO systems therefore inputs and outputs are not scalars rather they are vectors. Further the next sections are organized as depicts the MIMO-OFDM system and the system model. Adaptive Channel Estimation (ACE) is described in discusses the proposed ACE algorithm for MIMO OFDM systems. MIMO in combination with OFDM is widely used now-a-days due its best performance in terms of capacity of channels, high data rate and good outcome in frequency selective fading channels. In addition to this it also improves reliability of link. This is attained as the OFDM can transform frequency selective MIMO channel to frequency flat MIMO channels [4]. So it is widely used in future broadband wireless system/communications. Cyclic prefix is the copy of last part of OFDM symbol which is appended to the OFDM symbol that is to be transmitted. It is basically 0.25% of the OFDM symbol. We can say that one fourth of the OFDM symbol is taken as CP (cyclic prefix) and appended to each OFDM symbol. IFFT is used at the transmitter and FFT is used at the receiver which substitutes the modulators and demodulators. Doing so eliminates the use of banks of oscillators and coherent demodulators. Moreover the complex data cannot be transmitted as it is, therefore it is first converted to analog form which is accomplished by IFFT. It basically converts the signal from frequency domain to time domain.

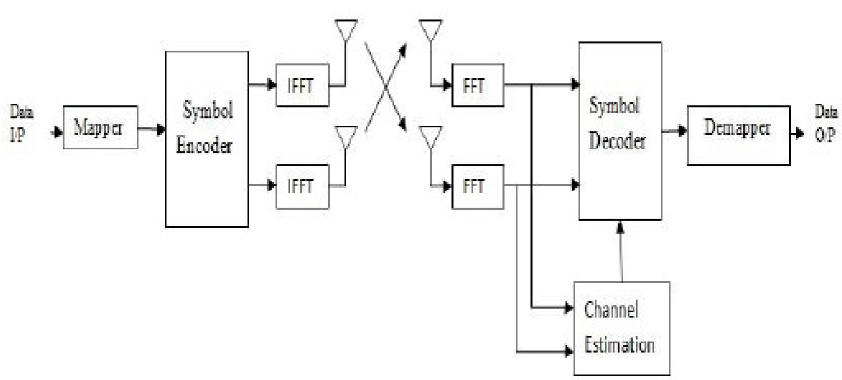

Fig. 1. MIMO-OFDM system model.

Prior to IFFT operation symbol mapping is performed which is nothing but the modulation block. Any of the widely used modulation techniques can be applied like BPSK, QPSK, QAM, PSK etc. Further there are higher order modulations are also available which provide more capacity at little expense of BER performance degradation. After IFFT block pilot insertion is done and then CP (cyclic prefix) is added. Below shows the block diagram constituting MIMO and OFDM. Any antenna configuration for the MIMO can be used according to the system requirement. Higher the configuration more will be the capacity and more will be the computational complexity of the transceiver design. It is seen that in the case of estimating channel the computational complexity is increased. Mapper defines the modulation to be used. Symbol encoder takes the shape of the STBC (Space Time Block Code) if spatial diversity is to be used and it takes the shape of the de-multiplexer/multiplexer if spatial multiplexing is to be used. The received signal at j^{th} antenna can be expressed as Rj[n.k] = Σ Hij[n,k] Xi [n,k] + W[n,k] (1) Where H is the channel matrix, X is the input signal and W is noise with zero mean and variance. Also bi[n,k] represents the data block i^{th} transmit antenna, nth time slot and k^{th} sub channel index of OFDM. Here i and j denoted the transmitting antennas index and receiving antenna index respectively. The MIMO-OFDM system model [4] with NR receive antennas and NT transmit antennas can be given as: = + (2)

$$\begin{bmatrix} Z_1 \\ Z_2 \\ \vdots \\ Z_N \end{bmatrix} = \begin{bmatrix} H_{1,1} & H_{1,2} & \cdots & H_{1,NT} \\ H_{2,1} & H_{2,2} & \cdots & H_{2,,NT} \\ \vdots & \vdots & \ddots & \vdots \\ H_{NR,1} & H_{NR,2} & \cdots & H_{NR,NT} \end{bmatrix} \begin{bmatrix} A_1 \\ A_2 \\ \vdots \\ A_{NT} \end{bmatrix} + \begin{bmatrix} M_1 \\ M_2 \\ \vdots \\ M_{NT} \end{bmatrix} \quad (2)$$

Where, Z represents O/P data vector, H denotes Channel matrix, A denotes I/P data vector and M represents Noise vector. The wireless channel used is AWGN channel. After receiving the signal the CP is removed then the pilots are also removed from main signal received. After this the signal that is in time domain can be again converted to frequency domain by taking FFT of the received signal. The sequence on each of the OFDM block is then provided to channel estimation block where the received pilots altered by channel are compared with the original sent pilots. Channel estimation block consists of the algorithms that are applied to estimate the channel. These are discussed below in the following sections.

II. ADAPTIVE CHANNEL ESTIMATION

CE (channel estimation) methods are divided into two types. One is training based and the other one is blind i.e. without training sequences. There are various types of channel estimations and broadly they can be classified as Training based estimation, semi blind estimation and blind channel estimation. Training based requires pilot bits to be sent along with the data. Arrangement of pilot bits can be block type and comb type [7]. In block type transmission of pilot is done on each and every subcarrier at successive intervals of time. While in comb type pilots are sent for whole time i.e pilots are implanted into apiece OFDM emblem. Blind channel approximation is done by exploiting the statistical [7] properties of the network. It is advantageous to use as it does not wastes bandwidth as no pilots are needed. But it has performance less than pilot based so rarely used. Moreover it makes the receiver more complex. Adaptive CE (channel estimation) methods or algorithms are being widely deployed in channel estimation. As we know that the wireless channel is time varying and totally random in nature. Therefore to keep track of it an adaptive algorithm best suits it. These CE algorithms after successive iterations converges to the optimum solution [8]. Also they provide good tracking capability. Various adaptive CE estimators available are LMS, RLS, NLMS etc. They continuously update their parameters until they reach the optimum solution. Moreover they need only the received signal which includes the training sequences which were sent at the transmitter. These are known to the receiver which are used by these adaptive CE algorithms to check the error value or we can say that to minimize the error value in order to reach the optimum solution. Updating the parameters is dependent on the step size parameter in case of stochastic gradient algorithms [8]. The greater the step size the more will be the convergence speed. The time required by the algorithm to reach the optimum solution decreases hence the steady state error is reached. While if it increases too much then there is a chance that system may become unstable. If the case of recursive algorithms is seen we see that they are not dependent on the step size parameter, thus making them good and fast estimators. But there is a con in them i.e. they are very complex. Their complex structure requires more hardware cost also. Though they are faster than stochastic gradient algorithm but complexity marks them as unusable but now the scenario is changing with the improved hardware structures in use.

A. LMS algorithm

Least Mean Square (LMS) method or algorithm is widely used in numerous applications which includes system identification. i.e. it is an adaptive channel estimation technique.

LMS is a very simple and adaptive CE method among others. LMS has slow convergence speed. Moreover its complexity is less. Basically LMS algorithm can be expressed as follows Where, is initial weight vector, is final weight vector, is step size, is input vector and is error signal. Also [8] is the maximum eigen value of the correlation matrix.

III. RESULTS

A new closed-loop transmit diversity scheme for Optimized STBC Site Diversity Technique for MC-CDMA System diversity systems based on space-time block coding (STBC). The receiver of the scheme checks the output signal-to-noise ratio (SNR) of the space-time decoder against an output threshold and requests the transmitter to replace the transmit antenna resulting in the poorest path with an unused antenna if the output SNR is below the threshold. We provide some interesting statistical analysis and obtain closed-form expressions for the cumulative distribution function the probability density function and the moment-generating function of the received SNR.

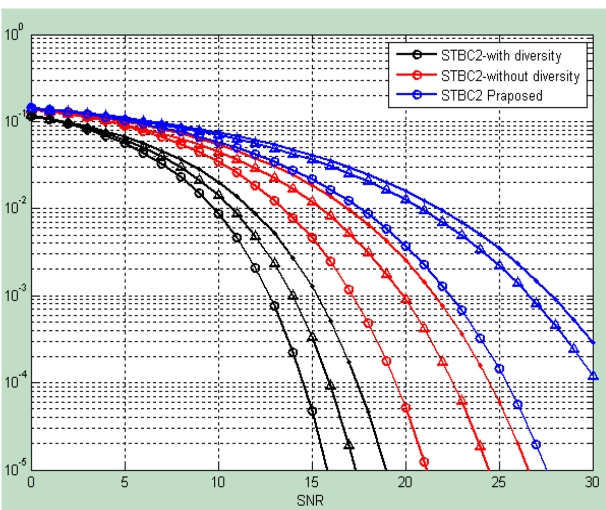

Fig. 2. BER vs. SNR for STBC2 with diversity, STBC2 without diversity, STBC2 Proposed.

We show through scheme offers a significant performance gain with a very minimal feedback load over existing open-loop diversity systems, and for a properly chosen threshold, its performance is commensurate with a more complicated generalized-selection-combining-based transmit diversity system. The purposed algorithm is applied for channel estimation in MIMO OFDM system using BPSK as modulation. Channel used is Gaussian channel. Above Fig. shows the BER vs SNR plot for the RLMS algorithm and LLMS algorithm. It is seen that the curve for RLMS shows a decrease in BER as compared to LLMS algorithm. Initially the BER performance is not improved much but as the SNR value increases the BER performance also increases. It has been observed that at BER 10^-2.5 the SNR required is 9.51db for LLMS and 8.88 for Similarly the MIMO OFDM system is checked for channel estimation using the two algorithms i.e. LLMS and RLMS respectively shows that the modulation used is QPSK. As the value of M increases in M-PSK the BER performance decreases and the capacity increases. The BER performance is decreased than the previously used for BPSK modulation. But the RLMS algorithm here again shows better performance than LLMS algorithm. By using QPSK it has been observed that at BER 10^-2.5 the SNR required is 12.50dB for LLMS and 11.73dB for RLMS algorithm. Thus there is SNR improvement by using RLMS algorithm.

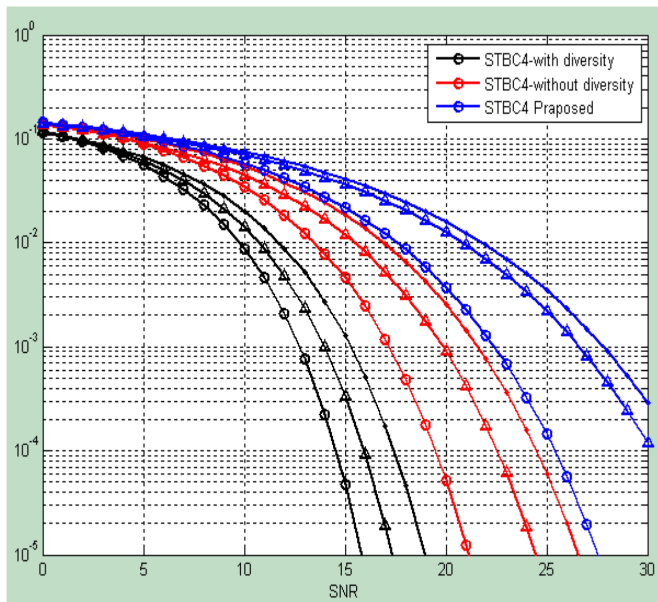

Fig. 3. BER vs SNR for Performance of the system with, without, and proposed diversity for various antennas.

IV. CONCLUSION

A novel receiver scheme has been investigated for MC-CDMA systems using Alamouti's space-time block coding. In particular, we considered a Minimum Conditional Bit-Error-Rate (MCBER) MUD linear receiver in order to reduce the computational complexity without significant performance degradations with respect to the formal MBER criterion.

In the perspective of a real receiver deployment, an adaptive LMS-based implementation of the MCBER detector has been integrated with a robust and computationally affordable channel estimation assisted by a genetic optimizer. The proposed MCBER approach always allows improving BER performances with respect to other state-of-the-art linear detectors working with the same degree of channel knowledge. It is worth noting that the performance improvement with respect to MMSE-MUD strategies is achieved by spending a reduced computational effort, linearly increasing with the number of users. Numerical results evidenced that BER curves of MCBER and ideal MMSE are getting closer as the number of users approaches the maximum allowable value. This behavior is intrinsic to the linear multiuser detection and fully motivated by the nature of the MCBER criterion adopted. Activities might concern the utilization of evolutionary optimization algorithms (e.g., GA, Particle Swarm Optimization (PSO), etc.) to provide a numerical solution to the MCBER problem instead of the proposed LMS-based solution. Also the adoption of PSO-assisted channel estimation, instead of GA-assisted one, may represent an interesting topic for future research STBC Space Time Block Coding is a technique that is used within wireless communication networks for the purpose of transmitting multiple copies of one data stream across many antennas, so that the different received versions of that data can be utilized to help improve the data-transfer reliability rating In MC-CDMA systems, each data undergoes a different channel condition and arrives with a different error rate at the base station. By transmitting message data based on the Channel State Information (CSI), a new data transmission scheme called Adaptive Multi-Carrier CDMA a higher system capacity than a conventional MC-CDMA at various noise scenarios STTC with two-transmit antennas. The trellis diagram is similar to those used in the trellis coded modulation (TCM). State bits are shown at the right of the trellis; each line represents a possible transition with the input bits shown besides the line. Current state outputs and inputs are shown in the matrix at the left of the trellis and are grouped together for different transmit antennas. Symbol bits are fed as input to the upper and lower branches. The branch coefficients are arranged alternatively in the generator matrix, with i a representing the most significant bit and bi, the least significant it. The output of the encoder is computed.

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