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Analysis of MIMO-OFDM System with Transmission

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ABSTRACT: In this paper we provide complete analysis of MIMO-OFDM system in detail with transmission schemes. Paper deals with brief idea of MIMO system used in different analysis with methodologies and graphical analysis proposed. Orthogonal frequency division multiplexing (OFDM) is popular method for high data rate wireless transmission. resulting in a multiple-input multiple-output (MIMO) configuration. This paper explores various physical layer research challenges in MIMO-OFDM system design, including physical channel measurements and modeling, analog beam forming techniques using adaptive antenna arrays, space–time techniques for MIMO-OFDM, error control coding techniques, OFDM preamble and packet design, This paper presents the performance evaluation of Alamouti's space-time block coded (ASTBC) MIMO-OFDM systems covering channel model, channel capacity, coding scheme and diversity gain. Performance analysis of the system with graphical approach is presented in this paper.

KEYWORDS: MIMO, OFDM, ASTBC, Adaptive antennas, broadband wireless.

I. INTRODUCTION TO TRANSMISSION SCHEME FOR MIMO-OFDM

In recent years, orthogonal frequency division multiplexing (OFDM) technique has attracted a lot of attention in the standardization of broadband wireless systems. OFDM technique is multicarrier modulation technique with a rather simple implementation performed using FFT/IFFT algorithms, and robust against frequency-selective fading channels which is obtained by converting the channel into flat fading sub channels [1]. OFDM has been adopted for various of transmission systems such as Wireless Fidelity (WIFI), Worldwide Interoperability for Microwave Access (WIMAX), Digital Video Broadcasting (DVB), Long Term Evolution (LTE)[2].Combining OFDM with multiple input multiple output (MIMO) technique increases spectral efficiency to attain throughput of 1 Gbit/sec and beyond, and improves link reliability [3]. MIMO concept can be implemented in various ways, if we need to use the advantage of MIMO diversity to overcome the fading then we need to send the same signals through the different MIMO antennae, and at the receiver end, the different antennae will receive the same signals travelled through diverse paths. If we want to use MIMO concept for increasing capacity then we need to send different set of data at the same time through the different MIMO antennae without the automatic-repeat request of the transmission. Theoretically, MIMO technique to be efficient the antenna spacing needs to be at least half the wavelength of the transmitted signal, even though, in some recent research this theoretical bound has been conquered and recently some broadband mobile phones support more than one antenna [3]&[4]. Efficient implementation of MIMO-OFDM system is based on the Fast Fourier Transform (FFT) algorithm and MIMO encoding, such as Altamonte Space Time Block coding(STBC), the Vertical Bell-Labs layered Space Time Block code VBLASTSTBC, and Golden Space-Time Trellis Code (Golden STTC).

In this paper, a new transmission scheme for MIMOOFDM systems is proposed. The new transmission approach reduces significantly the complexity of the conventional MIMO-OFDM systems for the symmetric channel. The principal of the proposed scheme is based on channel coding which make use of the estimated channel parameters extracted from a pilot signal transmitted by the destination receiver. Thus, the transmitted signal is very much adapted to the channel impairments and variations. The paper is organized as follows. In section II, the conventional MIMO-OFDM system is described. In section III, the new transmission model is presented. In section IV, the performances of the proposed transmission scheme are analyzed via simulations, and a comparative study with the conventional MIMO-OFDM system using Altamonte encoder is also conducted. Finally, conclusions are drawn in section V. Although formatting instructions may often appear daunting, the simplest approach is to use this template and insert headings and textinto it as appropriate.

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II. CONVENTIONAL MIMO-OFDM SYSTEM

The general structure of MIMO-OFDM system is shown in figure 1. The proposed system consists of 2 transmit and 2 receive antennae. The OFDM signal for each antenna is obtained by applying the inverse Fast Fourier transform (IFFT) and can be detected using Fast Fourier transform (FFT) [5]. A pilot sequence is inserted and used for the channel estimation. Also, acyclic prefix is inserted in front of the OFDM symbol at the last step of OFDM modulation block.
The time length of the cyclic prefix should be greater than the maximum delay spread of the channel. The main function of the cyclic prefix is to guard the OFDM symbol against InterSymbol Interference (ISI), hence, this cyclic prefix is called the guard interval of the OFDM symbols [Ref]. The MIMO coding can use several encoders such as STBC, VBLAST and Golden coding. In this paper, the conventional MIMO-OFDM system is implemented using Alamouti STBC with two transmits and two receive antennas.

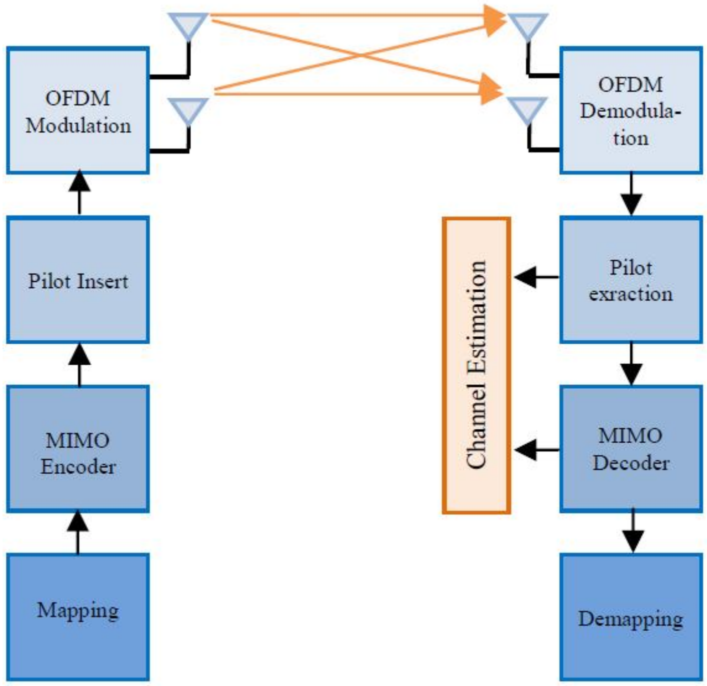

Figure 1. MIMO-OFDM system model.

III. NEW TRANSMISSION MODEL

The new transmission model is suitable for symmetric channels, such as the transmission between two base stations, microwave links, or radio beam transmission. The proposed MIMO-OFDM model is shown in the following figure 2.

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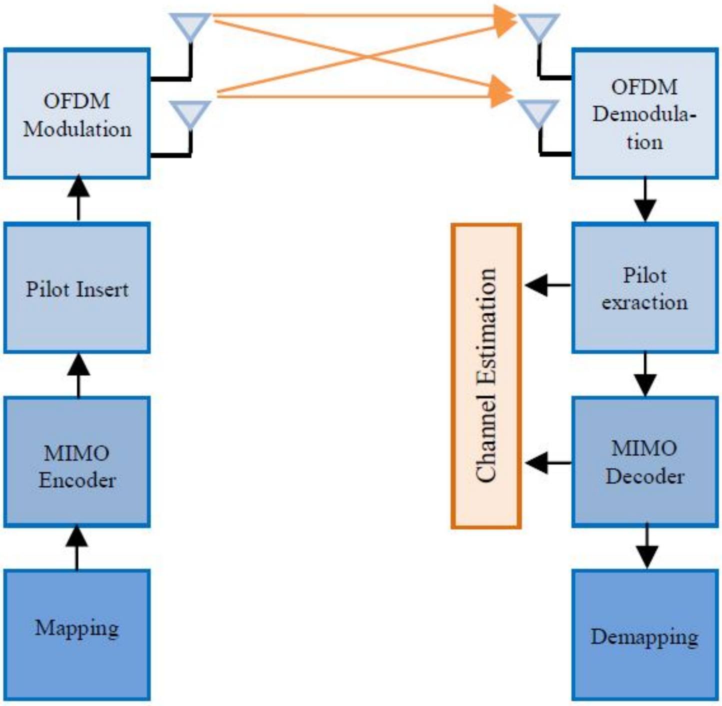

Figure 2. Proposed MIMO-OFDM system model for symmetric channel.

In this new MIMO-OFDM model, the channel parameters are estimated from a pilot data transmitted by the receiver end. These estimated parameters are used by a special channel coding block to adapt the transmitter signal to the diverse channel impairments and variations. To reduce the system complexity we have removed the pilot insert, the pilot extraction, the MIMO encoder and the MIMO decoder from the conventional MIMO-OFDM scheme. The channel coding is based on the channel variations, this channel in our case is between two transmit antennae and two receive antennae, and it can be modelled as shown in the figure 2. First, the receiver send a pilot signal to the transmitter, which can expressed as follows :

$$\begin{cases} Y_1^p = H_{11}.X_1^p + H_{21}.X_2^p + N_1^p \\ Y_2^p = H_{12}.X_1^p + H_{22}.X_2^p + N_2^p \end{cases} \quad (1)$$

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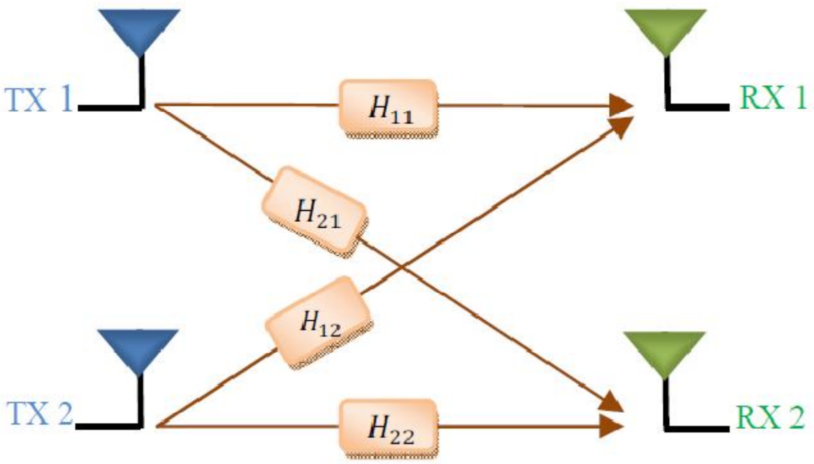

Figure 3. MIMO channel model.

Where:
X_1^p and X_2^p are the orthogonal transmitted pilot signals from the transmit antenna RX1 and RX2, respectively.
Y_1^p and Y_2^p are the received pilot signals on the receive antenna TX1 and TX2, respectively.
Y_1^2 and Y_2^2 are the received information at time slot 2 on receive antenna RX1 and RX2, respectively.
H_{ij} is the channel from j^{th} transmit antenna TXj to i^{th} receive antenna RXi, with i and $j \epsilon \{1,2\}$.
N_1^p and N_2^p are the noise components on receive antenna TX1 and TX2, respectively.
N_1^2 and N_2^2 are the noise at time slot 2 on the receive antenna TX1 and TX2 respectively.

IV. MIMO SYSTEM DESCRIPTION

The key challenge of future wireless communication systems is to provide high data rate wireless access at high quality of service. Since spectrum is a scarce resource and propagation conditions are hostile due to fading caused by destructive addition of multi-path components and interference from other users, it is required to radically increase spectral efficiency and to improve link reliability as a solution. During the last decade, many researchers have proposed multiple-input multiple-output (MIMO) wireless technology that seems to meet these demands by offering increased spectral efficiency through spatial multiplexing gain and improved link reliability due to antenna diversity gain [1, 2]. In addition, the MIMO system containing multiple antennas both at transmitter and receiver end can potentially meet the growing demand for higher capacity in wireless communications [3, 4].The information capacity of wireless communication systems increases dramatically by using multiple transmitting and receiving antennas. Space-time coding, an effective approach for increasing data rate over wireless channels, employs coding techniques appropriate to multiple transmitting and receiving antennas. Hence, a new generalized complex orthogonal space time block code for several transmit antennas with full rate has been proposed in [5, 6]. In the fourth generation wireless communication systems the data rate may be as high as 1Gbps. For that, space-time coding techniques may be employed in conjunction with the multi-carrier code division multiple access (MC-CDMA) system to achieve very high data rate [7]. Different types of space-time trellis and block codes have been proposed for MC-CDMA systems in [8]. Many literatures has proposed space-time block coding schemes for orthogonal frequency division multiplexing (OFDM) systems based on the Alamuoti's scheme [9]. In frequency selective fading channels, space-time coded OFDM is a popular approach to provide transmit diversity and coding gains, which are termed as space-time trellis coded OFDM [10], and space-time block coded OFDM [11-16]. In particular, the combination of orthogonal space time block codes (OSTBCs) and OFDM, or simply OSTBC-OFDM has drawn much attention because it attains the maximum transmit diversity and has a simple maximum-likelihood (ML) receiver structure [12-16]. OFDM in conjunction with MIMO techniques allows us

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to realize and satisfy the ever growing demands of multimedia services and applications. OFDM has already been used successfully in standards for digital audio broadcasting (DAB), terrestrial video broadcasting (DVB-T), and wireless local area networks (WLANs) [17]. In this paper, we present an Alamouti's STBC coded MIMO-OFDM system for various antenna configurations to fulfill the demand of 4G wireless technology. A brief discussion on Alamouti's STBC is presented. Simulation results of Alamouti's STBC with various antenna configurations are analyzed to evaluate the performance in terms of BER. Finally, mathematical models of MIMO channel capacity for deterministic, random fading ergodic and correlated MIMO channels are presented and capacity of the different MIMO channels is evaluated for various antenna configurations under different channel correlation matrix.

V. SIMULATION RESULTS

Simulation results are presented to evaluate the performance of ASTBC coded MIMO-OFDM system with more than one antenna at the receiver and channel capacity for MIMO-OFDM system under independent, identically distributed (i.i.d) and spatially correlated MIMO-OFDM Rayleigh fading channels. This section is divided into two parts, i.e. the performance analysis of ASTBC coded MIMO-OFDM system and capacity analysis of deterministic, ergodic and spatially correlated MIMO-OFDM system under Rayleigh fading channel with different correlation matrix.

A. ASTBC MIMO-OFDM SYSTEM

At first the performance of Alamouti's Space Time Block Coded MIMO-OFDM system under Rayleigh fading channel is investigated with various antennas configurations. The

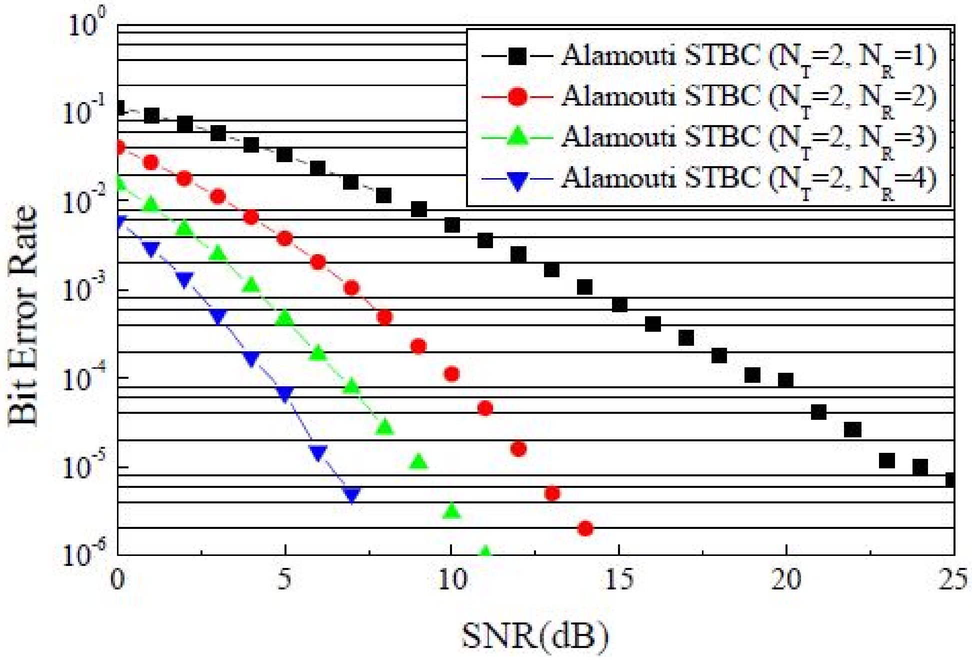

Figure 2. BER Performance of Alamouti's STBC for Various Antenna Configuration

simulation model employs BPSK modulation scheme and Alamouti's coding scheme using two transmit antennas and more than one receive antennas. In this case, we assume that transmit and receive antennas are uncorrelated, that is, those antennas are separated far enough from each other so that the fading processes affecting those antennas can be considered to be independent and identically distributed. We also assume that the channel coefficients are constant during each OFDM frame. Figure 2 compares the BER for different number of receive antennas and two transmit antennas system under Rayleigh fading channel. We observe that the performance of two transmit antennas with four receive antennas is much better than that of the system with two transmit antenna and less than four receive antennas in term of BER. We observe that the receive diversity gain increases with the number of receive antenna in the system and

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consequently the BER reduces quickly at the low value of SNR that improves the system performance of ASTBC MIMO-OFDM in terms of diversity gain.

B. MIMO CHANNEL SYSTEM

The performance of deterministic, ergodic and correlated MIMO channel capacity per unit bandwidth is investigated as a function of SNR. We also investigated the cumulative density function in the case of ergodic channel capacity. Finally the channel capacity of correlated MIMO channel for case 1 and case 2 as described above in section 5.3 is investigated. Figure 3 and Figure 4 shows both deterministic channel capacity and MIMO ergodic channel

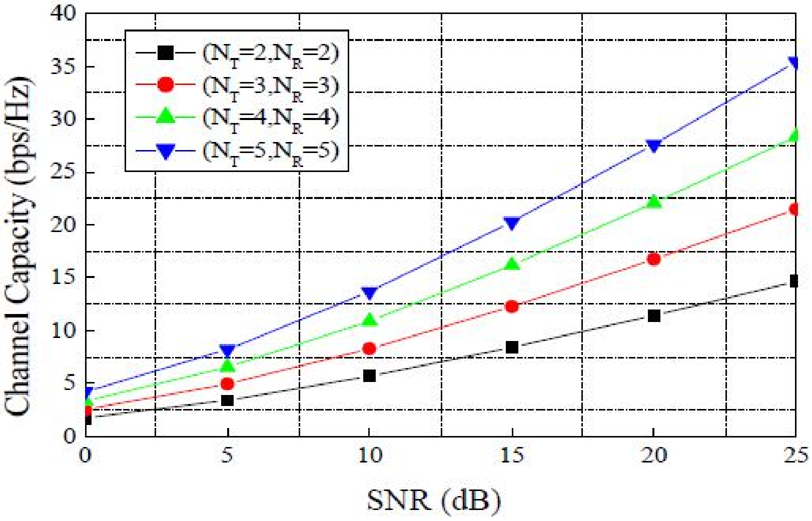

Figure 3. Deterministic MIMO Channel Capacity in Terms of SNR

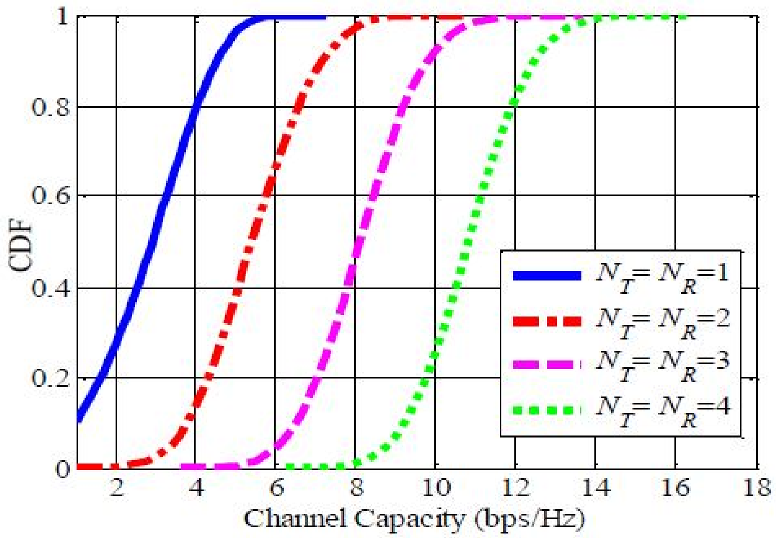

Figure 4. Ergodic MIMO Channel Capacity in Terms of SNR

VI. CONCLUSION

This paper has discussed a number of PHY layer issues relevant for the implementation of broadband MIMO-OFDM Systems. We have discussed in detail the peculiar issues relating to MIMO-OFDM synchronization and channel Estimation. We then discussed space–time coding strategies for closed loop MIMO-OFDM systems where knowledge

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of the channel is available at the transmitter. Error correction coding was discussed with an emphasis on high-rate LDP codes. Adaptive analog beam forming techniques were discussed that can provide the best possible MIMO channel environment. In this paper we evaluated the performance of the ASTBC MIMO-OFDM system under Rayleigh fading channel. We observe that the performance of two transmit antennas with more receive antennas is much better than that of the system with two transmit antenna and less receive antennas in term of BER due to the more diversity gain of Alamouti's code.

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