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A Literature Review for Performance Analysis of MIMO-OFDM System

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Abstract:- Orthogonal Frequency Division Multiplexing is a scheme used in the area of high-data rate mobile wireless communications such as cellular phones, satellite communications, wireless LANs and digital video/audio broadcasting. This method mainly utilizes to combat ISI. OFDM is a special form of Multi Carrier Modulation with densely spaced subcarriers with overlapping spectra, thus allowing for multiple-access. These multiple subcarriers overlap in the frequency domain, but do not cause Inter-Carrier Interference due to the orthogonal nature of the modulation. Multi Carrier Modulation is the principle of transmitting data by dividing the stream into several bit streams, each of which has a much lower bit rate, and by using these sub-streams to modulate several carriers. This technique is being investigated as the next generation transmission scheme for mobile wireless communications networks. Multiple transmit antennas may be used to obtain transmit diversity and to form MIMO channels. In this review paper we have analyzed MIMO systems for archiving the improvement in the performance further the capacity by a factor of minimum number of transmit or receive antennas.

Keywords- MIMO-OFDM; Channel estimation; multipath propagation; MMSE; diversity; spatial multiplexing; space time coding.

I. INTRODUCTION

Wireless communications is an emerging field, which has seen enormous growth in the last two decades. The next generation of broadband wireless communication systems is expected to provide users with wireless multimedia services such as high speed internet access, wireless television and mobile computing. The rapidly growing demand for these services is driving the communication technology towards high data rates, higher mobility, and higher carrier frequencies that are needed to enable reliable transmissions over mobile radio channels.

In Multiple Input Multiple Output System multipath propagation would cause channel fading, which is regarded as a harmful factor to wireless communication. Though, study shows that in a MIMO system, multipath transmission can be favorable to the wireless communication. Multiple antennas (or array antennas) and multiple channels are used in the transmitter and receiver of MIMO system [2]. In the transmitter, the serial data symbol stream after the necessary space-time processing is sent to the transmit antennas, and then transmitted to the receiver. In the receiver, the received data symbols are recovered through a variety of space-time detection technologies. In order to guarantee effective separation of the various sub-data symbol streams, the antennas must be separated with a sufficient distance (usually more than half a carrier wavelength) in order to prevent too much correlation between the received signals at the different antennas. Fig. 1 illustrates a MIMO system.

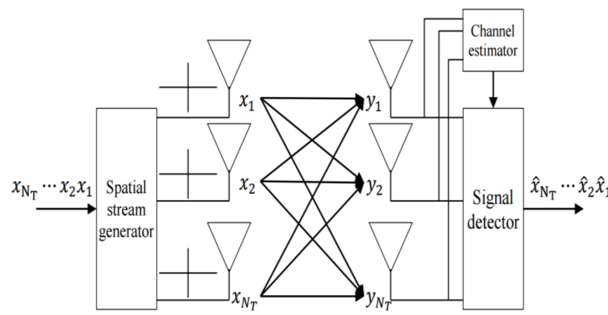

Fig. 1 MIMO system

Signals are transmitted through antennas, and after propagating over the wireless channel such as the urban channel, they are received at the receive antennas. Each receiving antenna receives a superposition sum of the signals from the transmitting antennas. In OFDM, the channel is divided into a number of orthogonal sub-channels and the high speed data signal is converted into parallel low speed sub-streams.

Those sub-streams are modulated on each sub-channel to be transmitted. Fig. 2 illustrates the basic processing in an OFDM system. OFDM is effective against frequency selective fading and Inter Symbol Interference. Since orthogonal sub-carriers are using as sub-channels, the spectral efficiency has been greatly improved. Wireless data services are asymmetric, such that the transmission capacity requirement of downlink is greater than of uplink. While using OFDM, the number of sub-channels can be adjusted flexibly to meet the different rate of downlink and uplink transmission. OFDM can be jointly used with other access methods that improve the reliability of signal transmission in physical layer. Generally, in OFDM, a certain length of the guard interval should be added and it overcomes the ISI when the duration of GI is greater than the maximum multipath delay spread of the radio channel. Typically the GI is filled with a cyclic prefix.

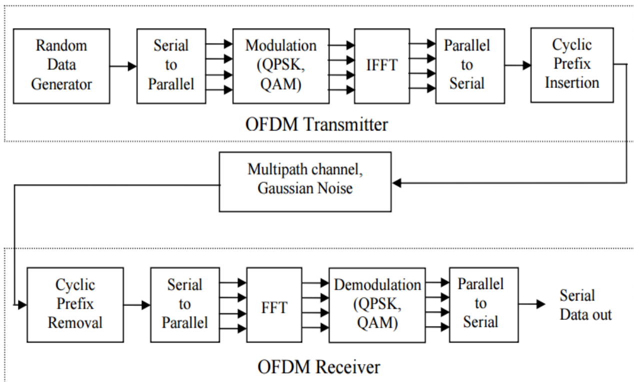

Fig. 2 OFDM system

A major advantage of OFDM technology is that fast Fourier transform (FFT)/ inverse fast Fourier transform (IFFT) could be used for the implementation of modulation and demodulation of orthogonal sub-channels [5]. For the N point FFT operation, one needs N × log (N) complex multiplications, which would be required by a straight forward implementation. OFDM is the key technology in LTE. There are various joint OFDM technologies also: V-OFDM, W-OFDM, F-OFDM and MIMO-OFDM etc. In this, it will focus on the study of five different detectors of MIMO-OFDM in LTE.

II. SYSTEM MODEL

Channel Model

While the wireless signal travels from the transmit antenna to the receive antenna, the characteristics of the signal changes because of the following factors: 1) the distance between the two antennas, 2) the path taken by the signal and 3) the environment (building and other objects) around the path. The medium between the transmit antenna and the receive antenna is called the channel. The effects of the channel can be characterized by a linear response. For MIMO-OFDM in frequency domain, the received signal and the transmitted signal may be expressed as

$$y = Hx + n \tag{1.1}$$

To analyze performance of a communication system, there is a need a channel model. There are three key components of the channel response: 1) path loss, 2) shadowing and 3) multipath.

MIMO Channel

MIMO system employs multiple antennas in the transmitter and/or receiver. The correlation between transmit and receive antennas is an important aspect of the MIMO channel. In the literature, two methods of modeling a correlated MIMO channel are used: a correlation matrix-based Intelligent Multi-Element Transmit and Receive Antennas channel model and a ray-based 3GPP spatial channel model. The correlation matrix-based channel model can be implemented with a spatial correlation matrix for the spatial channel. The ray-based channel model requires neither Doppler spectrum nor spatial correlation matrix, as the mobility effects and the antenna correlation are directly calculated from the time development of the modeled rays.

Equation (1.2) can be represented as below:

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_{NR} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1N_T} \\ h_{21} & h_{22} & \vdots & h_{2N_T} \\ \vdots & \vdots & & \vdots \\ h_{N_R1} & h_{N_R2} & \cdots & h_{N_RN_T} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_{NT} \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \\ \vdots \\ n_{NR} \end{bmatrix} \tag{1.2}$$

Where N_T represents the number of transmit antennas and N_R represents the number of receive antennas, y denotes $N_R \times 1$ received signal vectors, x denotes $N_T \times 1$ transmitted signal vectors and n denotes $N_R \times 1$ noise vectors. The element of the $N_R \times N_T$ channel matrix H in position (i, j) denotes the channel from the transmit antenna to the receive antenna.

III. LITERATURE REVIEW

Sahrab, A.A. & Marghescu, I. [1] investigated in the Multiple-Input Multiple-Output systems offer considerable increase in data throughput and link range without additional bandwidth or transmit power by using several antennas at transmitter and receiver to improve wireless communication system performance. At the same time, Orthogonal Frequency Division Multiplexing has becoming a very popular multi-carrier modulation technique for transmission of signals over wireless channels. OFDM eliminate Inter-Symbol-Interference and allows the bandwidth of subcarriers to overlap without Inter Carrier Interference. A MIMO-OFDM modulation technique can achieve reliable high data rate transmission over broadband wireless channels. This research deals with the analysis of a MIMO-OFDM system by using MATLAB software. The performance of the system is evaluated on the basis of Bit Error Rate and Minimum Mean Square Error level.

Matsuoka, H.; Doi, Y.; Yabe, T.; Sanada, Y. [6] presented the performance of an overloaded multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) system with a repetition code. It has been demonstrated that diversity with block coding prevents the performance degradation induced by signal multiplexing. Though, the computational complexity of a joint decoding scheme increases exponentially with the number of multiplexed signal streams. Thus, this research work proposes the use of a repetition code in the overloaded MIMO-OFDM system. In addition, QR decomposition with M-algorithm (QRM) maximum likelihood decoding (MLD) is applied to the decoding of the repetition code. QRM-MLD significantly reduces the amount of joint decoding complexity. In addition, virtual antennas are employed in order to increase the throughput that is reduced by the repetition code. It is revealed that the proposed scheme reduces the complexity by about 1/48 for 6 signal streams with QPSK modulation while the BER degradation is less than 0.ldB at the BER of 10-3.

Yabe, T. and Sanada, Y., [7] Abstract: This research presents a correlation reduction precoding scheme for joint decoding in an overloaded multiple input multiple output (MIMO)-orthogonal frequency division multiplexing (OFDM) system. In the overloaded MIMO system, the number of receive antenna elements is less than that of transmit antenna elements. Through joint maximum likelihood (ML) decoding frequency diversity suppresses the BER degradation owing to the spatial multiplexing of signal streams. This research work proposes the precoding scheme that reduces the correlation on the Rician channel. Numerical results obtained through computer simulation show that the proposed scheme improves the BER by a factor of 1/10 on the Rician channel with the Rician factor of 10.

Ben Hassine, I.; Bouallegue, R., [8] Abstract: With their very Algebraic-construction based on Quaternionic algebra, Algebraic Space Time Codes (ASTC), called the Golden codes, have a full rate, full diversity and non-vanishing constant minimum determinant for increasing spectral efficiency. They have also uniform average transmitted energy per antenna and good shaping; readily lend themselves to high data rate situations. In this work, author first analyzed the performances of the ASTC codes in correlated Rayleigh channel. Author considers a coherent demodulator using different decoding schemes and they analyze the Bit Error Rate (BER). In order to increase the spectral efficiency and to maximize the coding gain, ASTC have been proposed for MIMO flat fading channels. To deal with the frequency selectivity, they use the OFDM modulation. They analyze the performances of an ASTC-MIMO-OFDM system in terms of BER.

Long Shi; Wei Zhang; Xiang-Gen Xia, [9] researched the Partial interference cancellation group decoding is an attractive decoding alternative for multiple-input multiple-output (MIMO) wireless communications. It can well deal with the tradeoff among rate, diversity and decoding complexity of space-time block codes. In this research work, a design criterion of full-diversity space-frequency codes (SFC) is proposed for MIMO-OFDM systems with the PIC group decoding. Based on the criterion, a systematic design of full-diversity SFC is proposed that can achieve full diversity under the PIC group decoding. Simulation results of the newly proposed codes demonstrate the theory.

Mang Liao; Youguang Zhang; Zixiang Xiong, [10] worked on space-time-frequency (STF) codes have focused on frequency-selective but independent fading channels for MIMO-OFDM systems. This work give the effect of STF coding on the performance of MIMO-OFDM systems with general spatial, temporal, and frequency/path correlated channels. Specifically, they first derive an upper bound on the maximum achievable diversity and then prove achievability by giving an STF code design example. Finally, they show that author's general diversity result recovers those in the existing literature for special correlation structures.

Doi, Y.; Inamori, M.; Sanada, Y., [11] presented a low complexity joint decoding scheme of block coded signals in an overloaded multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) system. In previous literature, a joint maximum likelihood decoding scheme of block coded signals has been evaluated through theoretical analysis. The diversity gain with block coding prevents performance degradation induced by signal multiplexing. Though, the computational complexity of the joint decoding scheme increases exponentially with the number of multiplexed signal streams. This research proposes a two step joint decoding scheme for the block coded signals. The first step of the proposed scheme calculates metrics to reduce the number of the candidate codewords using decoding based on joint maximum like-hood symbol detection. The second step of the proposed scheme carries out joint decoding on the reduced candidate codewords.

IV. PROBLEM STATEMENT

Problems in OFDM systems are: Sensitive to phase noise, frequency offsets and timing errors Relatively high peak to average power ratio compared to single carrier system, which tends to reduce the power efficiency of the RF amplifier Though the developments of OFDM technology, there are two considerable contributions to OFDM which transform the original “analog” multicarrier system to today’s digitally implemented OFDM. The modulation type 16QAM and 64QAM are clearly affecting the performance. In the case of AWGN channel the performance of single carrier and OFDM systems are comparable but the overall performance of the second one is higher having in mind that the OFDM systems achieve a higher capacity, coverage and reliability.

V. CONCLUSION

In the history of the development of wireless communication MIMO-OFDM plays a significance roll, the contradiction between the growing demands of the data throughput with limited radio spectrum resources has been an important force driving wireless communication technology innovation. Next-generation wireless communication systems for higher demand on data transfer rate, requiring high-speed, high-performance data transfer with limited spectrum, is a huge challenge for the 4G wireless communication. In this review article we have analyzed about the MIMO-OFDM systems, the channel parameter estimation is crucial in the decoding process. Most of the channel estimation methods used for the OFDM systems are for the single transmit and receive antenna case, where there is no interference.

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