

A Survey On Channel Estimation In Mimo-Ofdm Systems

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Abstract: In Communication Systems, MIMO (Multiple Input Multiple Output) Channel have been introduced to achieve high data speed and better bit rate. The system becomes more efficient when OFDM (Orthogonal Frequency Division Multiplexing) is combined with MIMO to obtain high transmission rates, good quality of service and minimize the probability of error. Channel estimation is of great importance in MIMO-OFDM system. Channel estimation is used to estimate the transmitted signal using the corresponding receiver signal. Channel capacity of MIMO-OFDM system is also increased by channel estimation. A main challenge in MIMO-OFDM system is retrieval of the channel state information accurately. Channel state information is retrieved with the help of channel estimation i.e. all the channels between the transmit antenna are accurately known. In this paper we describe the basic introduction of MIMO-OFDM system and survey the different channel estimation techniques used in MIMO-OFDM system considering the various system parameters.

Keywords: MIMO, OFDM, Channel Estimation, STBC

1. Introduction

In wireless communication system many techniques are used for the transmission of signals like TDMA, CDMA, FDMA and OFDM. In TDMA (Time Division Multiplexing Access) the information is transmitted into time slots so in each slot only one user is allowed to either transmit or receive. In FDMA (Frequency Division Multiplexing Access) individual channel are assigned to individual user, each user is allocated a unique frequency band. In CDMA (Code Division Multiplexing Access) many users may transmit simultaneously but then near-far problem occurs [1]. OFDM has attracted lot of attention in the field of wireless communications. OFDM is a multicarrier modulation technique [2] which is widely used for transmission of signals over the wireless channels. The prime advantage of OFDM is its ability to cop with the severe channel conditions like attenuation, interference and multipath fading without complex equalization filters. OFDM has been adopted in several wireless standards such as DVB-T (Digital Video Broadcasting-Terrestrial), DVB-T2, ISDB-T (Integrated Services Digital Broadcasting for Microwave Access), LTE (Long Term Evolution) and others[3]. OFDM is also in demand for short range communications.

Now a days the demand of high speed communication has increased. To achieve the high speed and reliable

communication MIMO channels are introduced [4]. MIMO channels provide higher spectral efficiency as compare to SISO (Single Input Single Output), SIMO (Single Input Multiple Output) and MISO (Multiple Input Single Output) channels [5]. Wi-Fi, LTE and many other radio and wireless technologies are using MIMO wireless technology to provide increased link capacity and spectral efficiency. MIMO can increase the diversity gain and also improves the system capacity of time variant and frequency selective channels [6].

Channel estimation is a challenging problem in the wireless systems. The transmitted signal travels to the receiver by undergoing many unknown effects that may corrupt the signal [6]. In wireless communication the transmitted signal arrives at the receiver along multiple paths. Channels are random in nature due to which it is hard to predict the channel. In MIMO channels the precision and speed convergence of the channel estimator affect the performance of receiver. Many techniques are proposed for better channel estimation. In sec.3 we discuss some channel estimation techniques.

2. MIMO-OFDM

In Modern communication systems MIMO channels are a

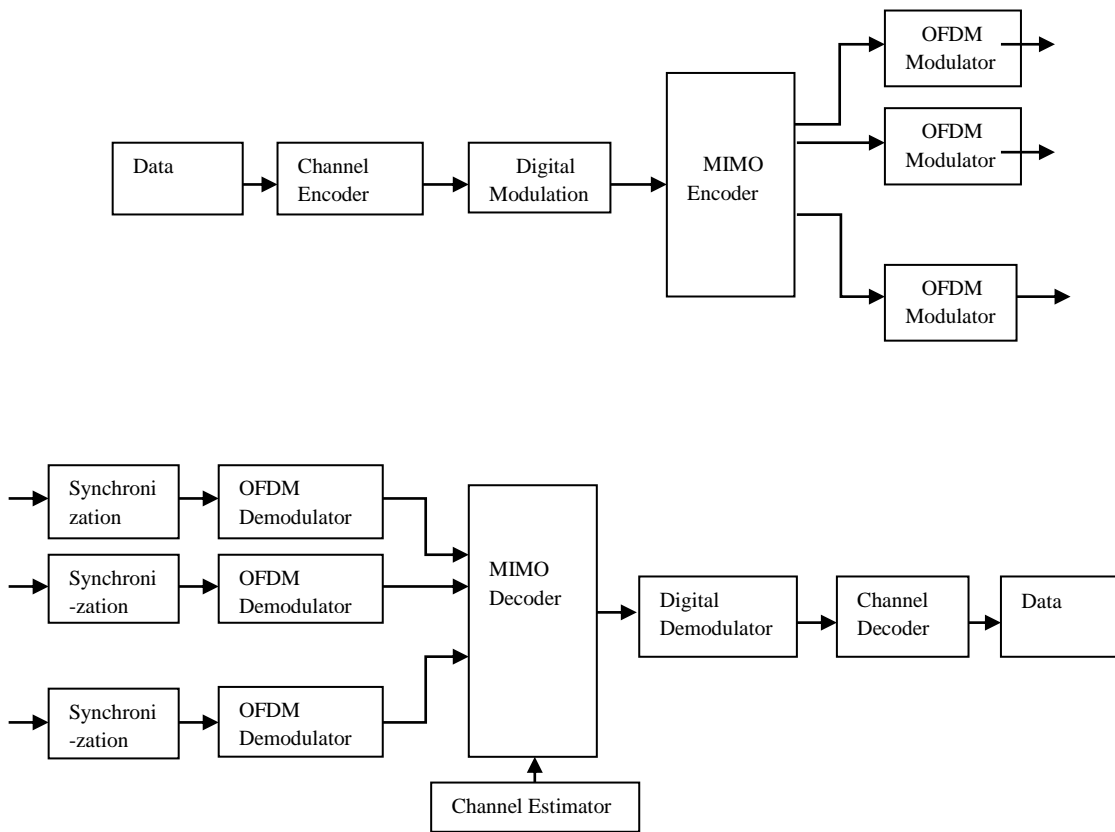


Figure 1: Block Diagram of MIMO-OFDM System.

Combined with OFDM to provide robustness [7] and high spectral efficiency [8]. MIMO-OFDM playing an important role in current and future wireless communications [9]. It combines MIMO which multiplies capacity by transmitting different signals over multiple antennas and OFDM which divides the radio channel into a large number of closely spaced sub channels to provide more reliable communication at high speed. It provides the highest capacity and data throughput. MIMO technology is the most significant method which is employed to improve the signal to noise ratio for wireless technologies. MIMO systems are combine with OFDM to ensure that the signals are transmitted orthogonally with each other. OFDM necessitates time and frequency synchronization to sustain its orthogonality between subcarriers and also resistive to frequency offset which can be caused either by Doppler shift due to relative motion between the transmitter and receiver or by the difference between the frequencies of the local oscillator at the transmitter and receiver[6].

MIMO-OFDM is the foundation for most advanced wireless communication and mobile broadband network standards. It is said to be future of 4G and 5G broadband communications.

3. Channel Estimation:

The wireless channel is highly complex. Channel Estimation is an important task in wireless systems. To receive the

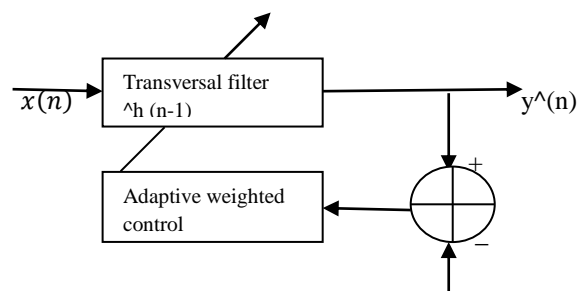
information correctly, the receiver must be able to estimate the channel frequency response[8]. The main aim of channel estimation scheme is that data received at the receiver should be same as the data transmitted from the transmitter. In MIMO-OFDM many techniques are employed for channel estimations. Some commonly used methods are explained in subsections.

3.1 Adaptive Channel Estimation schemes:

Adaptive channel estimation is become the most important research field in wireless where the channel is rapidly time varying. In adaptive algorithm the parameters of the system changes as it obtain more information of changing environment. For adaptive channel estimation two types of schemes are generally used.

- (a) LMS (Least mean square)
- (b) RLS (Recursive mean square)

We use adaptive filter to track the channel when the channel keep changing quickly [17]. The diagram of adaptive filter is shown in figure 2[3].



y (n)

Figure 2: Adaptive Filter

LMS CE: LMS algorithm has been proposed to minimize the squared differences between the received and estimated signal. LMS algorithm is designed to find optimal weight vector so as to minimize the mean square error. In LMS algorithm the estimator changes its parameter correspondence to changing environment [4].

$$W_{est}(m+1) = W_{est}(m) + \eta S(m)e^*(m)$$

$W_{est}(m+1)$ denotes the weight vector to be computed at $(m+1)$.

η is LMS step size which is related rate of convergence. $\eta S(m)e^*(m)$ is correlation factor which is applied to adjust the tap weight factor.

RLS CE: The recursive channel estimation requires all the past samples of its input and desired output. The values must be available at each iteration [4]. RLS algorithm suffers from high complexity than LMS. On the other side the RLS CE algorithm has better anti noise as well as tracking ability. RLS CE always better performance than LMS. It uses recursive method in such a way that eliminates the signal error due to noise and decision error [3].

$$W(m) = W(m-1) + K(m)\epsilon^H(m)$$

$\epsilon(m)$ is prior estimation error

$$\epsilon(m) = H(m) - W^H(m-1)S(m)$$

3.2 Space time block coding (STBC):

STBC Scheme was proposed in 1998 by Alamouti [10]. STBC is the most efficient method due to its provision of full diversity and simple linear decoder [11]. STBC for MIMO-OFDM with multiple antennas is actually a type of coding which is implemented in time domain. To be more specific Alamouti's code is taken into consideration which is shown to be most favorable block codes. Efficient implementation of MIMO-OFDM system is based on the Fast Fourier transform algorithm such as Alamouti STBC, the vertical Bell-labs layers space time block code (VBLASTSTBC) and golden space time trellis code [12]. STBC provides diversity gain with very low decoding complexity. STBC must be concatenated with an outer code to provide coding gain. To achieve full diversity space frequency codes or space time frequency codes are generated for mapping information symbols to antennas. STBC are used for both spatial and frequency diversity [13].

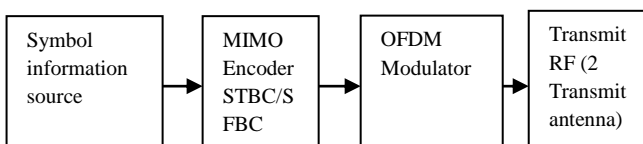


Figure 3: Block Diagram for Transmitter side in Differential STBC MIMO-OFDM Systems [14].

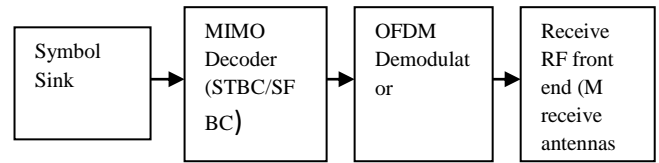


Figure 4: Block Diagram for Receiver side in Differential STBC MIMO-OFDM Systems [14].

4. Survey of Channel Estimation Techniques:

In 2001, Rick S Blum, [15] proposed an improved space-time coding for multiple input and multiple output orthogonal frequency division multiplexing using QPSK modulation for four transmit and four receive antennas. Furthermore they showed a 4-antenna, 16 state codes that achieve an additional 2-dB improvement with lower complexity and a 256 state code that achieves an additional 2-dB gain. The 256-state code performed within 3db of outage capacity.

In 2004, Garden L. Stuber [16] discussed a number of physical layer issues relevant for the implementation of broadband MIMO-OFDM systems. They discussed space-time coding strategies for closed loop MIMO-OFDM systems where knowledge of the channel is available at the transmitter. Error-correction coding was discussed with an emphasis on high rate LDPC codes. Adaptive analog beam forming techniques were discussed that can provide the best possible MIMO channel environment.

In 2006, Toufiquel Islam [17] presented multiuser channel estimation technique for space time block coded orthogonal frequency division multiplexing (STBC-OFDM) systems based on simple blocked pilot grid. The estimation of multiuser channels is based on least square (LS) and Minimum mean square estimation (MMSE) schemes. The simulation result shows that for a slowly faded quasi-static channel estimated characteristics closely agree with the actual channel characteristics. Different Doppler fading effects on MMSE performance are also presented.

In 2009, Y. Mlayels [7] investigate an extra processing added to conventional LS estimation to improve its performance in MIMO-OFDM systems. The new technique proposed is based on knowledge of the power delay profile. The application of the improved estimator is useful when employing advanced MIMO adaptation techniques. Simulation results showed performance of MIMO techniques closed to that offered by perfect channel.

In 2011, Zang jie et al. [18] presents a simulation model of MIMO-OFDM system based on STBC which built and

transmission performances under different channels are analyzed. The simulation results show that the MIMO-OFDM system based on STBC outperforms other MIMO-OFDM system without STBC in BER performance.

In 2013, Andre Antonio dos Anjos [8] addressed the problem to perform accurate channel estimation. They presented some channel estimation techniques that can be used in MIMO-OFDM systems that designed for diversity gain. The influence of interpolation technique on channel estimation error and MER has been analyzed. Different channels with different delay profiles have also been analyzed. A linear relationship between channel estimation error and the MER has been proposed.

In 2014, Melli, X.Wang, K.Zang [10] analyzed the least mean square (LMS) and Recursive least square (RLS) algorithms. They applied these two algorithms to MIMO-OFDM system based on space time block coding (STBC). From the simulation results it is found that the RLS is better than LMS algorithm. They showed the practical aspect of analyzed scheme in MATLAB environment.

5. Conclusion:

In this paper we have survey the various Channel Estimation Techniques used in MIMO-OFDM systems. The performance of the system can be improved if channel state information of MIMO channels is estimated by channels estimation schemes. From the survey it is concluded that further modification in channel estimation techniques will make the system better. Thus the future work will be conducted on the further improvement in channel estimation technique for MIMO-OFDM systems.

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Author Profile



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