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Study of Channel Estimation of MIMO-OFDM System

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Abstract: In this paper a brief study of channel estimation for MIMO-OFDM system has been described. The demand for high data rates in wireless communication systems is increasing as well the demand for new (communication) services. Expanding of existing services or introducing new services needs a portion in the radio spectrum. The need for reliable, high-throughput, mobile wireless communication technologies has never been greater as increases in the demand for on-the-go access to information, entertainment, and other electronic services continues. Two such technologies, which are at the forefront of current research efforts, are orthogonal frequency division multiplexing (OFDM) and multiple-input multiple-output (MIMO) systems, their union being known simply as MIMO-OFDM. Multi-input and multi-output (MIMO) and orthogonal frequency division multiplexing. (OFDM) have attracted significant attention, and become promising techniques for high data rate wireless communication systems.

Keywords: OFDM, MIMO, MIMO-OFDM, channel estimation, channel prediction, channel.

I. INTRODUCTION

During the past decades, wireless communication has benefitted from substantial advances and it is considered as the key enabling technique of innovative future consumer products. For the sake of satisfying the requirements of various applications, significant technological achievements are required to ensure that wireless devices have appropriate architectures suitable for supporting a wide range of services delivered to the users. In the foreseeable future, the large-scale deployment of wireless devices and the requirements of high bandwidth applications are expected to lead to tremendous new challenges in terms of the efficient exploitation of the achievable spectral resources. Among the existing air-interface techniques, OFDM has shown a number of advantages and has attracted substantial interest. OFDM converts a frequency-selective channel into a parallel collection of frequency flat sub channels. The subcarriers have the minimum frequency separation required to maintain orthogonality of their corresponding time domain waveforms, yet the signal overlap in frequency. Hence, the available bandwidth is very efficiently used. If knowledge of the channel is available at the transmitter, then the OFDM transmitter can adapt its signaling strategy to match the channel. Due to the fact that OFDM uses a large collection of narrowly spaced sub channels.

II. MIMO System

In most scattering environments, antenna diversity is a practical, effective and, hence, a widely applied technique for reducing the effect of multipath fading [1]. The classical approach is to use multiple antennas at the receiver and perform combining or selection and switching in order to improve the quality of the received signal. The major problem with using the receive diversity approach is the cost, size, and power of the remote units. The use of multiple antennas and radio frequency (RF) chains (or selection and switching circuits) makes the remote units larger and more expensive.

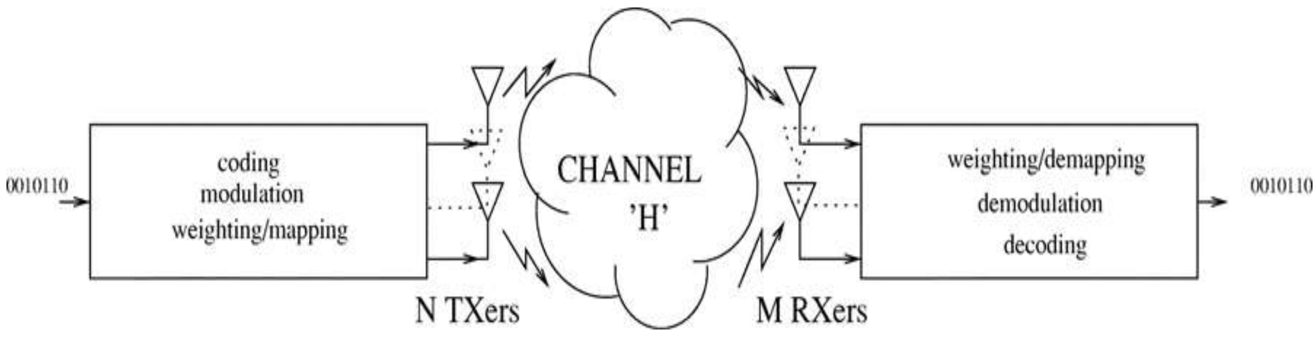

Figure 1.1 Diagram of MIMO wireless systems

MIMO Channel

We know that a signal propagating in a wireless medium is subject to large scale propagation effects (like path-loss and shadowing) and small scale propagation effects (fading) [01]. The mobile radio channel is characterized by 'multipath reception'. The signal offered to the receiver contains not only a direct line-of- sight radio wave, but also a large number of reflected radio waves. These reflected waves interfere with the direct wave, which causes significant degradation of the performance of the network. A wireless network has to be designed in such way that the adverse effect of these reflections is minimized. Although channel fading is experienced as an unpredictable, stochastic phenomenon, powerful models have been developed that can accurately predict system performance

III. LITERATURE SURVEY

D.B. Bhoyar and Vaihali B. Niranjane [1] compare channel estimation based Least square, Minimum Mean Square Least mean square(LMS) and Recursive Least square of MIMO OFDM based systems are studied.. The complexity of RLS is larger than other estimators. The RLS estimator has good performance but high complexity. The LS, MMSE and LMS estimator has low complexity but its performance is not as good as that RLS at low SNRs.

Kala Praveen Bagadi and Prof. Susmita Das [2] compare channel estimation based on both block-type pilot and comb-type arrangements in both SISO and MIMO OFDM based systems. Channel estimation based on comb-type pilot arrangement is achieved by giving the channel estimation methods at the pilot frequencies and the interpolation of the channel at data frequencies. The estimators can be used to efficiently estimate the channel in both OFDM systems given certain knowledge about the channel statistics.

Risanuri Hidayat, Anggun Fitrian Inawati an Budi Setiyanto [3] propose a pilot aided channel estimation method for MIMO-OFDM Mobile WiMax systems. Channel estimation in is used to analysis MIMO-OFDM for STBC technique with the block and comb pilot type. The result of this research stated that comb type methods are results poor performance than block type pilot based methods for the reason that of fast fading channels.

IV. CHANNEL ESTIMATION

A channel can describe everything from the source to the sink of a radio signal. This includes the physical medium (free space, fiber , waveguides etc.) between the transmitter and the receiver through which the signal propagates. An essential feature of any physical medium is, that the transmitted signal is received at the receiver, corrupted in a variety of ways by frequency and phase-distortion, inter symbol interference and thermal noise. A channel model on the other hand can be thought of as a mathematical representation of the transfer characteristics of this physical medium. Channel estimation is simply defined as the process of characterizing the effect of the physical channel on the input sequence. If the channel is assumed to be linear, the channel estimate is simply the estimate of the impulse response of the system. It must be stressed once more that channel estimation is only a mathematical representation of what is truly happening.

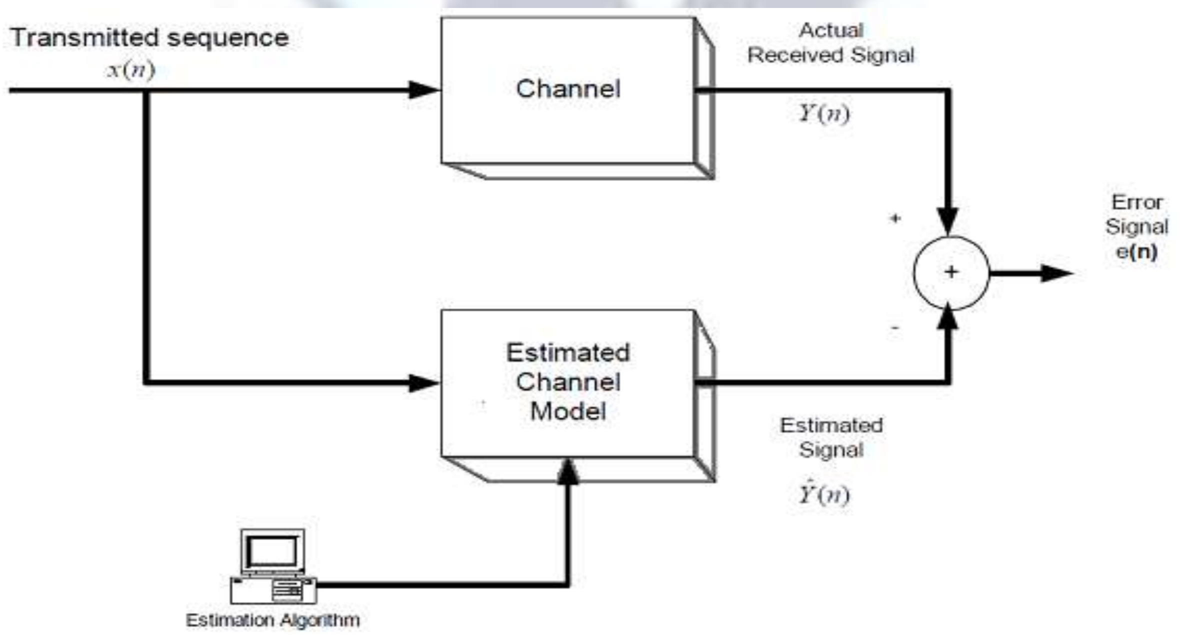

Figure 1.2: A general Channel Estimation Procedure .

In the figure above e(n) is the estimation error. The aim of most channel estimation algorithms is to minimize the mean squared error (MMSE), $E[e^2(n)]$ while utilizing as little computational resources as possible in the estimation process.

Need for Channel Estimation

Channel estimation algorithms allow the receiver to approximate the impulse response of the channel and explain the behavior of the channel. This knowledge of the channel's behavior is well-utilized in modern radio communications. Adaptive channel equalizers utilize channel estimates to overcome the effects of inter symbol interference. Diversity techniques (for e.g. the IS-95 Rake receiver) utilize the channel estimate to implement a matched filter such that the receiver is optimally matched to the received signal instead of the transmitted one. Maximum likelihood detectors utilize channel estimates to minimize the error probability. One of the most important benefits of channel estimation is that it allows the implementation of coherent demodulation. Coherent demodulation requires the knowledge of the phase of the signal. This can be accomplished by using channel estimation techniques.

V. TYPES OF CHANNEL ESTIMATIONS

Training Sequences

Once a model has been established, its parameters need to be continuously updated (estimated) in order to minimize the error as the channel changes. If the receiver has a-priori knowledge of the information being sent over the channel, it can utilize this knowledge to obtain an accurate estimate of the impulse response of the channel. This method is simply called Training sequence based Channel estimation. It has the advantage of being used in any radio communications system quite easily. Even though this is the most popular method in use today, it still has its drawbacks. One of the obvious drawbacks is that it is wasteful of bandwidth. Precious bits in a frame that might have been otherwise used to transport information are stuffed with training sequences for channel estimation.

Blind methods

Blind methods on the other hand require no training sequences. They utilize certain underlying mathematical information about the kind of data being transmitted [4]. These methods might be bandwidth efficient but still have their own drawbacks. They are notoriously slow to converge (more than 1000 symbols may be required for an FIR channel with 10 coefficients). Their other drawback is that these methods are extremely computationally intensive and hence are impractical to implement in real- time systems. They also do not have the portability of training sequence-based methods. One algorithm that works for a particular system may not work with another due to the fact they send different types of information over the channel.

CONCLUSION

In this paper various attributes and components of MIMO- OFDM system and channel estimation have been studied. Also, channel estimation has been analysed. A further suggestion for future investigation is to improve the channel estimation procedure at low signal to noise ratio. It may be possible to obtain the perfect channel knowledge performance at low signal to noise ratio with less number of pilot symbols.

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