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Survey of MIMO OFDM System under Different Estimators: A Review

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Abstract*:* In 4th generation (4G) broadband wireless communication system to achieve high gain can be made possible by the use of multiple antennas not only at transmitter but also at receiver ends. A multiple input multiple output (MIMO) system provides multiple independent transmission channels, thus, under certain conditions, leading to a channel capacity that increases linearly with the number of antennas. Also, orthogonal frequency division multiplexing (OFDM) is an effective technique for high data rate wireless mobile communication. By combining these two promising techniques, the researcher can significantly increase data rate, which is justified by improving bit error rate (BER) performance. this paper describe the concept of MIMO system and OFDM. orthogonality on OFDM in CDM (Code Division Multiplexing) system, as the Walls code plays an important role, orthogonality of OFDM also main point for spreading signals as an unique, meaning receiver finds out distinguish integer cyclic number from each signal. This paper deals with various estimators for the betterment of elements used in wireless communications like SNR (signal to noise ratio), MMSE (minimum mean square error) and least square error.

***Index Terms*—MIMO, OFDM , MMSE , Least square**

I. INTRODUCTION

A special blend of advanced techniques and technologies is required to overcome fading and other interference problems in non-line-of-sight wireless connections. Elements of a non-line-of-sight solution should include: high system gain, Fading mitigation, Dispersion mitigation, Multi-path compensation.

These can be achieved using technologies such as: Multiple-Input Multiple-Output and Orthogonal Frequency Division Multiplexing.

Multiple-input Multiple-output (MIMO), MIMO is a method of transmitting multiple data beams on multiple transmitters to multiple receivers. The advantage is that the odds of receiving the data are massively increased. Basically, if any one path is faded, there is a high probability that the other paths are not, so the signal still gets through. For MIMO to be effective, the paths need to be de- correlated (e.g., the signals traveling on those paths need to behave differently from each other). This can be done using techniques such as spatial separation of the antennas or separation of the transmitted waveforms via time separation, data sequence separation, polarization separation, frequency separation or modulation separation.

More recently, it has been recognized that the capacity of wireless communication links is increased by using multiple antennas both at the transmitter and the receiver [3], [4]. This scheme is able to provide a high spectral efficiency in a rich and quasi-static scattering environment. Owing to the large computational complexity required for this scheme, a simplified version, called Vertical BLAST (V-BLAST) has been proposed in [15]. A BLAST scheme is primarily based on the following three steps: 1) interference nulling to reduce the effect of the other (interfering) signals on the desired one; 2) ordering to select the sub-stream with the largest signal-to-noise ratio (SNR); and 3) successive interference cancellation (SIC). Moreover, it was observed also in [14] that a minimum mean-square-error (MMSE) criterion can be used instead of interference nulling (zero forcing) to mitigate both interference and thermal noise.

Orthogonal Frequency Division Multiplexing (OFDM): OFDM is as discrete multi-tone modulation because, instead of a single carrier being modulated, a large number of subcarriers are modulated by digital modulation techniques like QAM (M-QAM), BPSK, QPSK, DQPSK, DQAM etc. Parallel with the possible data rates, the transmission bandwidth of OFDM systems is also large. Because of these large bandwidths, noise cannot be assumed to be white with flat spectrum across subcarriers. This is a spread-spectrum technique that increases the efficiency of data communications by increasing data throughput because there are more carriers to modulate. In addition, problems with multi-path signal cancellation and spectral interference are greatly reduced by selectively modulating the clear carriers or ignoring carriers with high bit-rate errors.

In OFDM system design, a number of parameters are up for consideration, such as the number of subcarriers, without a guard time the data receiving in purpose is impossible except on Blind channel [10], symbol duration, subcarrier spacing, modulation type per subcarriers, and the type of FEC coding. IEEE 802.16d uses Orthogonal Frequency Division Multiplexing (OFDM). IEEE 802.16e (mobile) uses

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Orthogonal Frequency Division Multiple Access (OFDMA). The Wi MAX forum established that, initially, OFDM-256 will be used for fixed-service 802.16d (in 2004). It is referred to as the OFDM 256 FFT Mode, which means there are 256 subcarriers (figure 1 illustrates 5 subcarriers of OFDM signal in frequency domain) available for use in a single channel. Multiple Accesses on a channel is accomplished using TDMA. Alternatively, FDMA may be used.

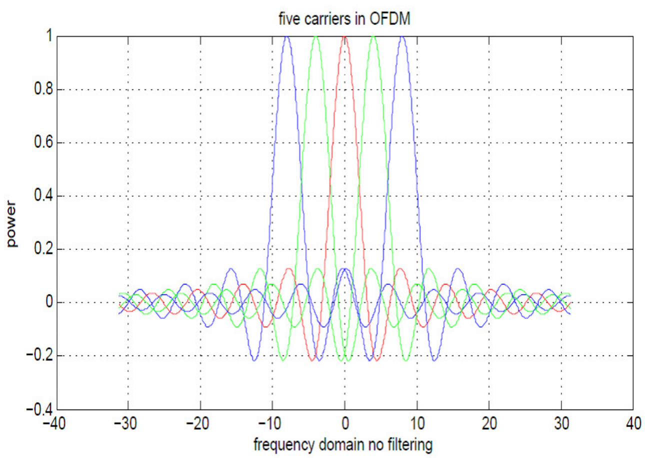

Figure 1. Five OFDM subcarriers in frequency domain.

Orthogonality on OFDM In CDM (Code Division Multiplexing) system, as the Walls code plays an important role, orthogonality of OFDM also main point for spreading signals as an unique, meaning receiver finds out distinguish integer cyclic number from each signal. Figure 2 shows the signals that even though they are a sum of sinusoids with each corresponding to subcarriers in time domain, they are orthogonal each other in frequency domain.

Mathematical model of orthogonal signals in continuous time at the receiver following:

$$\int_0^T S_i(t) * S_j(t)dt = 0 \qquad \begin{matrix} C & i = j \\ 0 & i \neq j \end{matrix}$$

In discrete time:

$$\sum_0^T S_i(t) * S_j(t)dt = 0 \qquad \begin{matrix} C & i = j \\ 0 & i \neq j \end{matrix}$$

Where S signal,

$$S_k(t) = \begin{matrix} \sin(2\pi * k * f_0 * t) & 0 < t < T & k = 1,2,...M \\ 0 & & otherwise \end{matrix}$$

Where f_0 is carrier spacing, M is number of carriers, T is the symbol period. From this equation we can notice that the highest frequency component is Mf_0 means the transmission bandwidth of channel.

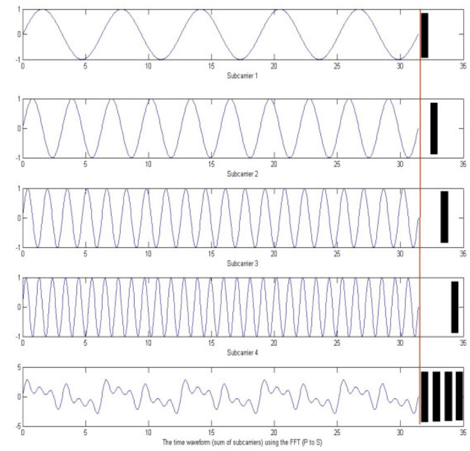

Figure 2. Subcarriers and general signal stream for transmission in time domain.

Here section II contains problems faced, section III is for literature review, section IV is analysis of different estimators, and at the last not least section V is the conclusion.

II. PROBLEMS

Among these schemes, the minimum mean square error (MMSE) receiver is a good choice, because it offers better performance than zero forcing (ZF), avoiding the noise-enhancement effect of ZF. In MIMO systems, the adaptation of the modulation at the transmitter side according to the channel characteristics allows for reducing the transmission power and/or enhancing the data rates[12]. To do so, a closed-form expression is needed, relating the average BER and the required transmission power for different candidate modulation schemes. Although having so many advantages also OFDM is having certain disadvantages.

- Sensitive to Doppler shift.
- Sensitive to frequency synchronization problems.
- High peak-to-average-power ratio (PAPR), requiring linear transmitter circuitry, which suffers from poor power efficiency.

Another important issue in OFDM transmission is synchronization. There are basically three issues that must be addressed in synchronization. The receiver has to estimate the symbol boundaries and the optimal timing instants that minimize the effects of inter-carrier interference (ICI) and inter-symbol interference (ISI). In an OFDM system, the sub-carriers are exactly orthogonal only if the transmitter and the receiver use exactly the same frequencies. Thus receiver has to estimate and Correct for the carrier frequency offset of the received signal. Further, the phase information must be recovered if coherent demodulation is employed. Another associated problem with OFDM systems is the effect of phase noise. Phase noise is present in all practical oscillators and it manifests itself in the form of random phase modulation of the carrier. Both phase-noise and frequency offset cause significant amount of ICI in an OFDM receiver. The effect these are

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worse in OFDM than single carrier systems. The use of efficient frequency and phase estimation schemes can help reduce these effects.

III. LITERATURE REVIEW

Mobasher et al. (2007) In (MIMO) systems, maximum-likelihood (ML) decoding are equivalent to finding the closest lattice point in an N-dimensional complex space. In general, this problem is known to be NP-hard. In this paper, a quasi-ML algorithm based on semi-definite programming (SDP) is proposed. The proposed relaxation models are also used for soft output decoding in MIMO systems. A method for quasi-ML decoding based on two semi-definite relaxation models is introduced. The proposed semi-definite relaxation models provide a wealth of tradeoffs between the complexity and the performance. The strongest model provides a near-ML performance with polynomial-time worst case complexity (unlike the SD that has exponential-time complexity).

Jiang etal.(2009) This paper presents an in-depth analysis of the (ZF) and (MMSE) equalizers applied to wireless (MIMO) systems with no fewer receive than transmit antennas. In spite of much prior work on this subject, they reveal several new and surprising analytical results in terms of the well-known performance metrics of output signal-to-noise ratio (SNR), encoded error and outage probabilities, diversity-multiplexing (D-M) gain tradeoff, and coding gain.

Babu. T, Dr. Kumar (2009) said that in wireless communication systems, equalization process is needed to suppress ISI caused by multipath channels. Conventional equalization techniques use training signals. A blind equalization index is presented for the purpose of selecting the best equalizer. This paper deals with the equalization techniques using MIMO FIR (finite impulse response) equalizers. They performed a theoretic frame work on blind MIMO - FIR channel equalization is established in this paper. [7]

Ketonen(2012) proposed the use of decision directed (DD) channel estimation in a MIMO and OFDM downlink receiver is studied in this paper. The 3GPP long term evolution (LTE) based pilot structure is used as a benchmark. The space-alternating generalized expectation-maximization (SAGE) algorithm is used to improve the performance from that of the pilot symbol based least-squares (LS) channel estimator. The DD channel estimation improves the performance with high user velocities, where the pilot symbol density is not sufficient. MMSE filtering can also be used in estimating the channel in between pilot symbols. The pilot based LS, MMSE and the SAGE channel estimators are implemented and the performance-complexity trade-offs are studied. They concluded that complexity and power consumption of the LS and MMSE estimators are low.. A good performance-complexity trade-off can be achieved by allowing a longer processing delay for the SAGE estimator. The MMSE filter and the SAGE estimator improve the pilot symbol based LS performance with high user velocities when the channel changes frequently between pilot symbols. They said that the MMSE estimator is suitable for systems with high pilot densities. [4]

Khan etal. (2012) said that in pilot-symbol-aided OFDM system, MMSE estimator performs better than LS estimator; however, computational complexity associated with the MMSE method is relatively higher than the LS. Although, the LS estimator has lower complexity and requires minimum knowledge the channel state information, the estimator suffers from inherent additive Gaussian noise and Inter Carrier Interference (ICI). Following that, in this study an efficient and improved channel estimation technique is proposed based on the LS algorithm. Simulation results show that the proposed method performs considerably better than the conventional LS method for a range of SNRs. In addition, the performance of the proposed method is found to be almost equal, if compared with the MMSE estimator. Despite the proposed method experiences relatively higher computational complexity than the LS, the complexity is yet to be achieved about 40 % lower than the MMSE. [5]

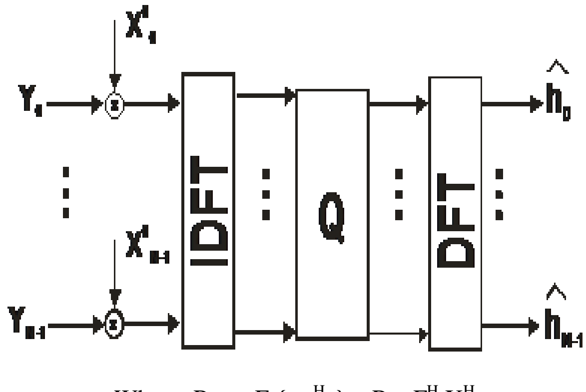
Ylioina etal. (2013) discussed an iterative receiver for a MIMO OFDM system is considered to jointly decode the transmitted bits and estimate the channel state. The receiver consists of the a posteriori probability (APP) algorithm, the repeat-accumulate (RA) decoder, and the least-squares (LS) channel estimator. The problem of finding the optimal activation schedule for the detector, the channel estimator and the decoder in an iterative receiver was considered. The issue is to study the concept with more realistic complexity definitions in the scheduling and with algorithms being computationally less intensive. [6]

IV. ANALYSIS ON DIFFERENT ESTIMATORS

MMSE AND LS ESTIMATORS

The estimation techniques have the general structure as presented in Figure. If the channel vector g is Gaussian and uncorrelated with the channel noise n, the MMSE estimate of g becomes

$$g'_{MMSE} = R_{gy} R^{-}_{yy}\, y$$



$$\text{Where, } R_{gy} = E\{gy^H\} = R_{gg} F^H X^H$$

$$R_{yy} = E\{yy^H\} = XFR_{gg} F^H X^H + \sigma_n^2 I_N$$

are the cross-covariance matrix between g and y and the auto covariance matrix of y. Further R_{gg} is the auto covariance matrix of g and σ_n^2 denotes the noise variance. These two

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qualities are assumed to be known. Since the columns in F are orthonormal,

g'_{MMSE} generates the frequency domain MMSE estimate h'_{MMSE} by

$$h'_{MMSE} = F\, g'_{MMSE} = F\, Q'_{MMSE} F^H X^H y$$

where, Q'_{MMSE} can be shown to be

$$Q'_{MMSE} = R_{gg} [(F^H X^H X F)^{-1} \sigma_n^2 + R_{gg}]^{-1} (F^H X^H X F)^{-1}$$

This MMSE channel estimator has the form shown in Figure If g is not Gaussian, h'_{MMSE} is not necessarily a minimum mean-square error estimator. It is however the best linear estimator in the mean-square error sense. In either case (g, Gaussian or not) the channel estimate is to be denoted as h'_{MMSE}.

The LS estimator for the cyclic impulse response g minimizes $(y-XF_g)^H (y-XF_g)$ and generates

$$h'_{LS} = F Q_{LS} F^H X^H y,$$

Where,

$$Q_{LS} = (F^H X^H X F)^{-1}$$

It is to be noted that h'_{LS} also corresponds to the estimator structure. Above equation reduces to

$$h'_{LS} = X^{-1} y,$$

The LS estimator is equivalent to what is also referred to as the zero forcing estimators. Both estimators LS and MMSE have their drawbacks. The MMSE estimator suffers from a high complexity, whereas the LS estimate has a high mean-square error.

V. CONCLUSION

In this paper it is concluded that different techniques used for achieving high gain and directivity in wireless communication. Various advantages as well as the problems occurred in such techniques has been discussed. So we have used various estimators to estimated different parameters to find the system efficiency as well as its adaptability. Such parameters are like SNR (Signal to noise Ratio), MMSE (Minimum Mean square error), LS (least Square). The future work can be extended to modify the various algorithms so that to remove such problems caused in estimators like complexity and mean square error.

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