

MIMO-OFDM surveys on various types of channel estimation techniques in communication systems

* Shuja Behna, Neetu Sikarwar

Institute of Engineering, Jiwaji University, Gwalior, Madhya Pradesh, India

Abstract

This article presents different channel estimation techniques in MIMO-OFDM. The grouping of MIMO and OFDM increases the bit rate as well as capacity. A major challenge in the MIMO-OFDM system is the retrieval of channel state information (CSI) correctly and the synchronization between the transmitter end and receiver end. The CSI is retrieved by the help of various types of estimation algorithms such as training based, blind and half blind channel estimation. This article focuses the fundamental introduction of OFDM, MIMO-OFDM system and explains diverse channel estimation algorithms, optimization techniques and their exploitation in MIMO systems for fourth generation (4G) wireless mobile communication systems.

Keywords: MIMO-OFDM, CSI

1. Introduction

The features of the fourth generation (4G) cell phone system have very well than earlier invention networks such as 2G and 3G. Key brave faced through upcoming communication system is to offer high data rate among high quality of service. Comparing the second generation (2G) and third generation (3G), the data transmission velocity is extremely high in 4G. It can supports multimedia services with great feature, audio, video collection, the internet and other broadband services through greater quality. It provides a client to choose any preferred services with additional freedom and elasticity.

Mobile communication systems transmit data through varying their amplitude or phase of broadcasting waves. At the recipient side of the mobile system, amplitude or phase can differ commonly. This leads to deprivation in the feature of the system while the presentation of the receiver is extremely dependent on the precision of estimated immediate channel. In a wireless bond, channel state information (CSI) provides the identified channel properties of the bond. It provides the detail of signal circulation between the transmitter and the receiver and tells about the special effects of scattering, fading. The CSI can integrate present channel situation with transmission data for achieving consistent communication. This CSI must be estimated at the receiver and feedback to the transmitter.

The CSI can be obtained by special types of channel estimation algorithms. This estimation can be complete with a situated of a familiar sequence of distinctive bits for a particular transmitter and the equations can be recurring in each transmission burst. Thus the channel estimator estimates the channel impulse response for every fracture individually from the familiar transmitted bits and equivalent received samples. This paper describes the basics of the MIMO-OFDM system and learns of diverse channel estimation technique and their performance.

2. Orthogonal Frequency Division Multiplexing (OFDM)

2.1 Over View of OFDM

Orthogonal frequency division multiplexing is a category of

frequency-division multiplexing technique which can be used as a digital multi-carrier modulation technique. Typically a great amount of closely-spaced orthogonal subcarriers is used to bring data. The data is spliced interested in different parallel data streams or channels, single for every sub-carrier. Every subcarrier is modulated by digital modulation techniques i.e. QAM or QPSK at a short symbol rate, maintaining whole data rates like too predictable single-carrier modulation schemes in the similar bandwidth. The Modulator outputs are joint and the resultant signal is transmitted.

2.2 Features

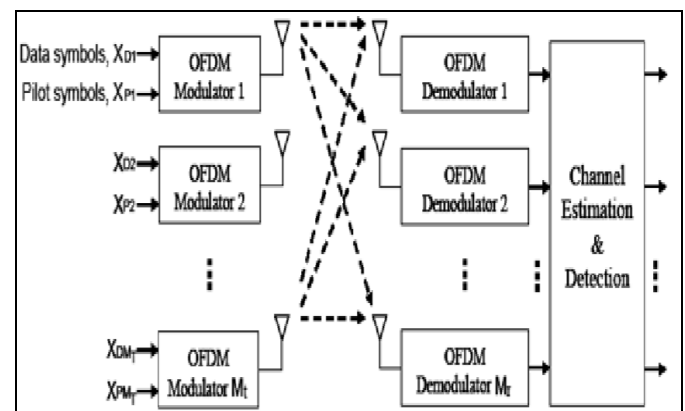


Fig 1: Typical MIMO System Model

The subcarriers are orthogonal to everyone in OFDM. It prevents interference between sub channels, so it does not have to be needed for the protective band. So that the design of both transmitters and receivers becomes easy. Unlike FDM, for each sub-channel, a separate filter is not necessary. It is easy to insert a guard interval between the rump symbols when each period is high. By this way, the inter symbol interference is ended. The guard interval also eliminates the need for a pulse-shaped filter.

Mathematical Description

If the N sub-carrier is used, and each sub-carrier M is controlled by the alternative symbols, then OFDM is the combined joint in each alphabet. The low pass equivalent of OFDM signal is given as

$$v(t) = \sum_{k=0}^{N-1} x^k e^{j2\pi kt/T} \quad (1)$$

Where,

X_k - Data Symbols.

N - Number of Subcarriers

T - OFDM Symbol Time.

3. MIMO-OFDM System

MIMO-OFDM is a modern wireless broadband technology that has a high capacity for high-rate data transmission and multipath fading and its strength against other channel losses. In MIMO system, several numbers of transmitters at a single end and many numbers of receivers at the extra end are successfully joint to improve the channel ability of the wireless system. This expertise extremely improves the spectrum effectiveness, reliability of system & reporting area. An easy MIMO system with M_t transmits antennas and M_r receiving antennas shown in Figure 1. Pre coding is one of the multi stream beams forming method which is engaged at the transmitter. In beam forming, the similar type of indication is emitted from every one of the transmit antennas with suitable phase weighting such that the highest received enter signal power at the receiver. This method increases the received signal gain, by employing signals emitted from several antennas and also reduces the multipath fading property. It requires accurate information of channel state information (CSI) at the transmitter.

Spatial multiplexing requires MIMO antenna design. In spatial multiplexing, a high rate sign is a divide into some small rate data streams and each flow is transmitted by the facilitate of special broadcast antennas which are having the similar rate of recurrence. If these signals received at the receiver antenna collection through special spatial signatures, the receiver can simply split this stream of information into equivalent channels. It is single of the outstanding method to amplify the channel facility and improves the high signal to noise ratio. Diversity Coding techniques are used when there is rejection channel information at the transmitter. In diversity coding, and an only data stream is transmitted with a coding method called as space-time coding. The indication is emitted from every of the transmit antennas with complete or close to orthogonal coding. Diversity coding exploits the autonomous desertion in the various antenna links to improve signal diversity.

Spatial multiplexing is able to join through pre-coding while the channel is identified at the transmitter or joint with diversity coding when decoding consistency is in exchange. A spatial multiplexing method makes the receivers especially difficult. Therefore it is generally joint by OFDM or with OFDMA modulation, where the harms formed by multi-path channel are handled competently.

3.1 Mathematical Description

A Narrowband flat-fading channels with multiple transmits

and receive antennas (MIMO), the system is modeled as

$$y = Hx + n \quad (2)$$

Where, y =Receive vectors, x = transmit vectors, H =Channel matrix, and N =noise vectors.

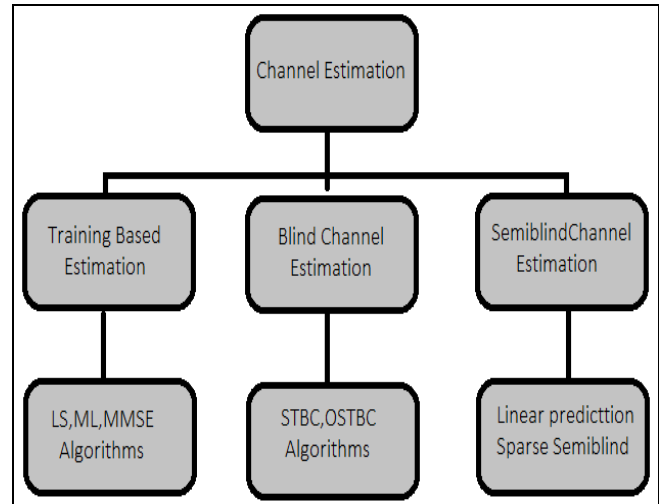


Fig 2: Classification Channel Estimation Algorithms

Ideally, the channel matrix H is famous completely due to channel evaluation errors, the channel information can be represented as

$$\text{Vec}(H) \sim \text{CN}(\text{vec}(H_{\text{estimate}}), \text{Error}) \quad (3)$$

Where H_{estimate} is the channel estimate and Error is the estimation error covariance matrix. CN is the circular symmetric complex normal.

3.2 Channel Estimation

In a wireless communication connection, channel state information provides the identified channel property of the tie. This CSI must be predictable at the receiver and frequently fed reverse to the transmitter. Thus, the transmitter and receiver can contain dissimilar CSI. The Channel State information can be immediate or statistical. In immediate CSI, the present channel situations are identified, which can be viewed by knowing the impulse response of the transmitted order. But Statistical CSI contains the statistical personality that is fading distribution, channel gain, spatial correlation etc. The CSI acquirement is basically restricted by how speedy the channel situation is changing.

In fast fading systems wherever channel situation fluctuates quickly below the broadcast of a single Information symbol, simply statistical CSI is sensible. But, in slow fading systems, immediate CSI may be predictable with sensible correctness. So channel estimation method is introduced to recover correctness of the received signal.

3.3 Classification of Channel Estimation

Basic categorization of channel estimation algorithm is instruction based, blind channel estimation or half blind channel estimation. The training-based channel estimation

may be performed through Moreover block category pilots or comb category pilots. In block type pilot estimation, pilot tones are inserted into every frequency bins inside the episodic intervals of OFDM blocks. But in comb type pilot estimation, pilot tones are inserted into all OFDM sign with an exact time of frequency bins. This category of channel estimation is extremely greatly appropriate wherever the changes still in one OFDM block. The blind channel estimation is agreed out through evaluating the statistical information of the channel and exacting properties of the transmitted signals. This blind channel estimation has a rejection in the vapors defeat and it is simply appropriate for gradually time changeable channels.

4. A Pilot Structure

Depending on the arrangement of pilots, two special types of pilot structures are considered: block type, and comb types

4.1 Block Type

In this, OFDM signs among pilots at all subcarriers are transmitted periodically for channel estimation. By these pilots, a time-domain interruption is performed to estimate the channel along the occasion alliance. As the consistent time is known in an opposite form of the Doppler frequency in the channel, the pilot symbol time has to assure the following variation:

$$S_t \leq 1/(f_{\text{doppler}})$$

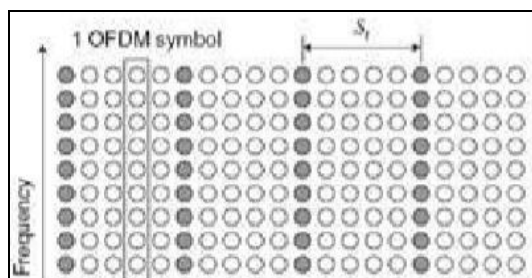


Fig 3(a): Block Type Pilot

4.2 Comb Type

In this, each OFDM symbol has pilot tones at the periodically-located subcarriers, which are used for a frequency-domain exclamation to approximate the channel alongside the frequency alliance. As the consistency bandwidth is resolute by an opponent of the highest wait extend S_{max} , the pilot symbol period must satisfy the following inequality.

$$S_f \leq 1/(\text{max})$$

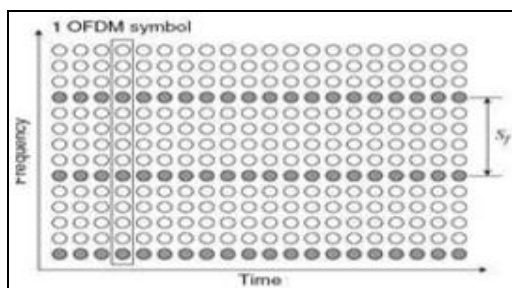


Fig 3(b): Comb Type Pilot

5. Conclusion

In this article, the fundamental concepts of Orthogonal Frequency Division Multiplexing, Multiple Input Multiple Output systems are discussed. The different channel estimation techniques such as training based, blind channel, half blind channel based algorithms and their presentation are also discussed.

6. References

1. Muhammet Nuri. Seyman Optimization of Pilot tones using differential evolution algorithm in MIMO-OFDM Systems in Turk Journal of Elec Engg & Comp Science. 2012; 20(1):1523.
2. Periera JM. Balancing Public and Private in Fourth Generation, The 12th IEEE International Symposium, Indoor and Mobile radio Communications. 2001; 12:125-132.
3. Moher ML, Lodge JH. TCMP- a modulation and coding strategy for Rician fading channels, IEEE Trans. Commun. Tech, 1967, 805-813.
4. Bria F, Gessler O, Queseth R, Stridh M, Unbehaun JWU, Zander J. Fourth Generation Wireless Infrastructure: Scenarios and Research Challenges, IEEE Personal Communications, 2001; 8:25-31.
5. MEng-Han Hieh, Che-Ho Wei. Channel Estimation for OFDM Systems based on COMBType Pilot arrangement in frequency selective fading channels, IEEE Trans. on Commun, 1998.
6. Razavi A, Xiao P, Tafazolli R. Information theoretic analysis of ofdm/oqam with utilized intrinsic interference, IEEE Signal Processing Letters, 2015.
7. Omri A, Bouallegue R, Hamila R, Hasna M. Channel Estimation for LTE Uplink System by perceptron Neural Network in International Journal of Wireless & Mobile Networks. 2010; 2(3):155-165.
8. Sandell M, Edfors O. A comparative study of pilot-based channel estimators for wireless OFDM Research report TULEA, Div. of signal processing, LULEA University of Tech, 1996.
9. Julia Fernandez-Getino Garcia M, Ove Edfors, Jose M, Paez-Borrillo. Frequency offset correction for coherent OFDM in mobile cellular systems, Procc. of IEEE, 2001.
10. Ganesh RS, Jaya Kumari J, Akhila IP. Channel Estimation Analysis in MIMO-OFDM Wireless System in Proceedings of 2011 IEEE International Conference on Signal Processing, Communication, Computing and Networking Technologies ICSCCN, 2011, 467-471.
11. Muhammet Nuri Seyman, Necmi taspinar. Particle Swarm Optimization for Pilot Tones design in MIMO-OFDM Systems in Eurasip Journal on Advances in Signal Processing, 2011.
12. Vidhya K, Shankar Kumar KR. Enhanced Channel Estimation Technique for MIMO-OFDM Systems with the aid of EP Techniques in European Journal of Scientific Research. 2011; 67(1):140156.