An Extensive Literature Review on Channel Estimation Methods in OFDM-IDMA Systems

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Abstract- Orthogonal frequency division multiplexing (OFDM) provides an effective and low complexity means of eliminating intersymbol interference for transmission over frequency selective fading channels. This technique has received a lot of interest in mobile communication research as the radio channel is usually frequency selective and time variant. In OFDM system, modulation may be coherent or differential. Channel state information (CSI) is required for the OFDM receiver to perform coherent detection or diversity combining, if multiple transmit and receive antennas are deployed. In practice, CSI can be reliably estimated at the receiver by transmitting pilots along with data symbols. Pilot symbol assisted channel estimation is especially attractive for wireless links, where the channel is time-varying. In order to improve the system performance of OFDM- interleave-division multiple access (IDMA)Systems this literature review research paper has been presented.

Keywords - OFDM-IDMA, Channel Estimation, Least Squares (LS) algorithm, Minimum Mean Square Error (MMSE) Algorithm.

I. INTRODUCTION

Radio transmission has allowed people to communicate without any physical connection for more than hundred years. When Marconi managed to demonstrate a technique for wireless telegraphy, more than a century ago, it was a major breakthrough and the start of a completely new industry. May be one could not call it a mobile wireless system, but there was no wire! Today, the progress in the semiconductor technology has made it possible, not to forgot affordable, for millions of people to communicate on the move all around the world.

The Mobile Communication Systems are often categorized as different generations depending on the services offered. The first generation comprises the analog frequency division multiple access (FDMA) systems such as the NMT and AMPS (Advanced Mobile Phone Services). The second generation consists of the first digital mobile communication systems such as the time division multiple access (TDMA) based GSM (Global System for Mobile Communication), D-AMPS (Digital AMPS), PDC and code division multiple access (CDMA) based systems such as IS-95. These systems mainly offer speech communication, but also data communication limited to rather low transmission rates. The third generation started operations on 1st October 2002 in Japan.

During the past few years, there has been an explosion in wireless technology. This growth has opened a new dimension to future wireless communications whose ultimate goal is to provide universal personal and multimedia communication without regard to mobility or location with high data rates. To achieve such an objective, the next generation personal communication networks will need to be support a wide range of services which will include high quality voice, data, facsimile, still pictures and streaming video. These future services are likely to include applications which require high transmission rates of several Mega bits per seconds (Mbps).

In the current and future mobile communications systems, data transmission at high bit rates is essential for many services such as video, high quality audio and mobile integrated service digital network. When the data is transmitted at high bit rates, over mobile radio channels, the channel impulse response can extend over many symbol periods, which lead to inter symbol interference (ISI). Orthogonal Frequency Division Multiplexing (OFDM) is one of the promising candidates to mitigate the ISI. In an OFDM signal the bandwidth is divided into many narrow subchannels which are transmitted in parallel. Each subchannels is typically chosen narrow enough to eliminate the effect of delay spread. By combining OFDM with Turbo Coding and antenna diversity, the link budget and dispersive-fading limitations of the cellular mobile radio environment can be overcome and the effects of co-channel interference can be reduced.

Digital Communication Systems

A digital communication system is often divided into several functional units as shown in Fig. 1.1. The task of the source encoder is to represent the digital or analog information by bits in an efficient way. The bits are then fed into the channel encoder, which adds bits in a structured way to enable detection and correction of transmission errors. The bits from the encoder are grouped and transformed to certain symbols, or waveforms by the modulator and waveforms are mixed with a carrier to get a signal suitable to be transmitted through the channel. At the receiver the reverse function takes place. The received signals are demodulated and soft or hard values of the corresponding bits are passed to the decoder. The decoder

analyzes the structure of received bit pattern and tries to detect or correct errors. Finally, the corrected bits are fed to the source decoder that is used to reconstruct the analog speech signal or digital data input.

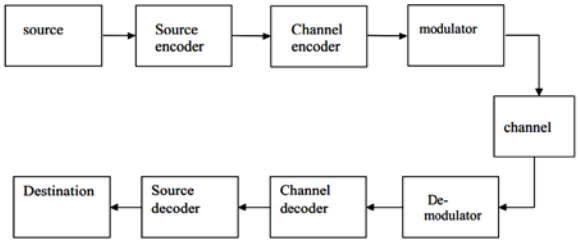

Fig 1.1: Functional Block in a Communication System

OFDM-IDMA Scheme

OFDM-CDMA is widely regarded as a promising candidate for the implementation of physical layer in the fourth generation (4G) wireless communication systems. A significant amount of research work has been spent on the OFDM-CDMA scheme, such as [10]. However, there are some disadvantages and difficulties related to OFDM-CDMA systems.

The OFDM - CDMA scheme often employs mutual orthogonal codes to distinguish users, and one major problem with the OFDM-CDMA scheme in frequency selective channel is the distortion of orthogonality among users (especially in uplink transmission scenario), which leads to serious MAI problem. MUD is a promising technique for the MAI problem, but the complexity related to MUD has been a major concern for its practical application. The maximum a posterior (MAP) multiuser detector has exponential complexity with the number of users *K*. Other linear multiuser detectors for conventional OFDM-CDMA system, e.g., the linear MMSE detector and the decorrelator, usually have quadratic complexity with the number of users *K*. The quadratic complexity is mainly due to the operations involved in resolving the correlation between spreading sequences. When K is large, the it is computationally prohibitive for practical implementation.

In OFDM-CDMA systems, spreading sequences are employed to distinguish signals from different users. From a coding theory point of view, it is not a wise choice to use spreading sequences for user separation, since the spreading operation analysis in bandwidth expansion without coding gain. The capacity of multiple access channels can only be approached, when entire bandwidth expansion is devoted to FEC coding.

II. SYSTEM MODEL

A wideband radio channel is normally frequency selective and time variant. For an OFDM mobile communication system, the channel transfer function at different subcarriers appears unequal in both frequency and time domains. Therefore, a dynamic estimation of the channel is necessary. Pilot-based approaches are widely used to estimate the channel properties and correct the received signal. In this authors have investigated two types of pilot arrangements.

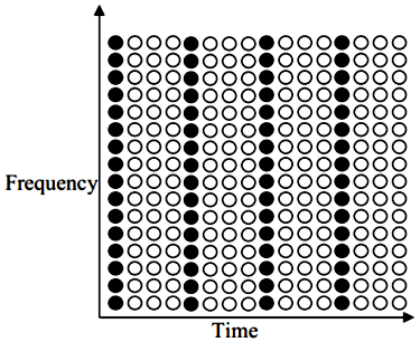

Fig. 1.2: Block type pilot arrangement

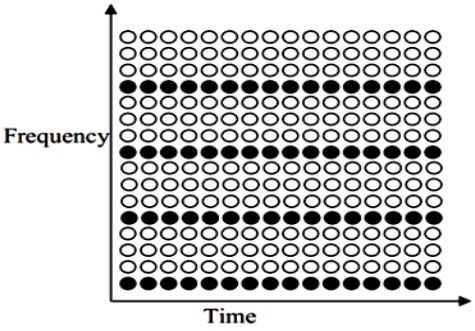

Fig. 1.3: Comb type pilot arrangement

The first kind of pilot arrangement shown in Fig. 1.2 is denoted as block-type pilot arrangement. The pilot signal assigned to a particular OFDM block, which is sent periodically in time-domain. This type of pilot arrangement is especially suitable for slow-fading radio channels. Because the training block contains all pilots, channel interpolation in frequency domain is not required. Therefore, this type of pilot arrangement is relatively insensitive to frequency selectivity. The second kind of pilot arrangement shown in Fig. 1.3 is denoted as comb-type pilot arrangement. The pilot arrangements are uniformly distributed within each OFDM block. Assuming that the payloads of pilot arrangements are the same, the comb-type pilot arrangement has a higher re-transmission rate. Thus the comb-type pilot arrangement system is provides better resistance to fast-fading channels. Since only some sub-carriers contain the pilot signal, the channel response of non-pilot sub-carriers will be estimated by interpolating neighbouring pilot sub-channels. Thus the comb-type pilot arrangement is sensitive to frequency selectivity when comparing to the block-type pilot arrangement system.

III. LITERATURE SURVEY

SR. NO.	TITLE	AUTHORS	YEAR	METHODOLOGY
1	Channel estimation techniques in OFDM-IDMA systems	N. Taşpinar and Ş Şimşir	2014	Pilot based channel estimation techniques for orthogonal frequency division multiplexing-interleave division multiple access (OFDM-IDMA) systems are investigated.
2	The OFDM-IDMA approach to wireless communication systems	L. Ping, Q. Guo and J. Tong	June 2007	This article outlines the principles of OFDM-IDMA. Comparisons with alternative technologies such as OFDM-CDMA and OFDMA are provided.
3	OFDM-IDMA versus IDMA with ISI Cancellation for Quasistatic Rayleigh Fading Multipath Channels	I. M. Mahafeno, C. Langlais and C. Jego	2006	Authors proposed a multi-user system combining OFDM and IDMA in the mobile radio environment for the uplink.
4	Novel techniques to improve downlink multiple access capacity for Beyond 3G	Shidong Zhou, Yunzhou Li, Ming Zhao, Xibin Xu, Jing Wang and Yan Yao	Jan. 2005	New spectrally efficient downlink multiple access techniques have been proposed.
5	Comparison of orthogonal and non-orthogonal approaches to future wireless cellular systems	P. Wang, J. Xiao and L. P	Sept. 2006	Demonstrated that non-orthogonal approaches have a spectral-power efficiency advantage over orthogonal
6	Interleave division multiple-access	Li Ping, Lihai Liu, Keying Wu and W. K. Leung	April 2006	This research provides a comprehensive study of interleave-division multiple-access (IDMA) systems.

N. Taşpinar and Ş Şimşir, [1] In this paper, pilot based channel estimation techniques for orthogonal frequency division multiplexing-interleave division multiple access (OFDM-IDMA) systems are investigated. Least Squares (LS) and Minimum Mean Square Error (MMSE) algorithms which are also utilized in pure OFDM systems to estimate the channel frequency responses, are used to obtain channel coefficients. The performance of OFDM-IDMA system is evaluated on the basis of Bit Error Rate (BER) and Mean Square Error (MSE) for different estimation algorithms. It is confirmed in this research that, OFDM-IDMA system using MMSE estimation algorithm shows much better performance than LS estimation algorithm. MMSE algorithm has the disadvantage of being more complex. Because of being multiuser system, the performance of OFDM-IDMA is also evaluated for different user numbers. It is shown that, the system performance decreases as long as the number of user is increased.

L. Ping, Q. Guo and J. Tong, [2] This article outlines the basic principles of OFDM-IDMA. Comparisons with other alternative technologies such as OFDM-CDMA and OFDMA are provided. Some attractive features of OFMD-IDMA are explained, including low-cost iterative multi-user detection, flexible rate adaptation, frequency diversity, and significant advantages regarding spectral and power efficiency.

I. M. Mahafeno, C. Langlais and C. Jego, [3] Interleave-Division Multiple Access (IDMA) is a multi-user scheme in which chip interleaves are the only means of user separation. The receiver involves a chip-by-chip iterative multi-user detection. Author proposed a multi-user system combining OFDM and IDMA in the mobile radio environment for the uplink. The OFDM-IDMA performance in terms of bit error rate and complexity is compared with that of IDMA with an Intersymbol Interference Cancellation technique, for quasi-static Rayleigh fading multipath channels. Authors results show that the IDMA with Intersymbol Interference Cancellation exploits path diversity in an optimal manner when Inter Symbol Interference (ISI) and Multiple Access Interference (MAI) are perfectly cancelled. Thus, it promises a good performance compared with the OFDM-IDMA when a priori information is perfectly estimated. Authors observe that during the iterative process, the OFDM-IDMA outperforms the IDMA with ISI Cancellation when user numbers increase. Indeed, the increase in the number of users requires the independent processing of MAI and ISI

that is carried out in the OFDM-IDMA. Moreover, this study shows that the complexity of IDMA with the ISI Cancellation receiver is about L times that of the OFDM-IDMA, where L is the number of paths.

Shidong Zhou, Yunzhou Li, Ming Zhao, Xibin Xu, Jing Wang and Yan Yao,[4] In future public mobile access with high data rates, one of the main challenges authorsface is spectral efficiency. In this article authorswill focus on the following new spectrally efficient downlink multiple access techniques that may be essential parts of China's Beyond 3G system development: dynamic code-division multiplexing, an adaptive multi-input multi-output technique in distributed wireless communications systems, and interleaver pattern division multi-access.

P. Wang, J. Xiao and L. P, [5] this article provides a comparative study of different multiple access techniques. It is demonstrated that non-orthogonal approaches have a spectral-power efficiency advantage over orthogonal ones for delay-sensitive applications in fading environments, and that this theoretical advantage can be realized in practice by exploiting recent progress in transmission and detection techniques. The practical aspects of these multiple access techniques are also discussed and compared.

Li Ping, Lihai Liu, Keying Wu and W. K. Leung, [6] This research provides a comprehensive study of interleave-division multiple-access (IDMA) systems. The IDMA receiver principles for different modulation and channel conditions are outlined. A semi-analytical technique is developed based on the density evolution technique to estimate the bit-error-rate (BER) of the system. It provides a fast and relatively accurate method to predict the performance of the IDMA scheme. With simple convolutional /repetition codes, overall throughputs of 3 bits/chip with one receive antenna and 6 bits/chip with two receive antennas are observed for IDMA systems involving as many as about 100 users.

IV.PROBLEM IDENTIFICATION

LS and MMSE channel estimation algorithms have been applied to OFDM-IDMA system to eliminate the distorting effect of fading channels. Their performances are compared based on both BER and MSE graph. It is observed from both BER and MSE graph that MMSE estimator is better in channel estimation with the disadvantage of its high complexity. OFDM-IDMA system performance is analyzed under different user numbers with the use of LS estimator. Simulation throughputs shows that, as the number of users increase, the system performance goes bad due to the enhancement of the parameter to be estimated and processed but the system performance may further improve to its optimum level.

V. CONCLUSION

A further simplification of the channel model for simulating multi-carrier systems in frequency domain is given by using the so-called uncorrelated fading channel model. This channel model is based on the assumption that the fading on adjacent data symbols after inverse OFDM operation and de-interleaving can be considered to be uncorrelated. This assumption holds when a frequency and time interleaver with sufficient interleaving depth has been analyzed.

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