An Extensive Review on 3GPP/LTE-A MIMO-OFDM

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Abstract- The objective of this examination is to study methods for optimizing the interface for multi–carrier multi–antenna wireless systems and to enhance performance measures suitable for the system level performance evaluation. In particular, the developed techniques can be applied to fast and accurate performance evaluation of MIMO–OFDM transmission in the system level studies. System level performance studies are necessary to analyze such topics as coverage, interference, frequency utilization, trafftc loading. Such quantitative results are required by standardization communities as well as mobile network operators for the network planning and optimization. The main objective is to provide a formal description of system model employed throughout this exploration. The model facilitates describing the transmission methods used in 3GPP LTE wireless network.

Keywords, wirelsess communication system, OFDM, 3GPP LTE, MIMO-OFDM, Modulation Demodulation.

I. INTRODUCTION

Wireless communications have evolved very rapidly. The rapid growth in the number of new subscribers, the development of different global technologies and wireless standards, the demand in the new, better quality, low cost services as well as higher data rates are the main motivations for the evolution in the wireless communications.

The communication over wireless channel has three fundamentaldistinctions fromthewirelinecommunication.First is the large-scale and small-scale fading, second is the interference between the transmitter- receiver pairs, and third is the user mobility in the network. The presence of fading, interference and mobility makes the design of wireless communication system challenging. The convectional design focusing on the reliability of the connection needs to mitigate the fading and multipath effects. Modern wireless system design focusing on the spectral efftciency gains from the rich multipath environment by means of utilizing spatial diversity through the Multiple–Input Multiple–Output (MIMO) communications. The MIMO system as a system with multiple antennas at the transmitter and the receiver theoretically allows linear growth of the link capacity. The capacity is proportional to the rank of MIMO channel. While high spectral efftciency can be obtained through spatial multiplex- ing, many other MIMO system beneftts such as improved signal quality and coverage can be achieved via spatial diversity, beamforming, space time coding and interface cancellation. However, all the gains cannot be achieved simultaneously due to their dependence on antenna conftguration and scattering environment.

Multi–carrier modulation such as Orthogonal Frequency Division Multiplexing (OFDM) is currently the most prominent technology for spectrum efftcient transmission. Since it is mitigating inter-symbol interference and enhancing system capacity, it is also well suitable for MIMO channel transmission. Furthermore, it facilitates using very simple equalization even in very broadband communications.

By combining MIMO system with OFDM technique the desired system requirements, such as good coverage in non-line-of-sight environment, reliable transmission, high peak data rates as well as high spectral efftciency, may be fulftlled. Multi-stream multi-carrier wireless transmission has been already standardized in IEEE 802.11n WLAN, IEEE 802.16 WMAN, IEEE 802.16 WiMAX as well as in 3GPP Long Term Evolution (LTE) and it will be the key transmission technology for the future 4G broadband wireless communication networks.

The aspects of MIMO–OFDM technology, such as multi–antenna configuration, sub-carrier scheduling and optimization, large number of re- source elements, need to be taken into account in the design of physical level, system level as well as interaction between link and system level called Link-to-System (L2S) interface. The evaluation of the quality of a radio link involving speciftc characteristics like spacial pre- and post-processing, synchronization, channel estimation, channel coding, modulation is done at a link level. The system level aims at evaluating the entire wireless network performance while taking into account terminal mobility, intercell interference, scheduling, handover, link adaptation in several typical deployment scenarios. The purpose of L2S interface is to determine the performance of radio link in terms of packet or block error rate in order to adapt transmission modes at the system level.

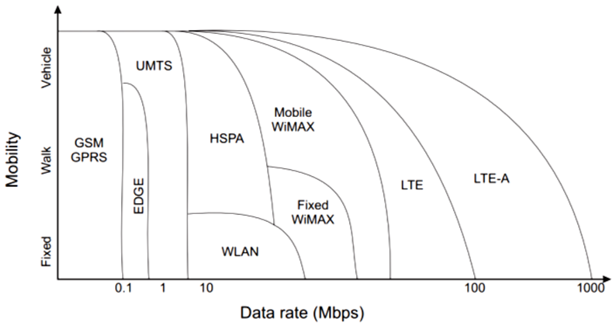

Figure: 1.1 Conceptual graph of the current wireless standard landscape.

Wireless communication systems have been subject to a drastic transformation during the last twenty years. From the old analog systems, focused exclusively on providing voice communication services, wireless technology has undergone a steep evolutionary path which has lead to today's wireless broadband systems, offering a wide range of multimedia services. A conceptual graph describing this evolution in terms of the data- rates and mobility degrees supported by various wireless communication standards is depicted in Figure 1.1. From the figure, it becomes apparent that a common trend has been driving the development of mobile wireless systems: a strive for higher data rates, even in high mobility scenarios. As an illustration, the International Telecommunication Union - Radio communication Sector (ITU-R) sets the target peak data-rate requirements for 4G systems, e.g. The Long Term Evolution Avanced (LTE-A) system, at 100 Mbps for users moving at vehicular speeds and 1 Gbps for low-mobility users.

II. MIMO-OFDM ITERATIVE DETECTION

Spectral sharing among the users, also referred to as multiple access, is carried out by dividing the signaling dimensions along the time, code, and/or frequency domains [29]. In time division multiple access (TDMA), the users are given orthogonal time slots, and each user occupies the entire frequency band over the assigned time slot. The GSM networks are based on TDMA. The users are separated by orthogonal codes in code division multiple access (CDMA). The spectrum sharing of the UMTS system is based on CDMA. In frequency division multiple access (FDMA), the total system bandwidth is divided into orthogonal frequency channels. Orthogonal frequency division multiple accesses (OFDMA) combine orthogonal frequency division multiplexing (OFDM) and FDMA and are one of the multiple access candidates for beyond 3G systems.

Multiple-input multiple-output (MIMO) processing exploits multiple antenna elements at the transmitting end as well as at the receiving end. The main idea in MIMO systems is space-time signal processing, where time and space domain signals are jointly processed. MIMO systems can be seen as an extension of conventional smart antenna systems. Those systems employ multiple antenna elements at only the transmitter or the receiver for beamforming or spatial diversity. Beamforming increases the average SNR by focusing the energy in the desired directions using correlated antenna elements. On the other hand, the correlation of antenna elements should be minimized when link reliability is improved by spatial diversity schemes.

a. Channel Estimation

The principle of synchronized (coherent) detection [63] is mainly used in the existing wireless communication systems. In other words, the channel state is estimated and the estimate is used in the detection and decoding as if it was the true channel state. Channel estimation can be avoided by using differential modulation techniques. However, this would limit the data rate and cause a drop in the performance [64, 65]. Another possibility, especially in systems with time division duplex (TDD) but also with frequency division duplex (FDD) [66], is to perform channel estimation at the base station and send a pre-distorted signal to the mobile. However, in fast fading channels, the pre-distortion would be uncorrelated with the channel, causing degradation in the performance.

b. MIMO Detection

An important problem in the design of digital communication system receivers is the detection of data from noisy measurements of the transmitted signals. Due to the noise, the receiver is bound to make occasional errors in any realistic scenario. Thus, designing a receiver which has the property of minimizing this error probability while being realistic from the computational complexity point of view has attracted a lot of attention amongst researchers.An overview of detection schemes applied for MIMO communications is provided below.

c. Iterative Detection

The capacity of MIMO channels cannot be achieved without using an outer channel code (providing redundancy for better protection of the information bits in the presence of burst fading, interference, or a strong noise) concatenated to a space-time mapper acting as an inner code. In such a system, the optimal joint detector/decoder is computationally infeasible, even with reasonable block lengths. The turbo principle, originally invented for the decoding of concatenated codes, can be used computationally efficiently to approximate the joint detection/decoding. This so called turbo equalization or iterative detection and decoding was first proposed and was further studied.

III. LITERATURE REVIEW

SR. NO.	TITLE	AUTHOR	YEAR	APPROACH
1	Iterative Demodulation and Decoding Algorithm for 3GPP/LTE-A MIMO-OFDM Using Distribution Approximation	T. Cui, F. Gao, A. Nallanathan, H. Lin and C. Tellambura,	2018	Soft iterative detection/decoding algorithms are fundamentally necessary for multiple-input multiple-output orthogonal frequency-division multiplexing
2	Mimo-OFDM Compressed Channel Estimation Using Forward-Backward Pursuit	A. Akbarpour-Kasgari and M. Ardebilipour	2018	Reported to use the joint sparsity of MIMO-OFDM channels using Forward Backward Pursuit (FBP) algorithm. In order to increase the accuracy of estimation,
3	Low-complexity zero-forcing detector for large-scale MIMO-OFDM systems	C. Mei and W. Huang,	2017	Adopt singular value decomposition (SVD) based ZF detection and employ power iterative method to reduce computational complexity of SVD
4	ICI mitigation in MIMO-OFDM by iterative equalization using OPT in time varying channels,	K. P. J. Sherin and E. Abhitha,	2017	A low complexity iterative method called operator perturbation technique (OPT) is used for MIMO-OFDM system to reduce ICI
5	Iterative decision-directed channel estimation for MIMO-OFDM system	Wenjie Zhang, Hui Li and Bin Li,	2016	An iterative decision-directed channel estimation algorithm is proposed for multiple-input multiple-output orthogonal frequency division multiplexing (MIMO-OFDM) system
6	Performance scrutiny and optimization of LDPC coded MIMO OFDM systems	V. S. Jadhav and P. Sawant,	2016	The implementable decoders and large collection of data transmission and storage channels can be admitted at the same time using low density parity check (LDPC) group of Linear block codes
7	M2M Communications in 3GPP LTE/LTE-A Networks: Architectures, Service Requirements, Challenges, and Applications	F. Ghavimi and H. Chen,	2015	Presents architectural enhancements for providing M2M services in 3GPP LTE/LTE-A networks and reviews the features and requirements of M2M applications.

T. Cui, F. Gao, A. Nallanathan, H. Lin and C. Tellambura, [1] Soft iterative detection/decoding algorithms are fundamentally necessary for multiple-input multiple-output orthogonal frequency-division multiplexing (MIMO-OFDM) adopted in the Third Generation Long Term Evolution (LTE)-Advanced in order to increase the capacity and achieve high data rates. However, their high performance critically requires log likelihood ratio computations with prohibitive complexity. This challenge will be addressed in this examination. First use the assumption of Gaussian transmit symbols to show the equivalence among several existing algorithms. Next develop a non-Gaussian approximation for high-order constellations, which paves the way for interference cancellation-based detectors. Based on both Gaussian and non-Gaussian approximations, thus develop several capacity-achieving iterative MIMO-OFDM demodulation and decoding algorithms. To this end, adopt K-best algorithms to take advantage of both the types of approximations and the list decoder. Unlike existing algorithms, our proposed K-best algorithms make use of the a priori probabilities to generate the list. Simulations of standard-compliant LTE systems demonstrate that the proposed algorithms outperform the existing ones.

A. Akbarpour-Kasgari and M. Ardebilipour, [2] Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing (MIMO-OFDM) channel estimation is considered recently utilizing Compressed Sensing (CS) based methods. Here, reported to use the joint sparsity of MIMO-OFDM channels using Forward Backward Pursuit (FBP) algorithm. In order to increase the accuracy of estimation, reported to take into account the common sparsity of MIMO channels in each step and to exploit common sparsity in the system model. Furthermore, the backward steps improve the accuracy by omitting evil previously gathered atoms. Simulation results represent the superiority of the proposed FBP-based channel estimation approach rather than the conventional CS-based approaches.

C. Mei and W. Huang, [3] Consider the uplink of multi-input multi-output (MIMO) orthogonal frequency division multiplexing (OFDM) systems. When the number of antennas is sufficiently large, the zero-forcing (ZF) detection performed at the Base station (BS) is near optimum to demodulate data symbols transmitted by users over each subcarrier. Nevertheless, it requires matrix inversion to perform the ZF detection especially when the number of users and subcarriers are large. In this work, adopt singular value decomposition (SVD) based ZF detection and employ power iterative method to reduce computational complexity of SVD. Furthermore, exploit the fact that the channel matrices of adjacent subcarriers are similar to reduce the required number of iterations in the power iterative method. Specifically, the initial vectors in the power iteration are substituted by the singular vectors obtained for the channel matrix corresponding to the previous subcarrier, rather than the randomly generated vector. It shows through computer simulations that the proposed method reduces the number of iterations by 40%~70%, which significantly reduces the computational complexity in broadband OFDM systems.

K. P. J. Sherin and E. Abhitha, [4] Time variation of channel in orthogonal frequency division multiplexing (OFDM) system destroys the orthogonality between subcarriers, and introduces inter carrier interference (ICI). Different methods have been used to combat ICI, but the computational complexity of some methods is high. In multiple-input multiple-output (MIMO) system the complexity is even higher. This examination reported a low complexity iterative method called operator perturbation technique (OPT) is used for MIMO-OFDM system to reduce ICI under the assumption of linear time-varying channels. It requires channel estimation based on linear time-varying channel model. Time-domain synchronous-OFDM suits for this proposed iterative technique because its receiver can easily estimate linear time-varying channels. Simulation with QPSK modulation demonstrates the performance of the proposed method. Here compare LTI and LTV performance for QPSK modulation. Result shows that the iterative method has nearly similar performance for both LTV and LTI channel irrespective of their channel condition. Also better BER and MSE performance for both LTV and LTI algorithm is achieved when the Doppler frequency is 10Hz.

Wenjie Zhang, Hui Li and Bin Li, [5] In this examination, an iterative decision-directed channel estimation algorithm is proposed for multiple-input multiple-output orthogonal frequency division multiplexing (MIMO-OFDM) system. The algorithm is divided into two parts: channel prediction and channel estimation. The basic idea of the channel prediction is to use the auto-regression model and a priori information of the channel to predict channel state. Then channel state is estimated by using the channel prediction information and received signal. The simulation results show that the proposed method can increase the accuracy of the channel estimation and improve the performance of the MIMO-OFDM system. The BER of the iterative DD-CE method has almost 10% promotion when the SNR is 30 and almost 2dB improvement of estimation accuracy than traditional DDCE method.

V. S. Jadhav and P. Sawant, [6] The implementable decoders and large collection of data transmission and storage channels can be admitted at the same time using low density parity check (LDPC) group of Linear block codes. Review some of the LDPC construction techniques and encoding problem for LDPC codes. Also certain special classes of LDPC codes which will resolve encoding problems will be introduced. Performance analysis and design optimization of LDPC coded multiple input multiple output(MIMO) orthogonal frequency division multiplexing(OFDM) has been considered. The tools of density evolution with mixture Gaussian approximations are used to optimize LDPC codes which are not regular and to compute minimum operational signal-to-noise ratios (SNRs) for ergodic MIMO-OFDM channels. In particular, the optimization is done for various MIMO-OFDM system configurations, which include a different channel models and different demodulation schemes; the performance which is optimized is checked with the corresponding channel capacity. The iterative message passing decoding algorithm which gives optimal performance will be presented. The performance of turbo-iterative receiver that consists of a soft maximum a posteriori (MAP) demodulator will be presented. From the LDPC profiles that already are optimized for ergodic channels, construct small block-size irregular codes for outage MIMO-OFDM channels.

F. Ghavimi and H. Chen, [7] Machine-to-machine (M2M) communication is an emerging technology to provide ubiquitous connectivity among devices without human intervention. The cellular networks are considered a ready-to-use infrastructure to implement M2M communications. However, M2M communications over cellular pose significant challenges to cellular networks due to different data transactions, diverse applications, and a large number of connections. To support such a large number of devices, M2M system architecture should be extremely power and spectrum efficient. In this examination provide a comprehensive survey on M2M communications in the context of the Third-Generation Partnership Project (3GPP) Long-Term Evolution (LTE) and Long-Term Evolution-Advanced (LTE-A). More specifically, this examination presents architectural enhancements for providing M2M services in 3GPP LTE/LTE-A networks and reviews the features and requirements of M2M applications. In addition, the signal overheads and various quality-of-service (QoS) requirements in M2M communications also deserve our attention. address M2M challenges over 3GPP LTE/LTE-A and also identify the issues on diverse random access overload control to avoid congestion caused by random channel access of M2M devices. Different application scenarios are considered to illustrate futuristic M2M applications. Finally, present possible enabling technologies and point out the directions for M2M communications research.

IV. PROBLEM FORMULATION

Channel estimation for wireless systems is a challenging problem and the literature treating channel estimation in wireless systems is vast. Channel estimation methods for OFDM systems could be grouped into two main categories: blind and non-blind methods. The blind methods require a large amount of data since they use the statistical behavior of the received signal to estimate the channel. Therefore, they are not applicable for fast-fading channels. The non-blind channel estimation schemes can be further categorized into data-aided (DA) and decision directed (DD) channel estimation methods. DD channel estimation can be also seen as a special case of iterative channel estimation. The recent development indicates that future wireless systems will be able to sup- port peak data rates in the range of several hundred megabits up to gigabits per second, while offering the same reliability and data rates as their corresponding wired counterparts.

V. CONCLUSION

This work presents an extensive survey of literature,during the last decade; many wired communication systems are being replaced by corresponding wireless services. With the increasing avail- ability of portable computers and personal digital assistants, for example, wireless services have shifted from voice-based to multimedia- oriented applications. Such services often tend to require even higher data rates. The use of multiple antennas at both ends of the wireless link is known as multiple-input multiple-output (MIMO) wireless technology and enables to transmit multiple data streams concurrently and within the same frequency band. Ths work introduces the channel estimation approaches and recent work in wireless MIMO OFDM system.

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