A Review Channel Estimation in Massive-MIMO-OFDM System Using Approimate Message Passing

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Abstract- *In communication systems, Multiple-Input Multiple-Output (MIMO) shows a major role because of its high performance. Massive-MIMO systems are capable of improving the channel capacity of the system. In MIMO systems, multiple antennas are used in both transmitter and receiver to improve the communication performance, whereas the orthogonal frequency division multiplexing (OFDM) is a multicarrier modulation method. MIMO-OFDM is commonly used for communication systems due to its high transmission rates and robustness against multipath fading. In MIMO-OFDM, channel estimation plays a major role and channel estimation is the estimation of the transmitted signal bits using the corresponding received signal bits. In this paper an extensive review on different channel estimation methods used in MIMO-OFDM like pilot based, least square (LS) and minimum mean square error method (MMSE), least mean square (LMS) and recursive least squares (RLS) methods and also other channel estimation methods used in MIMO-OFDM are discussed.*

Keywords- Massive MIMO, MIMO-OFDM, Channel Estimation, AMP, MMSE, Compressive Sensing.

I. INTRODUCTION

Over the last few years, massive multiple-input-multiple-output (MIMO) has shown up as an emerging technology for wireless communication systems. Featuring up to thousands of transmit/receive antennas, the possibility of creating extremely narrow beams for many users is gaining the attention of industry and academia.MIMO technology is an important method, which is employed to improve the signal to noise ratio for wireless technologies. MIMO wireless technology increases the spectral efficiency through spatial multiplexing gain, and due to antenna diversity gain, it enhances the link reliability. Researchers are focusing their efforts on the promised benefits of this technology to create the next generation of communication systems. The underlying idea is to scale up the number of antennas at the base station (BS) by at least two orders of magnitude. The end effects of indefinitely increasing the number of antennas are small fading effects and additive noise. In a multiuser MIMO scenario, Massive MIMO opens the possibility to steer many spatial streams to dozens of pieces of user equipment (UE) in the same cell, at the same frequency, and at the same time. Mobile networks are currently facing rapid traffic growth from both smartphones and tablets. Sequential improvements of service quality set the new challenge of increasing wireless network capacity about a thousand times within the next decade, but no current wireless access technique can provide a significant improvement in capacity. A possible solution to cope with such a capacity demand is through network densification by adding small cells (SCs) (Pico-cells and femtocells) that operate at high frequencies (e.g. 60 GHz) within the macro cell area.

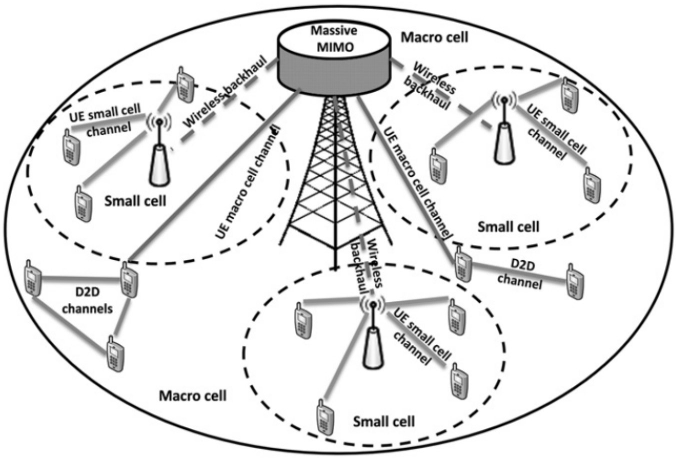

Figure 1 Architecture of HET-NET (Songlin Sun and Bo Rong et al. [11])

SCs that utilize the same band spectrum can increase the capacity of a mobile network from 10 to 100 times, depending on the number of SCs and frequency reuse method. The energy efficiency of massive MIMO and SC has been studied. The authors proved that massive MIMO has better energy efficiency when the number of SCs is low, while SC offers better performance when the number of SCs is high. However, a globally optimal trade-off between massive MIMO and SC efficiency is hard to achieve due to dynamic network behavior. A viable solution could be found by converging massive MIMO, SCs, and device-to-device (D2D) communications into a single cloud-controlled Heterogeneous network (Het-Net), as shown in figure 1.

II. MULTIPLE-INPUT MULTIPLE-OUTPUT SYSTEM (MIMO)

MIMO technology is also utilized to maximize the signal to noise ratio for wireless technologies, particularly in mobile Wi-MAX where there is a nonline-of-site situation and it needs to be adjustable to change the signal to noise ratio. It is clearly exposed that MIMO systems have the potential to provide higher capacity than the single input single-output (SISO) counterparts. Moreover, the system capacity can be considerably improved if multiple transmit and receive antennas are used to generate MIMO channels.

III. CHANNEL ESTIMATION

Channel estimation is an important task in coherent communication systems. As well as it is a major issue for coherent OFDM systems. As compared to the SISO systems, channel estimation is more difficult because of the increased number of channels to be estimated. Based on the signals correlation and MAI suppression, the channel estimation method is developed. Estimation of the signal amplitude and the propagation delay of each user are performed. Also, the effect of channel estimation is utilized in diversity combination and optimization of the receiver performance. The quality of the channel estimation method has a severe impact on the overall Bit Error Rate (BER) performance of the receiver.

IV. LITERATURE REVIEW

In this section, we describe the literature of different methodologies used for channel estimation in massive MIMO system.

A Review Of Literature Survey-

Taneja et al. [1] reviewed the work that has been already done in the field of channel estimation in the MIMO-OFDM system. In this paper the current best techniques Available for channel estimation has reviewed and provide a comparative analysis. A simulation has been performed for using various channel estimation techniques and reviews the different types of channel estimation in MIMO system by varying the precoding and modulation techniques. As the multiple signals are send using multiple antennas at transmitter and receiver side this will abolish the problem of multipath fading. In this paper OFDM technique is used as modulation technique to send the signals. Using MIMO with OFDM shows high data rate and robustness for multipath fading, this paper also discussed about the precoding techniques. This paper discussed the channel estimation techniques like Least Square (LS), Adaptive Least Square (ALS), and MMSE for MIMO-OFDM system.

Khumalo et al. [2] used AMP algorithm for data detection in MIMO sysytem. In MIMO systems the challenge is the detection of the individual signals from the composite signal with a large system limit. The approximate message passing (AMP) algorithm, designed for compressed sensing, has attracted researchers to counter this problem due to its reduced complexity with a large system limit. For this reason the AMP algorithm has been used for detection in massive MIMO systems. This paper focused on implementing this algorithm in a fixed point format. To obtain an implementation friendly architecture, approximations for the mean and variance estimation functions within the algorithm has been proposed. These estimation functions are obtained using the log sum approximation, then taking the exponent of the result. The log sum approximation is obtained by the Jacobian logarithm with a correction function, then transform the algorithm with the approximated functions to fixed point and provide a BER performance for the algorithm with the variables set to 16bit word lengths using the hybrid “Scaled-Double” data types.

Jeon et al. [3] proposed optimal data detection in multiple-input multiple output (MIMO) communication systems with a large number of antennas at both ends. In order to reduce the computational complexity, a variety of sub-optimal detection algorithms have been proposed. In this paper, author analyzed the optimality of a novel data-detection method for large MIMO systems that relies on approximate message passing (AMP). Here algorithm referred to as individually-optimal (IO) large-MIMO AMP (short IO-LAMA), is able to perform IO data detection given certain conditions on the MIMO system and the constellation set (e.g., QAM or PSK). Authors presented the IO-LAMA algorithm along with the state-evolution recursion. Using the results, some conditions established on the MIMO system matrix, the noise variance N0, and the constellation set for which IO-LAMA exactly solves the (IO) problem. While the presented results are exclusively for the large-system limit, this simulations indicate that IO-LAMA achieves near-optimal performance in realistic, finite-dimensional systems.

Meng and Sheng Wu et al. [4]: proposed detection algorithm for large-scale multiuser MIMO-OFDM systems. To achieve this, message passing algorithms used over the factor graph that represents the multiuser MIMO-OFDM systems and approximate the original discrete messages with continuous Gaussian messages through the use of the minimum Kullback-

Leibler (KL) divergence criterion. Several signal processing techniques are proposed to achieve near-optimal performance at low complexity. First, the principle of expectation propagation is employed to compute the approximate Gaussian messages, where the symbol belief is approximated by a Gaussian distribution and then the approximate message is calculated from the Gaussian approximate belief. Second, the first-order approximation of the message is utilized to further simplify the message updating, leading to an algorithm that is equivalent to the AMP algorithm. In the literature through the proposed message passing algorithms can achieve a near-optimal performance; it is also shown that the proposed message passing algorithms exhibit desirable tradeoffs between performance and complexity for a low-dimensional MIMO system.

Kaur et al. [5]: proposed various estimation techniques for Multiple-input-multiple-output (MIMO) communication system, MIMO system when joined with OFDM Scheme allows consistent transmission of data. There are the different estimation techniques, Pilot based channel estimation is one of the most used techniques for the channel estimation. This paper reviewed the research that has already been done to propose different techniques for channel estimation. This paper analyzed the implementation of Recursive Least Square (RLS) and Least Mean Square (LMS) algorithms for channel estimation in the MIMO-OFDM system.

Sun et al. [6] described about the Heterogeneous networks (Het-Nets) that play a crucial role to achieve expected coverage and capacity across venues. This paper correspondingly addressed software-defined network (SDN) as the central controller of radio resource management in massive MIMO Het-Nets. In this proposed scheme, SDN controller first collects the user channel state information in an effective way, and then calculates the null-space of victim users and applies linear pre-coding to that null-space. The design is highly beneficial and easy to be deployed, due to its high quality of service performance and low computation complexity.

Duangsuwan et al. [7]: this paper presents the optimal detection of data symbol in massive MIMO for 5G wireless communication. Based on the frequency non-selective fading MIMO channel, here consider three difference detectors for recovering the transmitted data symbols and evaluate their performance for Rayleigh fading and additive white Gaussian noise (AWGN). This paper discuss the performance evaluation of the existing detection methods of data symbol in the massive MIMO system. At the detector an optimal detector with the maximum likelihood detector (MLD), the minimum mean square error (MMSE), and inverse channel detector (ICD) is discussed.

Osman Musa et al. [8] described compressed sensing recovery techniques allow for reconstruction of an unknown sparse vector from an underdetermined system of linear equations. Problem of recovering the sparse vector from quantized CS measurements especially when measurements are corrupted by noise. To solve this problem, the highly efficient generalized approximate message passing (GAMP) algorithm used and provide closed-form expressions for the nonlinear steps and demonstrate the superiority of this approach in terms of the mean squared error (MSE) performance.

Ref. no.	TITLE	YEAR	Technology Used	Remark
1.	Review on Channel Estimation for MIMO OFDM System.	2016	Discuss various channel estimation techniques like LS, ALS, MMSE	The MMSE channel estimator is complex yet faster as compared to the LS estimator.
2.	Study on fixed point transformation of approximate message passing algorithm in massive MIMO systems	2016	Implementing the algorithm in a fixed point format to detect the individual signals from the composite signal. AMP, Log-sum approximation used.	Approximations proposed for the mean and variance estimation functions within the algorithm.
3.	Optimality of large MIMO detection via approximate message passing.	2015	Approximate message passing (AMP) algorithm, referred to as individually -optimal (IO) large-MIMO AMP (IO-LAMA).	Individually -optimal (IO) large-MIMO AMP (IO-LAMA)algorithm is able to perform IO data detection on the MIMO system.
4.	An expectation propagation perspective on approximate message passing.	2015	MMSE-SIC, BELIEF APPROXIMATION, AMP.	Message Passing algorithm used over factor graph, message passing shows better performance in MIMO systems.
5.	Review Paper on Performance Analysis of Channel Estimation in MIMO-OFDM System	2017	Both comb-type and Block-type Pilot arrangements based channel estimation. LMS, RLS, MMSE used.	In this paper pilot based estimation, LS, RLS, and MMSE channel estimation methods are reviewed.
6.	Integrating network function virtualization with SDR and SDN for 4G/5G networks.	2015	Heterogeneous networks (Het-Nets), software-defined network (SDN)	Het-Nets achieve expected coverage and capacity across venues, SDN act as central controller.
7.	Detection of Data Symbol in a Massive MIMO Systems for 5G Wireless Communication	2017	Maximum Likelihood Detector (MLD), Minimum Mean Square Error (MMSE), And Inverse Channel Detector (ICD)	This paper reviews the data detection in Massive MIMO system and also evaluates performance of the existing data symbol detection methods of in the massive MIMO.

8.	Generalized approximate message passing for one-bit compressed sensing with AWGN.	2016	Generalized Approximate Message Passing (GAMP) algorithm used.	Describe compressed sensing recovery techniques, message passing algorithm used and demonstrate the superiority of this approach in terms of the mean squared error (MSE) performance.

V. CONCLUSION

On the basis of literature survey, it is found that MIMO-OFDM systems have the characteristic to fulfill the demands of the future wireless communication systems by using the channel estimation techniques. Massive MIMO systems include numerous antennas at the transmitting end and receiving end enhances the spectral efficiency and energy efficiency largely. In this review paper, different methods for channel estimation in the MIMO-OFDM system are presented. Analysis has been done based on LS, RLS, MMSE, Belief propagation, Approximate Message Passing and other methods for channel estimation. Among the other methods, MMSE and Message passing methods are utilized mostly in which the error value is relatively lesser than the other methods. In the presence of time-varying Rayleigh fading and strong co-channel interference, the message passing algorithm shows better performance than other estimation techniques. Massive MIMO technology offers huge advantages in terms of energy efficiency, spectral efficiency, robustness and reliability

REFERENCES

[1] Taneja, Ashu. "Review on Channel Estimation for MIMO OFDM System." Vol. 9, No. 5 (2016), pp. 189-196.

[2] Mhlaliseni, Khumalo. " Study on fixed point transformation of approximate message passing algorithm in massive MIMO systems “(2016): 1-94.

[3] Jeon, Charles, Ramina Ghods, Arian Maleki, and Christoph Studer. "Optimality of large MIMO detection via approximate message passing." In *Information Theory (ISIT), 2015 IEEE International Symposium on*, pp. 1227-1231. IEEE, 2015.

[4] Meng, Xiangming, Sheng Wu, Linling Kuang, and Jianhua Lu. "An expectation propagation perspective on approximate message passing." *IEEE Signal Processing Letters* 22, no. 8 (2015): 1194-1197.

[5] Ramanpreet Kaur, Harjinder Singh" Review Paper on Performance Analysis of Channel Estimation in MIMO-OFDM System" Vol. 5, Issue 06, 2017.

[6] Sun, Songlin, et al. "Integrating network function virtualization with SDR and SDN for 4G/5G networks." *IEEE Network* 29.3 (2015): 54-59.

[7] Duangsuwan, Sarun, and Punyawi Jamjareegulgarn. "Detection of data symbol in Massive MIMO systems for 5G wireless communication." *Electrical Engineering Congress (IEECON), 2017 International*. IEEE, 2017.

[8] Musa, Osman, Gabor Hannak, and Norbert Goertz. "Generalized approximate message passing for one-bit compressed sensing with AWGN." *Signal and Information Processing (GlobalSIP), 2016 IEEE Global Conference on*. IEEE, 2016.