Multi User-MIMO in OFDM for 5G communication: A Review

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***Abstract*: The MU-MIMO technique has played the most important role in 5G wireless communication. It is anticipated that the new techniques employed in MU MIMO will not onlyimprove peak service data rates significantly but also enhance capacity, coverage, low-latency, efficiency flexibility, compatibility and convergence, thus meeting the focusing demands imposed by optical detection. This paper presents the optimal detection of data symbols in MU-MIMO for 5G wireless communication. Based on the frequency non-selective fading MIMO channel, we consider three difference detectors for recovering the transmitted data symbols and evaluate their performance for Rayleigh fading and additive white Gaussian noise (AWGN). At the results, we show that the probability of error rate (PER) performance of the detectors is significantly discussed. In the paper, an overview of MU MIMO systems in wireless communication which is the breakthrough in wireless communication technology nowadays is presented. MIMO systems are used to improve the noise and interference performances of a channel. In the paper, MIMO systems are used to expand channel capacity and BER are also highlighted. The discussion then proceeds further towards the limitations and advancements in this technology. In the modern scenario, MU MIMO includes the merger of OFDM with MIMO. By the use of MIMO-OFDM, very high data rates are achieved. Maximum Likelihood MU multiple-input multiple-output (MIMO) systems utilize hybrid beamforming techniques to alleviate the implementation complexity of combining a large number of antennas. this work proposed a hybrid processing algorithm via matrix decomposition for Maximum Likelihood MU MU-MIMO systems. Both inter-user interference (IUI) and inter-stream interference (ISI) within the user are taken into consideration.**

***Keywords*: MU MIMO; optimal detector; Rayleigh fading channel; PER; 5G wireless communication**

I. INTRODUCTION

The standard mobile technology is in the trends of digital transformation, a challenging new capability that will benefit research and development as a whole. The step from 4G to 4.5G was being launched [1]-[2], and the industry is toward to, initially in the advances LTE and then in 5G, will be even greater [3]. Standards that have been planned; that process expected will be in 2020 timeframe [4]. However, almost of operators have demonstrated many of 5G capabilities, and alsoshowed pre-standard networks for fixed applications as early as2017 [5]. The 5G is not to replace LTE, but in most deployments will co-exist with-it high-speed technologies tightly integrated in a manner transparent to users [6]-[7].Many of the capabilities that will make 5G so effective are appearing in advanced forms of LTE. With carrier aggregation(CA) [8], for example, operators have not only harnessed the potential of their spectrum holdings to augment capacity and performance, but the technology is also the foundation for entirely new capabilities, such as operating LTE in unlicensed bands. With long-term evolution (LTE) growth in smartphonesand usage limited by population, innovators are turning their attention to the Internet of Things (IoT), which promises billions of new wireless connections. Enhancements to LTE followed by 5G capabilities will connect wearable computers, the vast array of sensors, and other devices, leading to better health, economic gains, and other advantages. 5G addresses notonly IoT deployments on a MU scale, but also applicationspreviously not possible that depend on ultra-reliable and low-latency communications. Although a far more fragmented market than smartphones, the benefits will be so great that the realization of IoT on a MU scale is inevitable. The only question is how, exactly, the market will evolve [9]-[10].

5G research and development accelerates, in the early stages ofdefinition through global efforts and many proposed technical approaches, could start to be deployed close to 2020 and continue through 2030. The trends of development are focusing on propagation limitation [11]-[12], MU MIMO antennas [13]-[14], beam-steering [15]-[16], beam tracking, dual connectivity, carrier aggregation, small-cell architectures.These have been on research work increasingly, in particular, the MU MIMO provides the essential roles to enhance the channel capacity and spectral efficiency. To understand what the MU MIMO is, the MU MIMO or large scale antenna system is a form of multiuser MIMO in which the number of antennas at the base station is much larger than the number of devices per signal resource. The MU MIMO systems, which are equipped with tens or even hundreds of antennas. Firstly, energy efficiency can be significantlyincreased by MU MIMO system as they concentrate poweron a shape direction. Secondly, system throughput can begained by utilizing multi-user MIMO (MU-MIMO). Lastly, MU MIMO systems are more robust than conventional MIMO systems as they offer an excessive degree of freedom.Although the MU MIMO can achieve orders of increase inspectral efficiency, one of which is the practical signal detection algorithm in the uplink due to the increased multi-user interference (MUI).

In this paper, we discuss the performance evaluation of theexisting detection methods of data symbols in the MU MIMO system. Consider a transmission channel and system model that employs the multiple transmitting antennas and the receiving antennas, as shown in Fig. 1. We assume that the detector knows the elements of the channel matrix H perfectly. At the detector, we employ an optimal detector with the maximum likelihood detector (MLD), the minimum mean square error (MMSE), and inverse channel detector (ICD) is discussed. Simulation results show that the probability of error rate performance of the three detectors in a Rayleigh fading channel is most easily verified by using Monte Carlo computersimulation. Furthermore, the simulation results are also examined the number of users.

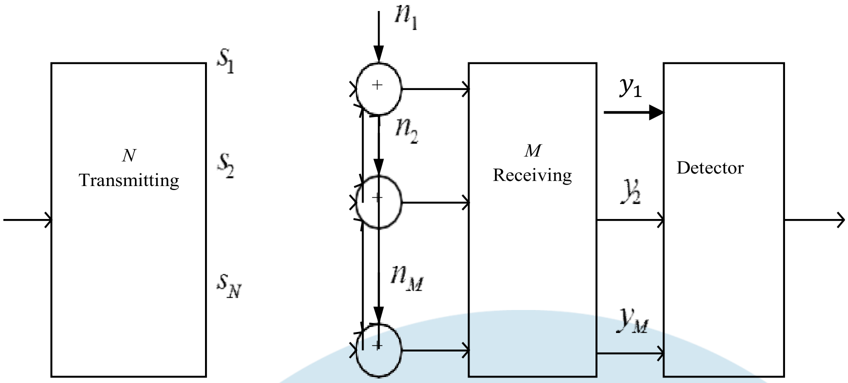

Fig. 1 An uplink communication system with the MU MIMO antennas for 5G wireless communication.

The goal is to design and simulate MU MIMO-OFDM System using proposed Maximum Likelihood Data Detector and Inverse Channel Data Detector and to Analyze proposed LTE-Advanced System design MU MIMO-OFDMin Rayleigh Fading Channel and reduce ISI and analyze the performance of the proposed model in terms of Bit ErrorRate (BER) and analyze the variations of a signal to noise ratio (SNR) with bit error rate for differentmodulators, like BPSK, QPSK, 16-QAM, 64-QAM.

Orthogonal Frequency Division Multiplexing

The next-generation communication system is beyond the current 4G IMT-A communication standards. The combination MU MIMO-OFDM is beneficial since OFDM enables support of more antennas and larger bandwidths since it simplifies equalization dramatically in MU MIMO systems. The main idea behind OFDM is the so-called Multi-Carrier Modulation (MCM) transmission technique. MCM is the principle of transmitting data by dividing the input bitstream into several parallel bit streams, each of them having a much lower bit rate, and by using these sub-streams to modulate several carriers [2]. The first systems using MCM were military high-frequency radio links in the late 1950s and early 1960s, like Cineplex, Andeft and Kathryn [2]. OFDM is a special form of MCM with densely spaced sub-carriers and overlapping spectra, whose main idea was patented by Chang, from the Bell Labs, in 1966[2]. OFDM abandoned the use of steep bandpass filters that completely separated the spectrum of individual sub-carriers, as it was common practice in older analogue FDMA systems. Instead, OFDM time-domain waveforms are chosen such that mutual orthogonality is ensured even though carrier spectra may overlap. Orthogonality is achieved by performing a Fourier Transform (or equivalently a Fast Fourier Transform) on the input stream[2].

Multiple Input Multiple Output(MIMO)

MIMO (multiple input, multiple outputs) in 1998 Bell Laboratories successfully demonstrated the MIMO system under laboratory conditions. In the following years, Gigabit wireless Inc. and Stanford University developed a transmission scheme and jointly held the prototype demonstration of MIMO. MIMO is an antenna technology for wireless communications in whichmultiple antennas are used at both the source (transmitter) and the destination (receiver) [6]. The antennas at each end of the communications circuit are combined to minimize errors and optimize data speed. MIMO is one of several forms of smart antenna technology, the others being MISO (multiple input, single output) and SIMO (single input, multiple outputs)[6]. By adopting Multiple-Input Multiple-Output (MIMO) and Orthogonal Frequency-Division Multiplexing (OFDM) technologies, indoor wireless systems could reach data rates up to several hundreds of Mbits/s and achieve spectral efficiencies of several tens of bits/Hz/s, which are unattainable for conventional single-input single-output systems. The enhancements of data rate and spectral efficiency come from the fact that MU MIMO and OFDM schemes are indeed parallel transmission technologies in the space and frequency domains, respectively. MIMO-OFDM when generated OFDM signal is transmitted through several antennas to achieve diversity or to gain a higher transmission rate then it is known as MIMO-OFDM. Efficient implementation of MIMO-OFDM system is based on the Fast Fourier Transform (FFT / IFFT) algorithm and MIMO encoding, such as Alamouti Space Time Block coding (STBC), the Vertical Bell-Labs layered Space-Time Block code VBLASTSTBC, and Golden Space-Time Trellis Code (Golden STTC) [6].

Rayleigh Fading Channel

Rayleigh fading is a statistical model for the strong influence of a propagation environment on a radio signal, used by wireless communication devices. Rayleigh fading models consider that the magnitude of a signal that has passed through a transmission channel or medium will very often and randomly, or fade, according to a Rayleigh distribution- the radial component of the addition of two uncorrelated Gaussian random variables. For wireless communications, the envelope of the received carrier signal is Rayleigh distributed; such a type of fading is called Rayleigh fading[7].

II- LITERATURE WORK

Wei Wu [1] work on Millimeter-wave (mmWave) MU multiple-input multiple-output (MIMO) systems utilize hybrid beamforming techniques to alleviate the implementation complexity of combining a large number of antennas. In this paper, they propose a hybrid processing algorithm via matrix decomposition for mmWave MU MU-MIMO systems. Both inter-user interference (IUI) and inter-stream interference (ISI) within the user are taken into consideration. They derive a closed-form expression of digital and analogue precoder/combiner to achieve nearly optimal performance. In the large system analysis, they prove that the proposed algorithm can obtain unconstrained optimal performance when the number of antennas is infinite. The results indicate that the proposed algorithm outperforms other existing hybrid designs in terms of BER and sum rate.

Arkady Molev Shteiman [2] analyze the resiliency of MU Multiple-Input Multiple-Output (M-MIMO) systems to Inter-Symbol Interference (ISI) when diversity combining techniques are used at the Base Station (BS). They show that Maximum Ratio Combining (MRC) alone can equalize an ISI channel as the number of antennas grows unbounded. Additional constraints on the nature of the channel must be postulated depending on whether the information of the Angle-of-Arrival (AoA) is exploited at the receiver or not. Interestingly, the simpler Equal Gain Combiner (EGC) receiver is also able to equalize the channel as the number of antennas grows but, in this case, at least one channel path must be Ricean faded. These findings are confirmed via simulation on WSSUS channels and channels generated with a ray-tracing engine simulating a real BS deployment in downtown Hong Kong and Shanghai. Finally, the observed scaling law indicates that normalized ISI power decreases N-fold for every N-fold increase in the number of antennas at the BS.

Ruchi Varshney [3] presented an overview of MU MIMO systems in wireless communication which are the breakthrough in wireless communication technology nowadays. MIMO systems are used to improve the noise and interference performances of a channel. In the paper, MIMO systems are used to expand channel capacity and BER are also highlighted. The discussion then proceeds further towards the limitations and advancements in this technology. In the modern scenario, MU MIMO includes the merger of OFDM with MIMO. By the use of MIMO-OFDM, very high data rates are achieved.

III. PROPOSED MODEL

For the proposed will work MU MIMO-OFDM LTE-Advanced System has been reviewed through many research papers related to MU MIMO and FFT-OFDM. To provide a low bit error rate (BER) at a given Signal to Noise ratio and its simulation is now a very important field of interest. So designing a software tool for field engineers particularly in the next generation communication model is the problem formulation of this thesis works. To solve this problem, the proposed method uses a MU MIMO and OFDM for Rayleigh Channel. A design of the proposed work will be done in MATLAB SIMULINK 2017a. The information bits are transmitted by Bernoulli binary generator with 20 samples perframe, the encoder comprises of CRC generator and is initially encoded by the Turbo encoder with a data rate equal to 1/3. The encoded bits are then interleaved. LTE- Advanced supports various modulation and coding and can be applied depending upon the channel condition. The encoded data stream is modulated with modulation schemes, namely BPSK, QPSK, 16-QAM and 64-QAM. The performance evaluation for the Single Channel MU MIMO-OFDM system with different modulation is experimented with and compared with the reference model[2]. The proposed model is designed for 20 samples per frame and using a turbo code generator of rate 1/3 with AWGN channel and observed better BER of 0.0092 at 5db SNR and BER of 0.0065 at 9db SNR for 16QAM. For designing of MU MIMO-OFDM LTE-Advanced System number of antenna, channel conditions, size of FFT and the loss in data due to channel noise would be major analyzing parameters. By experimenting with a set of input digital data the proposed model will be designed to make user friendly for any design engineer.

The proposed model combines the advantages of both MU MIMO and OFDM and provides effectivesolutions to ISI and spatial diversity (increase robustness). OFDM can completely remove ISI by adding a cyclic prefix. MU MIMO systems add space diversity to systems, so they can increase the robustness of the systems, for example, the transmitter sends one symbol from two antennae, if one channel between transmitter and receiver is in bad condition then it is more probable in the SISO system to fail, but in MU MIMO system that symbol fails in one channel but received in another channel, then we can say MU MIMO is robust. From the simulation results, we can see that MU MIMO- OFDM LTE-Advanced system outperforms in comparison to the reference paper in terms of BER performance.

IV. CONCLUSION

This paper presents the basic principles of MU MIMO-OFDM LTE-Advanced for next-generation wireless communication systems. Multiple Input Multiple Output (MU MIMO) in combination with Orthogonal Frequency Division Multiplexing (OFDM) is a recently proposed technique for multiple access communication. Thus, the number of the antenna in MU MIMO and cyclic prefix used inOFDM must be carefully designed to ensure good performance, low memory requirements and low computational complexity.

The performance of the proposed model is experimented with and compared for different modulators like BPSK, QPSK, 16QAM, 64QAM. Comparison is done in terms of bit error rate (BER) with other alternative technologies in a wireless communication system. The input data sequence is digital since it's a digital modulation scheme.

This work concludes with the successful implementation of the proposed single-channel MU MIMO-OFDM LTE-Advanced system for the next generation wireless communication system. The proposed model is experimented with for different parameters like different modulators and found quite efficient. Performance of the proposed model is experimented and compared for different modulators namely, BPSK, 16QAM, 64QAM, and QPSK for Rayleigh Fading channel with transmitter and receiver, and observed for better BER, and convergence is fast for a wireless communication system. Bit error rate (BER) is used for measuring performance. Results show that as we increase energy per bit to noise ratio(E_b/N_0) then BER decreases. The experimental results show better performance for BPSK and 16QAM at 5db and 9db respectively, when compared with reference paper.

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