PERFORMANCE ANALYSIS OF PRECODING TECHNIQUES FOR MASSIVE MIMO SYSTEMS

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Abstract: Achieving higher data rates has been and continues to remain a critical research issue in wireless communications. The requirement of better data rates resulted in many technologicalshifts across the different generations of networks. Rapid development in technology accelerates and ensures the availability of low-cost, high-quality communication devices. Approximately 8.9 billion broadband subscribers worldwide are anticipated by 2023 and a massive 39 % CAGR from 15 EB to 107 EB of the global cumulative monthly mobile data traffic.The work in this thesis targets designing an efficient, feasible precoding algorithm. This thesis also develops closed-form bit error rate expression for hybrid precoded wireless communication system. The next phase analyzes the performance of ZF, WF and MRT precoders across different channels. Motivated by the conversion of high dimensional, massiveMIMO networks into a low dimensional beam space, this thesis proposes a phase equalized WF based precoding. The next section observes the SE and bit error rate performance across different configurations of the system. The thesis work compares both spectral efficiency andthe bit error rate for mm Wave and Rayleigh channel.

Keywords: Massive MIMO, Precoder, GPRS , Spectral Efficiency.

I. INTRODUCTION

Wireless communication made a revolutionary change in the field of communication and it laid its first milestone when Marconi has successfully given the demonstration of radio transmission in 1895. Then therewas a rapid growth in technology advancement which enable the transmission over large distance relaying onbetter quality, less power, and economically cheaper devices. The advances in electronic industry reduced thesize of the gadgets drastically over the decades. This technological growth enables radio communication for both public and private use. Technological developmentin wireless technology has brought a wide variety of services in mobile communication.

The wireless technology is initially developed as the mode of communication to a wireless or mobile modulefrom a static base transmitter. As the wireless technology pass through its generations, several add on features got added to it. In addition to the basic voice communication, these features enable wirelesstechnology to be used for socio-economic development.Several online trading relays on wireless communication.In this chapter, the evolution of network generations is first analyzed. Then the importance of Fifth Generation (5G) mobile network is discussed. Further, the key parameters that can be improved to achieve 5Gstandards are listed. Then the 3 use cases of 5G are discussed along with the supporting technologies.Further the challenges and application of 5G are discussed. Next the note about massive-Multiple Input- Multiple-Output (M.I.M.O) is discussed via beamformingand precoding fundamentals. Finally, the necessity ofimproving Spectral Efficiency (SE) to improve throughputis studied. The development of wireless technology is categorized based on mobile generations.

Massive MIMO, the name itself holds the word massivewhich means larger in number. Massive MIMO is the system with a larger number of transmitter antenna at the BS. These increased numbers of BS antenna can be used for handling two-way communication between transmitter and receiver. Since the number of BS antenna is more than the number of active users, thereis a possibility of getting dedicated link from the transmitting BS to the receiver.

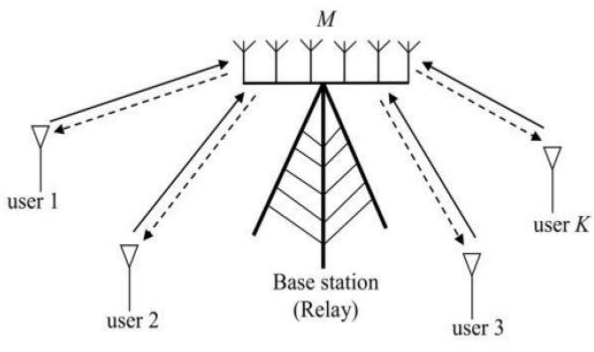

Figure 1: Massive MIMO Communication Model

Also a large number of connectivity can be used for serving IOT devices. 5G network with massive MIMO canhandle 20 times more data transmission than the existing 4G network. Figure 1 shows the block diagram of the massive MIMO system with M transmitting antenna serving K users. Usually M is very large compared to K. This means more than one antenna is available to serve a single user. This enables diversity and multiplexing capability of the massive MIMO networks which in turn increases the throughput and reliability of the system.

II. Literature Review

T. S. Rappaport et al. 2017 [1] provided the extended review of use of millimeter waves for 5th generation wireless networks and the focus of paper is on propagation models. The authors initially presided the key concepts of upcoming 5G wireless networks and available licensed as well as unlicensed millimeter waveband are described for various future applications. Further the propagation challenges associated with each millimeter wave band are described in detail and associated antenna technologies are also elaborated. The propagation parameters and channel models proposed by prominent international groups arepresented in much detail. Also the LOS probability model and various associated losses are compared for models presented in the paper.

E. Bjornson et al. 2016 [2] answered all the questions thata beginner in the field can have in the field. The authors highlighted the common misconceptions related to millimeter waves and next generation wireless networks as “Ten Myths”. The authors beautifully presented the answers to all misconceptions and relevant examples arealso elaborated in each section of the paper. This paper can be very helpful for the individuals who are the beginners in the field.

W. Hong et al. 2017 [3] focused on the key point that theuse of multi-beam antenna arrays in millimeter Wave spectrum is the key technology to address the requirements of next generation cellular communication.The authors provided an extensive review of variousmulti-beam antenna technologies that can provide enhanced spectral efficiency and power efficiency. In the paper, authors covered both active as well as passive antenna technologies including their design, implementation, operating principle and applications. In the end, preferred technologies for certain applications and associated challenges are highlighted.

X. Wu et al. 2018 [4] proposed a hybrid beamforming solution for a base station with high dimensional antennaarray. For the design, authors considered a single cell MU-MIMO system with perfectly known CSI. The authorsjointly designed the digital as well as analog precoder instead off traditional two-stage design approach. The proposed solution achieved impressive results for base station having large number of antennas as well as for lower dimensional MIMO systems. The authors claims that the proposed solution is having relatively lowercomplexity.

S. A. Busari et al. 2018 [5] presented an extensive review on millimeter Wave massive MIMO system and emphasized on the associated technologies, emerging trends, applications, associated challenges and futuredirections. This survey article covered the technology from root basics until the recent advancements and it canprovide the answers to all the questions that a beginner in the field can have. In the beginning, authors presentedthe expected performance parameter from 5G networks then the interconnection between densification ofnetworks, millimeter Wave communication and massive MIMO systems is beautifully presented. Further, the authors presents the journey of communication systems from SISO to massive MIMO system with their relative advantages and associated challenges. Furthermore, the authors presented the propagation characteristics of millimeter Wave Spectrum and massive MIMO architectures. In addition, the variety of precoding techniques for different massive MIMO configurations are discussed and compared. The authors covered almostevery aspect of future wireless communication systems including health issues and at the last authors concluded that the millimeter Wave massive MIMO system have avery vast potential to fulfill the requirements of future wireless communication systems.

Z. Mokhtari et al. 2019 [6] presented an extensive reviewof fact that in MIMO systems, enhancement in spectralefficiency is achieved by reusing the frequency as well as time slots for multiple users in a single cell. This has associated challenges that can degrade the system performance. In this review article, authors mainly focused on channel and hardware impairments likechannel estimation, fast moving user equipment and channel aging. which can significantly degrade the system performance. Further, the authors comparedsystem performance considering various communication scenarios, highlighted the significant work and provided the future directions.

G. Akpakwu et al. 2018 [7] explored the requirements, trend, associated technologies and application of modern Internet of Things (IOT) systems. The authors pointed that the upcoming 5th Generationcommunication technology is a key enabler for modernIOT systems. The authors present the emerging technologies for IOT, mainly 5G and also covered the challenges and research opportunities in IOT applications.

A. Gupta et al. 2015 [9] in the beginning of paperhighlights the evolution of wireless networks. Further, the challenges associated with 5G networks, facilitatorsto these challenges and related design fundamentals are presented. Further, the authors described the emerging technologies for 5G wireless networks. In the paper author’s reviewed prominent algorithms for device to device communication. Further, the authors also highlighted the research activities carried by prominent research groups and institutions in Europe aswell as America.

A. Elbir et al. 2020 [10] in their paper focused on developing less complex and low cost hybrid precodingtechnique based on deep learning approach that may provided the required system performance for massiveMIMO systems. The authors claimed that the frameworkproposed is superior to previous greedy and otheroptimization approaches, as these have associated highcomplexity. As the performance of all the approaches depends on correctness of channel information. The proposed DL based framework accepts imperfect channel information and designs the precoder and combiner for hybrid structure. In the first step, theoptimal solution is selected form the codebook design and further in the second step, the selected solution is trained using CNN. Then the performance of DL based solution is evaluated for multiple scenarios and it outperformed the previous optimization as well as greedy based approaches.

D. Muirhead et al. 2016 [11] presented a detailed survey focused on the challenges and opportunities specifically for small cell base stations to be used in 5G cellular communications. In the paper, authors highlighted the associated challenges in terms of size, cost and performance of small cell base stations. The authors alsocovered the effective use of multiple antennas in small cells. In addition, the authors reviewed the design considerations and advanced antenna techniques for small cells. In the end authors focused on the latest trendsin small cell technology. In the end authors conclude thatthe small cell technology is a key enabler for future 5G networks.

N. Hassan et al. 2017 [12] presented a review of homogenous and heterogeneous MIMO systems. In the beginning, authors summarized the prominent survey papers in terms of the various parameters covered and the extent to which these are covered. Later the authors covered the channel estimation methods and TDD is themost widely used for channel estimation, as acquiring the CSI is comparatively easy in case of TDD as compared toFDD. In addition, the detection techniques and related performance matrices are extensively reviewed in tabularform. Further the different beamforming techniques andassociated performance matric and performance outcome is elaborated in the tabular form.

S. Sun et al. 2018 [13] proposed four different massive MIMO schemes for millimeter Wave communication, designed mainly for the multi-cell and multi-userenvironment for wireless communication. Most of the other schemes proposed in the literature are focused onsingle-user and single-cell environment only. The proposed techniques are based on coordinated multipoint techniques. The performance of different schemes is evaluated and compared using different standards. The authors concluded that the coordinated approach outperformed the non-coordinated approach with significant margin in terms of spectral efficiency.

III. Research Methodology

The targeted research work is subdivided into systematicsteps to be followed for achieving proposed research objectives. The step by step methodology to be followedfor developing an optimum beamforming scheme is shown in figure 2 and is elaborated further.

1. Study of massive MIMO systems and beamforming techniques.
2. Study of latest 5G network standards to find the requirement w.r.t. key performance metric.
3. Review of millimeter Wave Spectrum in detail toevaluate the channel conditions and to find the frequency bands for different communication scenarios.
4. An Extensive review of massive MIMO beamformingtechniques build strong knowledge base, so that the influential research works can be evaluated against each other to establish the best.
5. Comparative analysis of prominent beamforming schemes in the literature will be implemented and their comparative analysis will provide betterunderstanding of the factors affecting theperformance in different configurations/conditions.
6. Design of optimal beamforming scheme for massive MIMO systems. As a consequence of the previous stages, an improved beamforming schemeshall be proposed.
7. Performance analysis of proposed beamformingscheme over the various performance metrics with prominent beamforming schemes for different MIMO configurations.

IV. Result Analysis

In this section, different cases are discussed dependupon number of transmitter are 128, 256 respectively.

Table 1 Simulation Parameter

Sr. No.	Parameter	Value
1	No. of Transmitter	128
2	User Equipment	4
3	No. of Path per user	10
4	Precision Bits	1,2

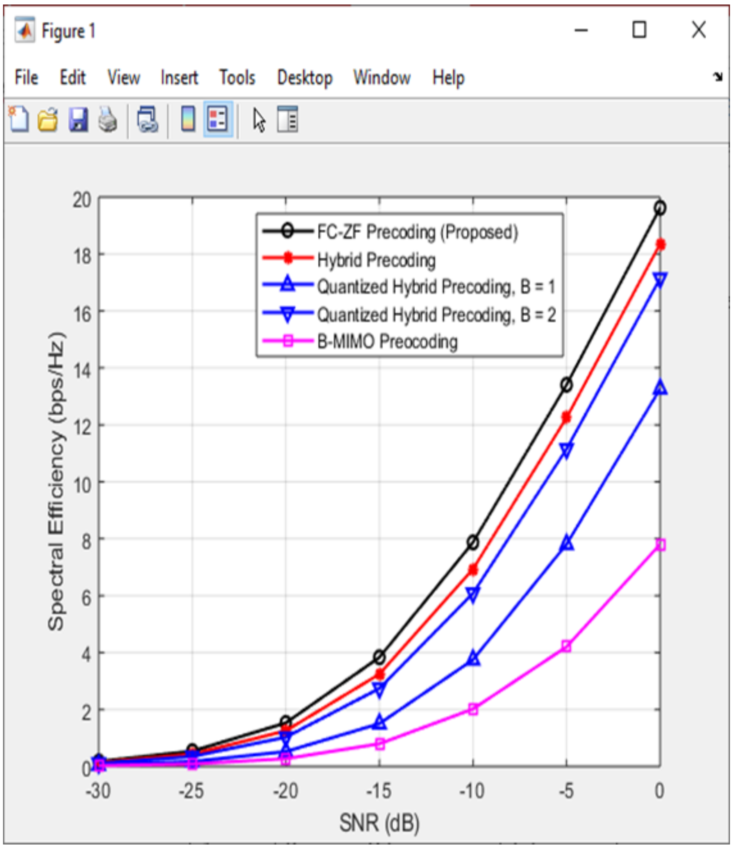

Fig 2 Spectral Efficiency for different PrecodingTechniques (= 128)
Elapsed time is 102.849311 seconds.

V. CONCLUSION

The proposed work for improving the SE for 5G wirelesscommunication in a MC environment is done. Several analysis based on system parameters is generated, Thisanalysis result is further be used for a BS transmission controller to decide the number of transmission antenna. The optimization of SE term for different interference scenarios is done. This identifies three environmental scenarios of the cell with three interference conditions. The analysis of this concludes that average interference condition well suits the practical scenario. This analysis gives the output ofachievable per cell SE and this result is further used for analyzing various system parameters. All the simulated results of SE with respect to coherence block length, SINR variations, number of scheduled users and hardware impairments prove that the proposed precoding method provides better results when theantenna numbers M is in the range of 500 to 1000. Thisantenna number is well suited for the 5G standard. Finally, the analytical results can be used by the BS transmission controller in deciding the number of the antenna array to be energized for data transmission. This serves for better EE of the BS.

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