Performance Evaluation of Beamforming Algorithms for mm-Wave MIMO systems

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ABSTRACT

Millimeter-wave system is promising to enhance the data rate of wireless communications, due to abundant frequency spectrum available, while it suffers from large path loss.A general setup which has no a priori information about the channel, and propose an iterative scheme to optimize the pre coder and combiner jointly.We propose to evaluate the performance of different Beamforming algorithms.The systems are considered to have only a fraction of the RF chains compared to the total number of antennas and employ analog phase shifters to steer the transmit and receive beams in addition to the conventional beamforming/combining invoked in the baseband domain. This scheme, which is popularly known as hybrid beamforming.In this paper,Simulation results show that the proposed algorithm outperforms the conventional algorithm in terms of higher spectrum efficiency and lower complexity.In this paper, we try to fill this gap byproposing an efficientrelay hybrid precoding algorithm for the sub-connectedstructure in mmWave massive MIMO systems. The proposed algorithm can be also extended to the full-connected structure.For both the subconnected and full-connected structures, therelay hybrid precoding algorithms are designed to minimizethemean squared error (MSE) between the transmitted andreceived signals with the power constraint.

Keywords: Beamforming , mm-Wave system,wireless communication,MIMO systems,Beamforming Algorithms

I.INTRODUCTION

IN the past few years, the massive Multiple-Input Multiple Output (MIMO) technique has been considered as one of the most promising candidates for the Fifth Generation (5G) standard of mobile communication, and, it is being standardized by the Third Generation Partnership Project (3GPP) . In massive MIMO systems, each Base-Station (BS) is equipped with tens to hundreds of antennas, where each BS antenna is connected to its own Radio Frequency (RF) chain, to serve tens of User Equipments (UEs) simultaneously in the same time-frequency resource. In this way, tremendous advantages could be achieved. One of the most important advantages is that such systems can simultaneously boost capacity and energy efficiency greatly due to its capability to achieve a very large array gain and aggressive spatial multiplexing at the same time.Despite the theoretical advantages, implementing a large number of RF chains in a massive MIMO system can be problematic, since it increases the system cost and power consumption, and lowers power efficiency. To address these issues, Hybrid Beamforming (HB) has been proposed. HB is realized by two-level beamforming. Specifically, the high-dimensional first-level RF Analog Beamforming (AB), which could be realized by a low-cost Phase Shift Network (PSN), is applied to decrease the number of RF chains, before the reduced-dimensional second-level digital baseband beamforming is employed.There has been increasing interest in HB for different application scenarios. In this paper, we focus on the important application of HB in a massive Multi-User MIMO (MU-MIMO) Orthogonal Frequency-Division Multiplexing (OFDM) system that serves multiple groups of UEs with each group being served by a different frequency resource. We further focus on sub 6GHz frequency bands used by cellular network today and will most likely still used in the future.As a

 ISBN : 978-93-87793-79-8

promising technology for the next generation of wireless communications, millimeter-wave (mmWave) communication has drawn extensive research interests in the recent years. By utilizing large spectrum bands between 30 GHz and 300 GHz, mmWave communication is capable of meeting the explosive growth of data rate. Although the mmWave signals undergo severe path loss, the path loss can be compensated by high antenna gain using massive multiple-input multiple-output (MIMO). However, mmWave communications are mainly applied in line-of-sight (LoS) dominant scenarios, since mmWave signals are sensitive to blockage. To mitigate the negative effects caused by blockage, relay can be employed in mmWave massive MIMO systems.
In a relay-assisted mmWave system, the channels from the source to the relay and from the relay to the destination may be LoS, and the transmission range and coverage can be extended. Similar to the conventional mmWave massive MIMO system, precoding plays an important role in the relayassisted mmWave massive MIMO system to compensate for the high path loss by the high antenna gain. However, the optimal precoding design for the relay-assisted mmWave massive MIMO systems is a challenging problem due to the complicated signal processing.

II. RELATED WORK

Through research of a bunch of IEEE papers and a few other articles makes it evident that beamforming and mmWave communication systems has a great potential in beating the receding research made in the communication sector Beamforming Techniques for Wireless MIMO Relay Networks

Project Desc: The continuous increase in mobile data traffic creates the need for radical innovations in the mobile broadband system design. The demand for high-speed and interference-free transmission and reception is inevitable and one sine qua non condition is the efficient spatial reuse. However, increasing traffic within a fixed limited bandwidth creates more interference in the system and degrades the signal quality.

MIMO related AND Multiuser MIMO networks

Project Desc: Recently, the mobile communication industry is moving rapidly toward Long Term Evolution, or LTE, systems. LTE aims to provide improved service quality over 3G systems in terms of throughput, spectral efficiency, latency, and peak data rate, and the MIMO technique is one of the key enablers of the LTE system for achieving these diverse goals. Among several operational modes of MIMO, multiuser MIMO (MU-MIMO), in which the base station transmits multiple streams to multiple users, has received much attention as a way of achieving improvement in performance.
Multiple Input Multiple Output (MIMO) Systems for Wireless Communications

Project Desc: In wireless mobile radio communication, there is an endless quest for increased capacity and improved quality. MIMO refers to radio links with multiple antennas at the transmitter and the receiver side. Given multiple antennas, the spatial dimension can be exploited to improve the performance of the wireless link. The performance is often measured as the average bit rate (bit/s) the wireless link can provide or as the average bit error rate (BER). Which one has most importance depends on the application.

 ISBN : 978-93-87793-79-8

MIMO Technologies in 3GPP LTE and LTE

Project Desc:As multimedia communications become increasingly popular, mobile communications are expected to reliably support high data rate transmissions. Multiple input multiple output (MIMO) has been treated as an emerging technology since it was proved that MIMO structure successfully constructs multiple spatial layers where multiple data streams are delivered on a givenfrequency.

III. PROPOSED WORK

Beamformers in mmWave are usually designed using a closed-loop beam training strategy, based on using a codebook which includes beam patterns at different resolutions. Some simple protocols use an iterative process to exchange information between the transmitter and receiver using a narrower and narrower beamwidth at each step, with the purpose of discovering the angular directions of the strongest signal between the receiver and transmitter (i.e. the best angle-of-arrival and angle-of-departure), without explicit channel estimation. Codebook beam training strategies use an iterative process to measure the angular power over its codebook.This procedure includes three phases: Coding for mmWave , setting all the parameters for a coarse beam adaptation which trains a combination of sector (at one end) and antenna (at the other end). The access point transmits the Initiator Transmit Sector Sweep (TXSS) on each of its sectors up to a maximum of 64 sectors per antenna and a total maximum number of sectors of 128.The third phase would be receiving the weights from the antenna array and performing hybrid beamforming process to visualize the output. we expect near to perfect impedance matching, increase in the spectral efficiency and gain and to show better directivity.

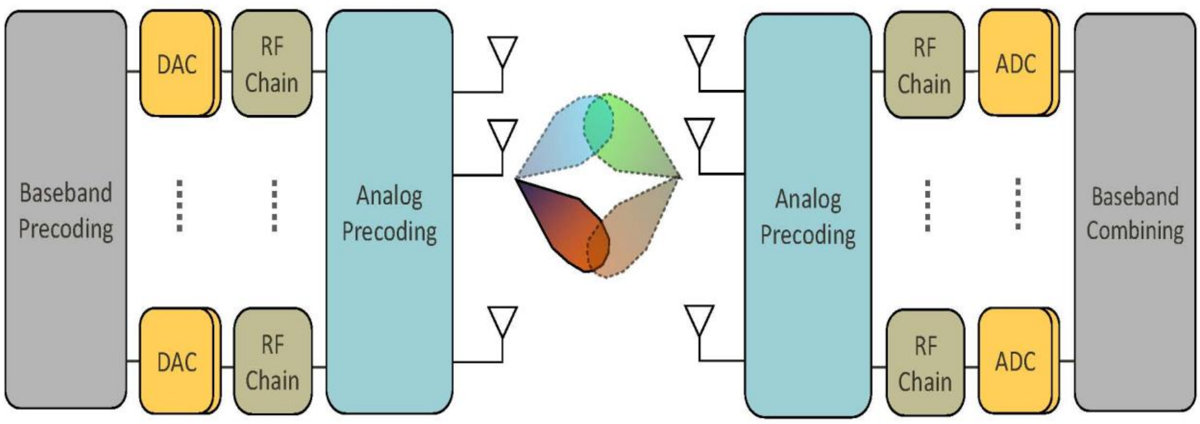

Fig 1: Block Diagram

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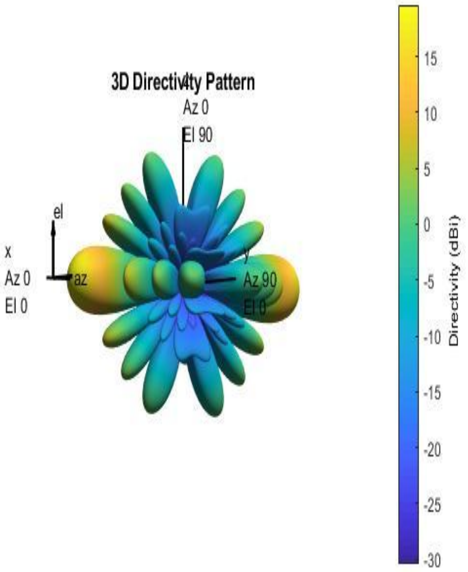
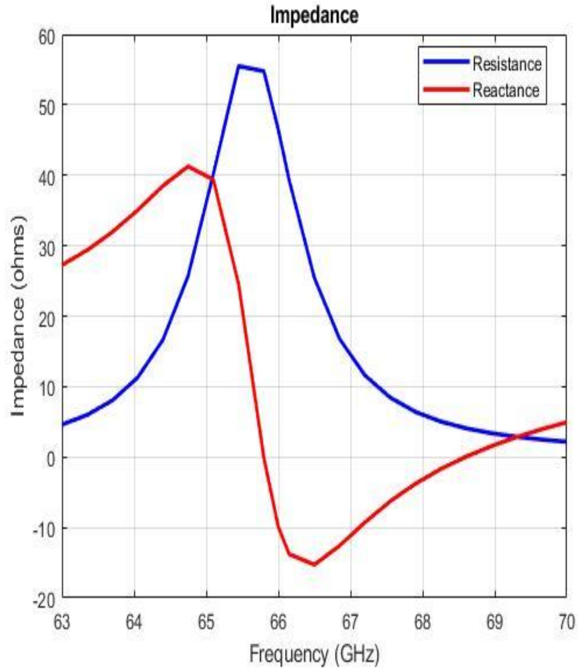
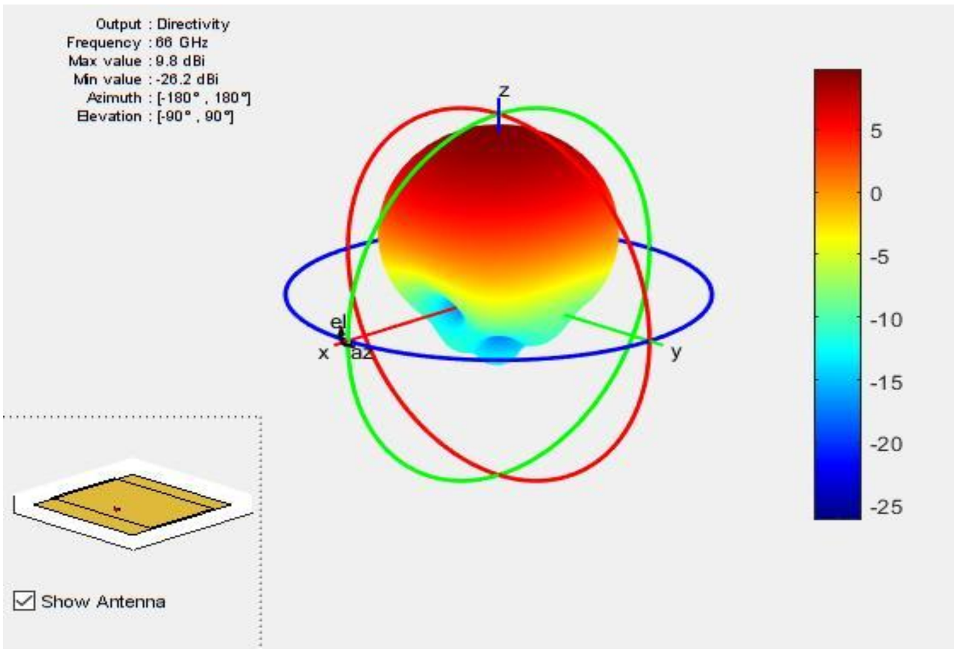
IV. RESULTS AND DISCUSSION







The project output shows on the result that perfect impedance matching of 50 ohms is achieved at 66 GHz and the 3d directivity pattern shows us that 15 db of directivity is achieved at the x-axis .The final diagram shows us that maximum directivity of 9.8 dB and a minimum of -26.2 dB is obtained at Azimuth [-180, 180] and elevation [-90,90].

V. HARDWARE AND SOFTWARE REQUIREMENTS

Hardware components:

- Baseband precoder
- DAC
- RF precoder
- RF combiner
- Baseband combiner
- DSP kit

Software components:

- MATLAB and Simulink.

VI. CONCLUSION

The goal of this system is to ultimately be able to send signals from transmission station to receiver station.

This project has reached a stage where coding for mmWave is achieved ,antenna array configuration for MIMO systems is achieved . Further, the beamforming element shows us why beamforming is a such a massive component in the communication sector. Hybrid beamforming would play an important role is attaining 5G communication as it is a mix of both analog and digital beamforming.By performing hybrid beamforming process to visualize the output. we expect near to perfect impedance matching, increase in the spectral efficiency and gain and to show better directivity

REFERENCES

i.) Z. Pi and F. Khan, "An introduction to millimeter-wave mobile broadbandsystems," IEEE Communications Magazine, vol. 49, no. 6, pp.101-107, 2011.
ii.) T. Rappaport, S. Sun, R. Mayzus, H. Zhao, Y. Azar, K. Wang,G. N. Wong, J. K. Schulz, M. Samimi and F. Gutierrez "Millimeter wavemobile communications for 5G cellular: It will work!," IEEE Access, vol.1, pp. 335-349, 2013.
iii)J. G. Andrews, S. Buzzi, C. Wan, S. V. Hanly, A. Lozano,A. C. K. Soong, and J. C. Zhang, "What will 5G be ?," IEEE Journalon Selected Areas in Commun., vol. 32, pp. 1065-1082, June 2014.
iv) Q. C. Li, Geng Wu, and T. S. Rappaport, "Channel model for millimeterwavecommunications based on geometry statistics," in GlobecomWorkshops(GC Wkshps), 2014, pp. 427-432, 8-12 Dec. 2014.
v.) M. K. Samimi and T. S. Rappaport, "3-D statistical channel models formillimeter-wave outdoor mobile broadband communications," in 2015IEEE International Conference on Communications (ICC), June 2015.
vi.)W. Roh et al, "Millimeter-wave beamforming as an enabling technologyfor 5G cellular communications: theoretical feasibility and prototyperesults," IEEE Communications Magazine, vol. 52, no. 2, pp. 106-113,Feb. 2014.
vii)S. Han, C.-L. I, Z. Xu, and C. Rowell, "Large-scale antenna systemswith hybrid analog and digital beamforming for millimeter wave 5G,"IEEE Commun. Mag., vol. 53, no. 1, pp. 186-194, Jan. 2015.
viii) O. E. Ayach, R. W. Heath, S. Abu-Surra, S. Rajagopal, and Z. Pi, "Lowcomplexity precoding for large millimeter wave MIMO systems," in2012 IEEE International Conference on Communications (ICC), pp.3724-3729, 10-15 June 2012.
ix.) A. Alkhateeb, O. El Ayach, G. Leus, and R. W. Heath Jr, "Hybridprecoding for millimeter wave cellular systems with partial channelknowledge," in Proc. of the Information Theory and ApplicationsWorkshop (ITA), San Diego, CA, Feb. 2013.
x.) A. Alkhateeb, O. El Ayach, G. Leus, and R. W. Heath Jr, "Channelestimation and hybrid precoding for millimeter wave cellular systems,"IEEE Journal of Selected Topics in Signal Processing, vol. 8, no. 5, pp.831-846, Oct. 2014.