Performance and analysis of MIMO for 5G applications by varying Number of antennas

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Abstract:
Massive multi-input-multi-output (MIMO) systems can enable very high energy and spectrum efficiency, making them crucial to the success of fifth-generation (5G) cellular networks and their potentially enormous data speeds. Mobile broadband networks face a significant problem in preparing for the throughput requirements of the next generation of wireless technology (5G), the primary feature of which is the universal availability of ultra-fast internet connections. By deriving the closed-form approximation for feasible data rate expressions, the performance of massive MIMO systems improves as the number of antennas goes to infinity with linear minimal mean square error (MMSE), zero forcing (ZF), and maximum ratio transmission (MRT). While MMSE, ZF, and MRT are used to decrease inter-cell interference signals between neighbouring cells, allowing for a higher signal-to-noise ratio (SNR). Distributed users inside the cell improve the possible sum rate for MMSE by reducing the inter-cell interference brought on by the transmission of the same signal by many cells. When it comes to flawless CSI, however, MMSE outperforms ZF by about 20% of the maximum sum rate.

Keywords: Massive multi-input-multi-output (MIMO), fifth-generation (5G), cellular networks.

1.0 INTRODUCTION

The first generation (1G) of mobile communication in the 1980s until today, the field of digital communication has tremendously evolved both in capacity and reliability. The emerging fifth generation (5G) is driving mobile communication systems towards an unprecedented evolution in terms of flexibility, data rate and latency, enabling wireless networks to support applications that are typically backed by wired technologies. The scenarios for the sixth generation (6G) are even harder to achieve considering the foreseen increase in flexibility, while supporting conflicting requirements for several applications in different verticals, besides higher data rates, higher coverage, higher frequency bands and extreme low latency. It is clear that future mobile networks cannot rely on a single radio access network to fulfill all these requirements. Different approaches are needed to address all requirements, but multiple-input multiple-output (MIMO) schemes represent a key technology for most future wireless systems. For example, in the agribusiness scenario, high data rates are necessary to transmit multi-spectral videos in infrared, ultraviolet and visible light in real time from drone to the cloud. In industry 4.0, very low latency is necessary for controlling robots and synchronizing autonomous actions with humans on the plant floor. MIMO can provide the necessary bandwidth, reducing the frame duration and increasing the robustness for data with a very short life span. MIMO systems with detection schemes that can harvest diversity and multiplexing gains are able to improve the throughput, increase coverage and reduce the outage probability at the same time. Although the mentioned advantages are appealing features in the future mobile communication context, they are accompanied by demanding drawbacks such as uncorrelated transmission channels requirement, in order to avoid weak conditioned channel matrices, high signaling coordination on MIMO channel estimation, considering each individual transmitting antenna and higher complexity for the network nodes. The challenges imposed by the mobile communication channels require complex processes on the receiver side to recover the information with a desired quality of service (QoS).

2.0 LITERATURE REVIEW

The continuously increasing demand for larger data rates is one of the primary motivations prompting the creation of MIMO antenna. In order to boost data transfer speeds in the future, the upcoming fifth-generation (5G) communication has got a lot of press. Understanding the propagation channels is critical for correctly building and testing 5G communications networks [1], which necessitates a huge number of channel measurements. MIMO technology has recently got a lot of interest in the field of wireless communication systems development. In order to accommodate a faster data rate, 5G mobile networks are already extending their spectrum. The World Radio Communication Conference (WRC) assigned frequency bands below 6 GHz for 5G candidates in 2015, with frequency ranges of 470–694, 2300–2700, 3300–3800, and 4500–4990 MHz proposed. Since it is widely recognized in most nations, sub 6 GHz band for 5G has got a lot of attention [2-3]. However, reducing mutual coupling between antenna parts in a small space while retaining dual-band operation and good gain is a difficult task. A Dual-band antennas has been designed using a number of approaches, including metallic resonators, slots, and stub elements. To improve the properties of isolation and bandwidth, numerous strategies have been described. The Slot loading, defective ground structure, neutralization lines, stub elements and orthogonal elements are some of the decoupling strategies that have been presented. A dual band MIMO antenna that achieves isolation of more than 15 dB using slot loading is presented [4]. A Compact monopole with T shape structure for dual band application has been reported [5]. The orthogonal Antenna element used defected ground structure to improve the mutual coupling reported [6]. The F bend shaped monopole MIMO antenna with T shape stub element is introduced to better isolation [7]. The neutralization line’s structure has been used to improve isolation of MIMO antenna [8]. The T shaped and metallic strip MIMO structure consist of partial gnd and orthogonal element for 5G Smartphone applications is reported [9]. The focus of this research is on the design of MIMO antenna and strategy for improving the antenna's performance. To reduce size, mutual coupling, and improve efficiency, several forms and approaches have been adopted. [10] This paper to comparative analysis of various antenna techniques for the 5G are covered that provides sufficient isolation, better correlation between antenna, maximum efficiency and sufficient bandwidth which makes the exceptional antenna. At present there are several 5G antenna are available that can achieve extremely high data rate in 5G band such as antipodal and rhombus shape monopole and few others mentioned. [11] In this study was to study, analyze and address the channel behavior in a mobile radio transmission chain. One of the major challenges in telecommunications networks (5G) is to minimize the propagation attenuation and consequently guarantee good Quality of Services. With the increased demand in terms of throughput and work coverage, a rigorous characterization of channels is demanded.

3.0 MASSIVE MIMO TECHNOLOGY

In a massive MIMO system, all BSs are prepared with large numbers of antenna arrays and use these to connect with each active user over the same time and frequency resources. In massive multiuser MIMO systems, as shown in Fig. 1, the system requires the number of antenna array at BS to be more than the number of active users كبې in order to provide high data rate. Massive MIMO technology can be used with high frequency bands to be able to work with large number of antennas that can provide achievable high data rate for many of active users. This type of system performance has received much attention in recent years Commonly, transmission signals between a BS and mobile terminals are presented by the orthogonalization of the channel so that the BS connects with each terminal in separate time-frequency resources. Consequently, at transmitted signal in the same time frequency resource, the higher data rates can be achieved between BS and mobile terminals. Nevertheless, some complex techniques must be used to mitigate inter-user interference, such as pilot contamination on both of the uplink and the downlink In addition, the massive MIMO system is also capable of increasing high capacity by approximately tenfold and instantly enhancing the emitted EE by approximately one hundred fold.

CHALLENGE MASSIVE MIMO:

The channel estimation is very important to improve the transmission performance at increase number of antenna arrays at the BS due to multi-user interference at both the reverse and forward links. In addition, every antenna elements contains radio frequency (RF) chains which consume more of power and caused noise amplifier at increase number of antenna array. For example, loop interference increases with the increment in spatial antennas and training symbols for channel estimation. The future 5G system depends on the ability of massive MIMO system because the massive MIMO can provide many interesting features Where, the channel capacities in massive MIMO system are very important to achievable high throughput and guarantee the quality of service (QoS). Moreover, the power processing, which is calculated by adding up the contributions from antennas, may contribute to an array of antenna gains. In this case can be obtain the adequate of the transmit power at the BS without decreasing the signal coverage. Channel estimation is generally used for deployment of multiple transmit and receive antennas. The channel reciprocity and strength against fading between a transmit and a receive antenna can be extensively improved by channel capacity and the space-time coding. Each channel of the transmit and receive antennas is the known channel estimation Consequently, channel estimation is very important in order to enable the channel to determine linearly the number of mobile terminals rather than the number of BS antennas, allowing for the increment of antennas elements without affecting the training overhead. This makes massive MIMO techniques one of the key factors for 5G wireless systems.

System model for the digital communication:

The resulting coded bits are then fed to the Waveform Modulator block, where different techniques may be used, e.g., symbol modulation and multicarrier techniques, leading to specific waveforms tailored for mobile MIMO channels. The channel block introduces time and frequency fading and it combines the transmitted signals at each receiving antenna, besides adding the additive white Gaussian noise (AWGN). On the receiver side, the Waveform Demodulation block is responsible for performing the time and frequency synchronization, waveform demodulation, antenna decoupling and data symbol estimation, while the Bit Decoding block is responsible for correcting the bit errors that might be introduced by the channel for retrieving the information on the receiver side from the distorted and noisy version of the transmitted signal. Both transmitter and receiver are designed based on the communication channel characteristics as noise and fading statistics, average scattering pattern, coherence time, coherence bandwidth and the impairments introduced by the transmitters and receivers RF front-end, among others. Specifically for a modern mobile communication system, the PHY must deal with double-dispersive MIMO channels, where each path between one transmitting and one receiving antenna is modeled as a time-variant and frequency-selective impulse response. We consider a scheme employing n transmitting antennas and m receiving antennas as a generalization of the mobile communication system, as it embraces more simplified arrangements, e.g., the usual soft-input soft-output (SISO) when m = n = 1. It is worth to mention that, assuming a SMMIMO case, when m = n ≥ 2, inter-antenna interference (IAI) takes place once each receiving antenna might collect signals from more than one transmitting antennas

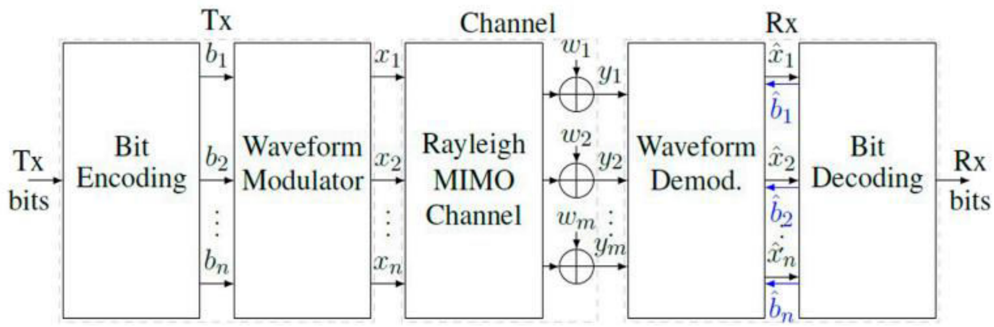

Figure 1: Simplified block diagram of a generic and communication system

It is worth to clarify that, despite of its importance in the communication research field, the availability of studies involving channel coding techniques are wide and easily found in literature, thus, beyond the scope of this work.

4.0 RESULTS AND DISCUSSIONS:

The increased number ofantenna array at BS, it will directly increase the achievable data rate. Moreover, the effected of channelestimation at the transmit power, reveals that the transmit power in massive MIMO dependent on increasingthe number of antennas and limiting the number of users, and can be decreased proportional to square root if the BS has imperfect CSI, with only a slight loss in data rate. The attainable sum rate of theMMSE receiver is better than, ZF and MRT because MMSE is able to suppress inter-cell interference andintra-cell interference at a high SNR while the linear decoding MRT is better than ZF at a low SNR. Theattainable sum rate of MRT also decreases at a higher SNR value

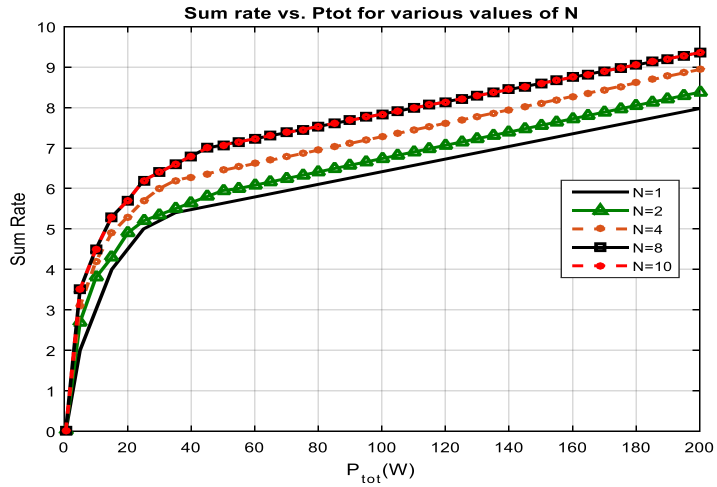

Figure 2: Sum rate vs ptot for various values of N

The Fig. shows the sum rate versus total power with respect to different values of N those are 1, 2, 4, 8, 10 and different colors used to represent graphs of different values of N. The Sum Rate increasing while increasing total power used in the 5G network and observed more sum Rate for N=10 and as around 9.1 at 200W total power.

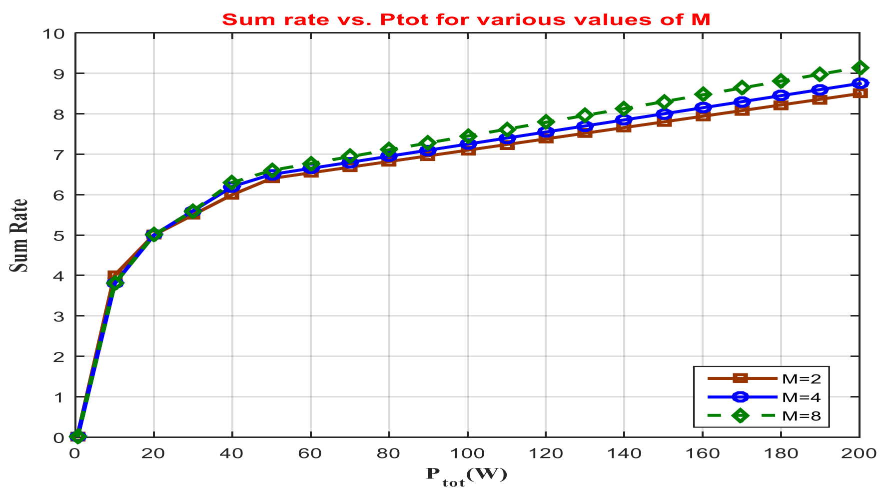

Figure 3: Sum rate vs ptot for various values of M

The Fig. represents the sum rate with respect to different M values of QAM and as three graphs, used three different colors to represent and those M values are M=2,4, 8. The Sum rate is rapidly increasing to increase the total power of a device. Among the different M-QAM inputs, M=8 has more sum rate, slow difference has their different M values while increasing the total Power and more deviation when total power=200W. The highest sum rate is 9.1,8.7,8.5 for different M values M=8,4,2.

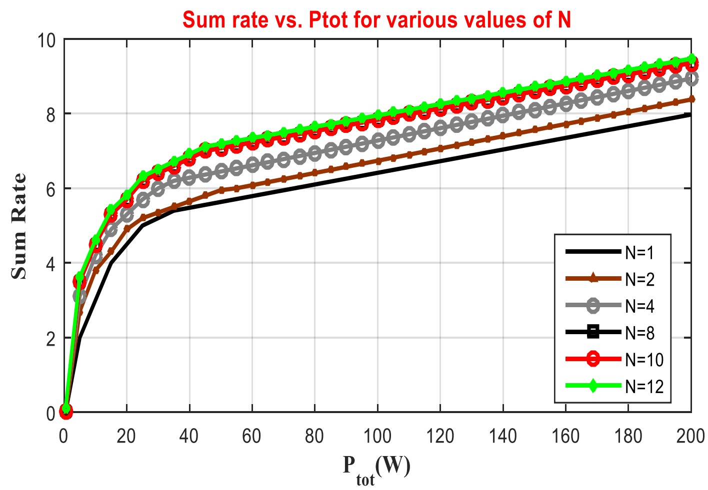

Figure 4: Sum rate vs ptot for various values of N

The Fig. indicates the sum rate versus total power of the antennas using multiple values of N (antennas) those are 1, 2, 4, 8, 10,12 and different colors used to represent graphs of different values of N. The sum rate of the device increasing while increasing the total power and has evaluated the sumrate for multiple N values (N=1,2,4,8,10,12). The slight deviation is there in low power and high deviation is there at maximum power (200W). the maximum rate is achieved is 9.2 at 200W for N=12

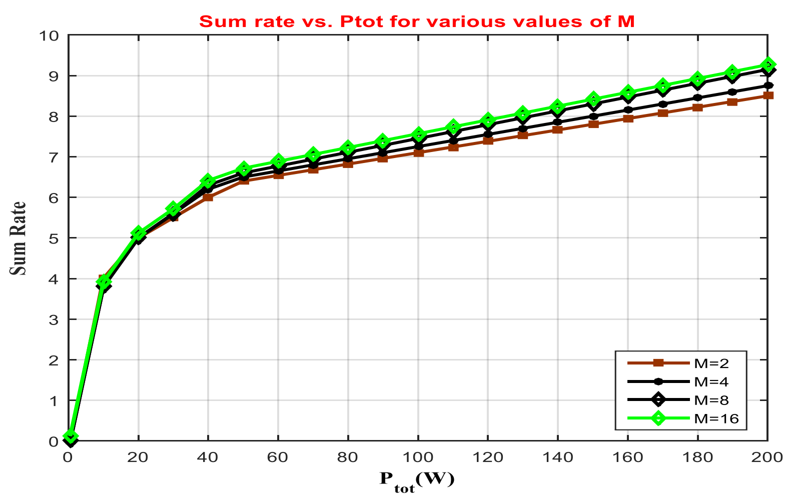

Figure 5: Sum rate vs ptot for various values of M

The Fig.4 represents the sum rate with respect to different M values of QAM and as four graphs, used four different colors to represent and those M values are M=2,4, 8,16. The Sum rate is rapidly increasing to increase the total power of a device. Among the different M-QAM inputs, M=8 has more sum rate, slow difference has their different M values while increasing the total Power and more deviation when total power=200W. The highest sum rate is 9.2, 9.1,8.7,8.5 for different M values M=16,8,4,2.

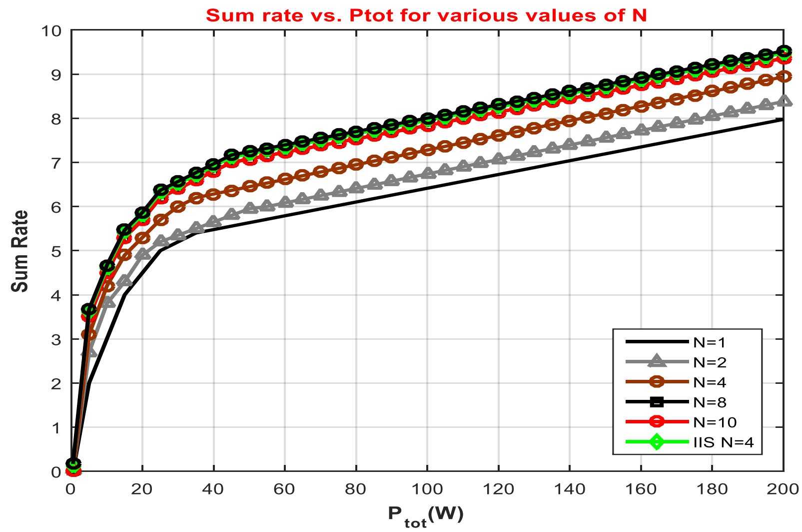

Figure 6: Sum rate vs ptot for various values of N

According to the figure, the sum rate is represented in four graphs using four different colors and the N values are 1,2,4,8,16. The Sum rate is rapidly increasing to increase device power. When the total power is 200W, N=4 has a higher sum rate, slow difference has a different M value, and the deviation is greater when the total power is 200W. The highest sum rate for N=1,2,4,8,10

Discussions:

5G Innovation represents the fifth Era Versatile innovation. 5G mobile technology has changed the resources that are needed to use cells inside of very high transmission capacity. Clients have never before seen such a high- value idea. Customers on the go today are savvy when it comes to portable (and versatile) PDA technology. The 5G upgrades include a wide variety of innovative capabilities, making it the most stunning mobile technology to date and expected to generate a lot of attention in the near future. One can also gain broadband internet access by connecting their 5G-enabled PDA to their computer. There are many features of 5G technology even thought of yet, such as a camera, MP3 recording, video player, large phone memory, quick dealing, a sound player, and much more. Bluetooth technology and Piconets have made it possible for kids to participate in performing.

Conclusion:

The attainable sum rate of MRT decreases at a higher SNR system while the attainable sum rate of the ZF receiver is better than MRT because ZF is able to suppress both inter-cell and intra-cell interference. The optimal number of RF chains in a massive MIMO system can exploit, to achievable high average sum rate under equal received power. As the attainable sum rates depends on using transmit power, when the number of users is equal to the number of cells, the channel prediction is able to recover part of the loss in data rate by taking into account the power consumption at the BS. The performance of the data rate increases with the average SNR, which depends on the increase in the number of antennas and limited users inside the cells. However, the optimal choosing a number of RF chains in the linear decoding able to mitigate the multi-user interference, which enhanced the system performance and increased the achievable high sum rate Future works on these topics might also embrace the use of iterative estimators, specially some mixture of the STPD or the LMS with the CWCU-LMMSE weighting diagonal, in order to attain unbiasedness and avoid costly matrix inversion while keeping a channel tracking mechanism, jointly with parallel interference cancellation methods applied on non-orthogonal waveforms in SM-MIMO applications, with potential to harvest diversity while achieving multiplexing gain at the same time. Moreover, artificial intelligence is a prominent alternative to replace the statistical-based solvers discussed here by more generalist algorithms.

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