Performance Evaluation of LTE Downlink Physical Layer System with Massive MIMO

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Abstract - Long Term Evolution (LTE) is the prominent system for QoS and high performance data communication. It is an advanced generation of communication which is being implemented around the world to connect each and every corner of the world together with its high deliverability. The advancements are keep in the progress to get more and more out of it so that it can the form itself its successor and become 5 generation of technology. But it needs lots of improvements to get its first step of and keep in the way of long term as its name. In this context this work has been trying to figure out the one of the advanced technology for high reliability high performance future generation of communication which is being evaluated and being tested by several researchers. This technology is massive-MIMO. The massive MIMO based LTE system is simulated with distinct antenna configurations along with higher indexed phase shift keying. Simulation outcomes shows the benefits and advantages of Massive-MIMO in the future communication system.

Keywords - Massive -MIMO, PSK, Pilot Encoding, 5G, LTE.

I. INTRODUCTION

In the last years wireless systems have attracted a great deal of interest due to the expansion of mobile communications in detriment of wired systems, which most of the times require higher investments at the deployment process. Radio wireless communications were traditionally based on Single- Input Single-Output (SISO) antenna systems, where detection and equalization techniques have affordable complexity [1]. However, the current user demand of higher rates and service reliability is turning the interest back to MIMO systems, airing at increasing the channel capacity and improving spectral efficiency [4]. Nowadays, MIMO is at the core of many modern communications systems such as High Speed Packet Access (HSPA) and Long Term Evolution (LTE) [5] in mobile communications.

Wireless communications are affected by fading, variations on the signal strength and may cause a dramatic degradation on the system’s performance. MIMO systems comprise a collection of techniques proposed to enhance the performance of wireless systems by exploiting the scattering environment as the result of having multiple antennas at the transmitter side and the receiver side.

As a physical-layer performance booster for wireless communications, the technology of MIMO has been incorporated into wireless broadband standards, such as IEEE 802.11n, IEEE 802.11ac, HSPA+, WiMAX and Long-Term Evolution (LTE). Among these, the current LTE standard allows for up to eight antennas on base stations and on terminals. Compared to single-antenna systems, the performance gain brought by the use of multiple antennas is due to the spatial degrees of freedom (DoF) that expand the dimensions available for signal processing. As wireless spectrum has become a precious resource, MIMO technology exploiting the spatial domain offers the opportunity of improving system performance without increasing the required spectrum.

Figure 1.1 illustrates the two categories. In SU-MIMO, the transmitter and receiver are equipped with multiple antennas. Performance gain in terms of coverage, link reliability and data rate can be achieved through techniques such as beamforming, diversity-oriented space-time coding, and spatial multiplexing of several data streams. These techniques cannot be fully used at the same time, thus typically find a tradeoff between them. For example, adaptive switching between spatial diversity and multiplexing schemes is adopted in LTE.

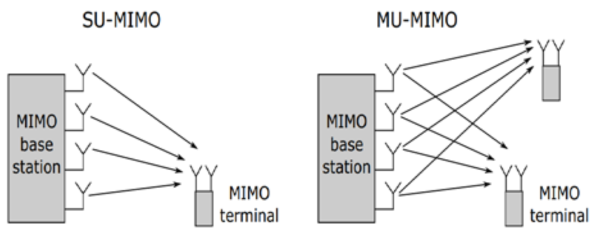

Figure 1.1 Single-User MIMO and multi-user MIMO.

The situation with MU-MIMO is radically different. The wireless channel is now spatially shared by different users, and the users transmit and receive without joint encoding and detection among them. By exploiting differences in spatial signatures at the base station antenna array induced by spatially- dispersed users, the base station communicates simultaneously to the users. As a result, performance gains in terms of sum-rates of all users can be impressive. A major challenge is, however, the interference among the co-channel users.

II. SYSTEM MODEL

Massive MIMO (MaMi) is MU-MIMO technique where the number of base station- antennas is much greater than the number of receiving terminals, which are typically assumed to be single-antenna devices. The extra antennas help by providing antenna gain, diversity and eliminating inter-user interference, bringing huge improvements in throughput and radiated energy efficiency. An increase of ten times or more in system capacity can be achieved with MaMi.

Unlike many other techniques, MaMi is well employed in rich scattering environments where the number of propagation paths is large. This makes MaMi well suited for urban environments, with many obstacles.

Another great benefit of MaMi systems is the opportunity for extensive use of inexpensive low-power components. MaMi-system have a great ability to average out errors over all the antennas which makes low complexity hardware a feasible solution for energy and cost reductions in MaMi-systems. This concept is the main core of this work.

Furthermore, in the excessive number of base station antennas, simple linear signal processing can be used in the base station in place of more complex non-linear processing without significant loss of performance. This lowers base station complexity and improves energy reductions.

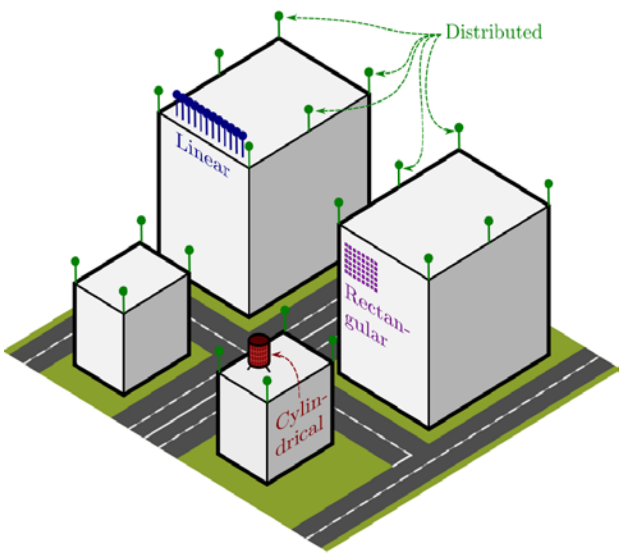

Figure 2.1 Illustration of possible deployments of massive MIMO antenna arrays.

Scaling up MIMO provides many more degrees of freedom in the spatial domain than any of today's systems. This rescues us from the situation that wireless spectrum has become congested and expensive, especially in frequency bands below 6 GHz.

In contrast to conventional MU-MIMO with up to eight antennas, represents MIMO with a large number of antennas "massive MIMO", "very-large MIMO" or "large-scale MIMO". As a simple illustration, Figure 2.1 shows possible deployments of massive MIMO antenna arrays. Antennas can be co-located in a linear, planar or cylindrical structure, or can be placed in a distributed manner.

In massive MIMO operation consider an MU-MIMO scenario, where a base station equipped with a large number of antennas serves many terminals in the same time-frequency resource. Processing efforts can be mostly made at the base station side, and terminals have simple and cheap hardware. Until now, many theoretical and experimental studies have been done in the massive MIMO context.

Massive MIMO Working

In Massive MIMO, TDD operation is preferable. During a coherence interval, there are three operations: channel estimation (including the uplink training and the downlink training), uplink data transmission, and downlink data transmission.

a. Channel Estimation

The BS needs CSI to detect the signals transmitted from the users in the uplink, and to precode the signals in the downlink. This CSI is obtained through the uplink training. Each user is assigned an orthogonal pilot sequence, and sends this pilot sequence to the BS. The BS knows the pilots sequences transmitted from all users, and then estimates the channels based the received pilot signals.

b. Uplink Data Transmission

A part of the coherence interval is used for the uplink data transmission. In the uplink, all K users transmit their data to the BS in the same time-frequency resource. The BS then uses the channel estimates together with the linear combining techniques to detect signals transmitted from all users.

c. Downlink Data Transmission

In the downlink, the BS transmits signals to all K users in the same time-frequency resource. More specically, the BS uses its channel estimates in combination with the symbols intended for the K users to create M precoded signals which are then fed to M antennas.

III. PROPOSED SYSTEM

The implementation and simulation of proposed work has done on Matlab and the simulation has performed on Matlab Simulink. Figure 3.1 shows the block representation of proposed system. The fundamental component block of proposed systems is as follows are a transmitter a channel and a receiver functioning and sub component of each block are described briefly

a. Transmitter

At a transmitter end input signal can be either data or information fed for processing through system there are three operations are performed on input signal.

1. PSK Modulation

A phase shift keying modulation is a digital modulation strategy utilized to modulate transmitted signal. A finite number of phases are used in PSK to assign each of binary digits. There are 8, 16, 32 and 64 bit PSK Modulation scheme are used to modulate information signal.

2. IFFT

Inverse fast Fourier Transform is utilized to convert PSK modulated frequency domain signal in to form of time domain vector signal.

3. Pilot Encoding Massive MIMO

In order to prepare data for transmission Pilot Encoding Massive MIMO is employed. Pilot sequences and uplink data sequences are transmitted at the same time and over the same frequencies from each user to the BS

b. Channel

Channel is a medium chough which a signal propagates in proposed system a Relay fading channel is utilized for signal propagation toward receiver end

c. Receiver

A receiver end receives signal transmitted from transmitter travel through a Relay Fading channel. There are following operations are performed on received signal to detect actual error free information.

1. Pilot Decoding Massive MIMO

The receiver receives the sum of data streams from all the transmitters, and estimates the channel. Decode Pilot Massive MIMO symbols.

2. FFT

A Fast Fourier transform is utilized at receiver end to converts time domain vector signals frequency domain vector signal before demodulation received signal.

3. PSK demodulation

A PSK demodulation is performed on FFT received signal to demodulated PSK 8, 16, 32 and 64 PSK modulated signal.

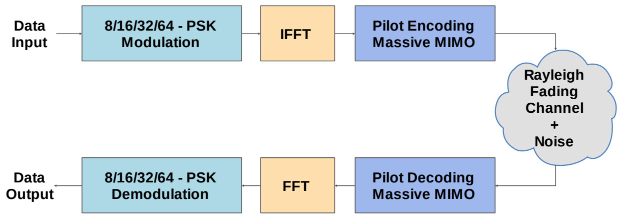

Figure 3.1 Block Diagram.

Process flow of proposed work based in Matlab environment has been shown in figure 3.2.

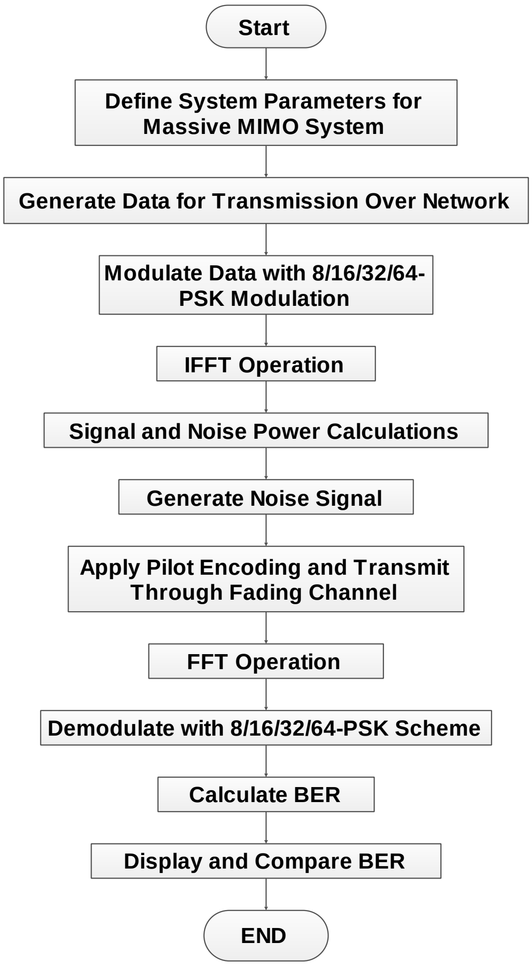

Figure 3.2 Process flow Chart of Proposed work.

Steps Involved in Simulation of proposed work has given as follows.

Step 1: Start Simulation with Matlab Simulation environment.

Step 2: Define system parameters for massive MIMO.

Step 3: Modulate data with 8/16/32/64 PSK modulation.

Step 4: Apply IFFT Operation on modulated Signal

Step 5: Signal to noise power calculation

Step 6: Generate noise signal

Step 7: Apply pilot encoding and transmit through fading channel.

Step 8: Apply FFT operation

Step 9: Demodulate with 8/16/32/64-PSK

Step 10: Calculate Bit error rate of received signal

Step 11: Display and compare BER with existing BER

Step 12: End Process.

IV. SIMULATION RESULTS

To simulate low complex hardware in the per-antenna functions, and IFFTs, and to investigate the impact on the system performance caused simulating hardware errors are necessary to include in the simulation model. To see the effects of hardware errors of different magnitudes, a parameter which can change this magnitude is necessary. The more specific implementation of this is explained the parameters concerning this are described.

Since there are random parameters involved in the system, such as the generated data and the Rayleigh fading channel, a simulation framework which can run the system model several times is needed to get statistically significant results.

The performance of proposed work has been evaluated in terms of BER (bit error rate) and compared with results of previous work. The simulation outcome of Matlab Simulink has been shown in figure 4.1 BER Vs SNR Curve for Massive MIMO with Antenna Configuration Tx=4 and Rx=4.

Figure 4.2 BER Vs SNR Curve for Massive MIMO with Antenna Configuration Tx=8 and Rx=8.

Figure 4.3 BER Vs SNR Curve for Massive MIMO with Antenna Configuration Tx=16 and Rx=16.

Figure 4.4 BER Vs SNR Curve for Massive MIMO with Antenna Configuration Tx=8 and Rx=16.

Figure 4.5 BER Vs SNR Curve for Massive MIMO with Antenna Configuration Tx=32 and Rx=32.

Innitialy the proposed system has been tested for 4 transmitter and receiver antennas No of transmitter and receiver antennas are further increased from 4 to 8, 16 and 32.

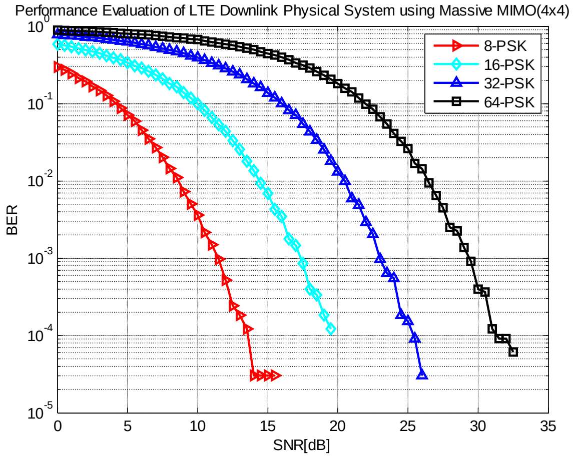

Figure 4.1 BER Vs SNR Curve for Massive MIMO with Antenna Configuration Tx=4 and Rx=4.

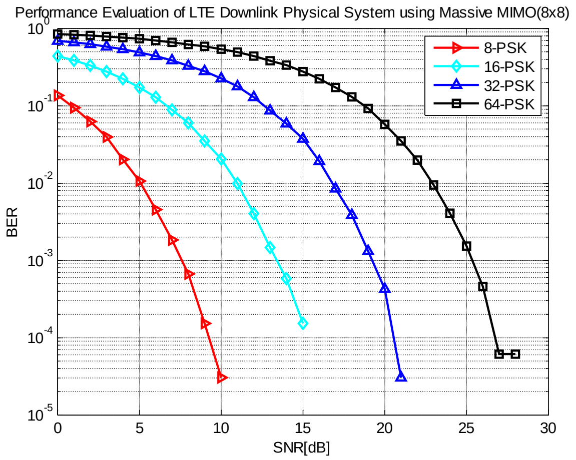

Figure 4.2 BER Vs SNR Curve for Massive MIMO with Antenna Configuration Tx=8 and Rx=8

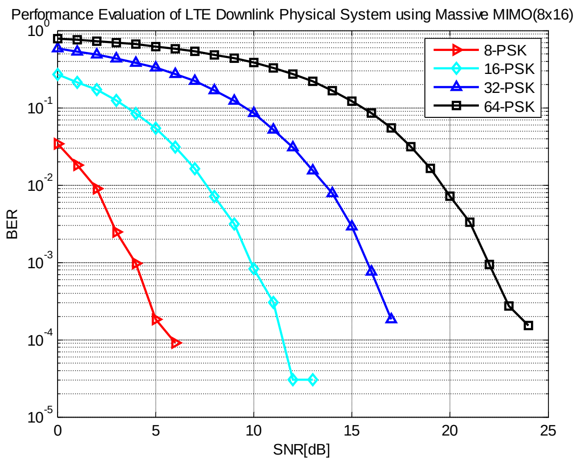

Figure 4.3 BER Vs SNR Curve for Massive MIMO with Antenna Configuration Tx=8 and Rx=16.

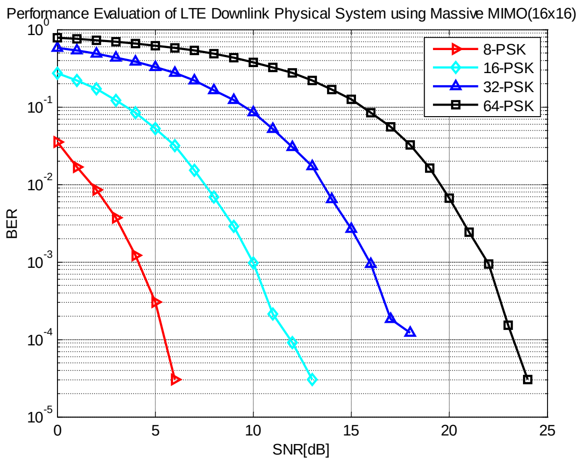

Figure 4.4 BER Vs SNR Curve for Massive MIMO with Antenna Configuration Tx=16 and Rx=16

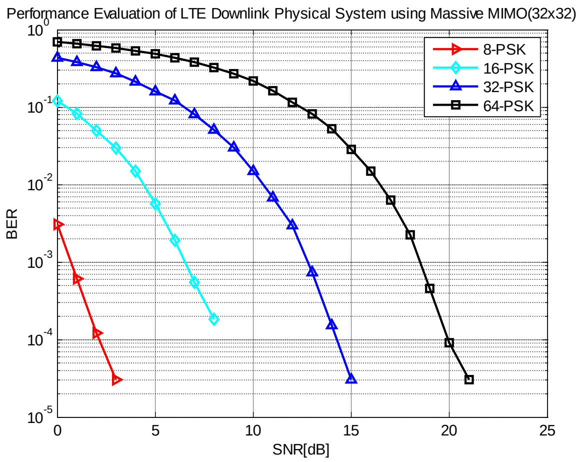

Figure 4.5 BER Vs SNR Curve for Massive MIMO with Antenna Configuration Tx=32 and Rx=32

V. CONCLUSION AND FUTURE SCOPES

In this work performance evaluation of LTE downlink physical layer system with massive MIMO has done on Matlab Simulink. As the number of antennas at the transmitter end is increased, the design of efficient MIMO receivers system is a challenging task because of the high-dimensional discrete input space. Ever for short word lengths, it is possible for massive MIMO systems to recover from some errors. However, there is a exchange between optimizing energy consumption by decreasing the number of bits used to represent the signal and the possible SNR degradation which results from this. The results have shown that by using only a few more bits a significantly better BER can be achieved, meaning that it could be worth to increase the complexity with these few bits in order to decrease the SNR degradation.

The simulations also show that the IFFT is effective to reduce signal error. In this work a PSK modulation 8/16/32/64 is utilized to recover from errors and antenna outage.

In future other possible continuations of this work is to investigate and develop digital signal processing functions which can discover and correct errors during run-time in order to build an even more error resilient system.

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