International Journal of Engineering Technology and Applied Science

(ISSN: 2395 3853), Vol. 7 Issue 04 April 2021

A Hybrid Compressive Sensing Mechanism for Channel Estimation in Massive MIMO System Using AMP-MMSE

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Abstract- Multiple Input-Multiple Output (MIMO) systems have turn out to be necessity of wireless communication systems to conquer bandwidth restrictions. Massive-MIMO systems are capable of improving the channel capability of the system. This paper presents design, architecture, challenges, limitations and the possible improvements in a Massive-MIMO system. In this dissertation proposed improved compressive sensing is simulated using MATLAB. The results of proposed mechanism are in the form of the Receiver Operating Curves (ROC plots), which are used to evaluate the performance of any binary hypothesis. Since compressive sensing is best modeled as a diagnosis that is carried out to MIMO detection, ROC plots are the best way of analyzing the detection process and done channel estimation.

Consider an uplink multiuser MIMO system with n = 16 independent users each UE equipped with a single antenna, and the receiver equipped with m = 64 and m = 128 receiving antennas. Used QPSK and 16QAM as modulation schemes. Generate a random channel matrix H and a random transmit vector x. Assume the channel model is a flat fading channel and the symbols in the random vector are uncorrelated. At the receiver the signal undergoes additive white Gaussian noise. We use the AMP algorithm for detection.

Keywords: MIMO, Compressive Sensing, ROC, AMP, QPSK, 16QAM.

I. INTRODUCTION

Over the previous couple of years, large multiple-enter more than one-output (MIMO) has proven up as an emerging technology for wireless communique structures. Featuring as much as lots of transmit/get hold of antennas, the opportunity of making extremely slim beams for many customers is gaining the eye of enterprise and academia. Researchers are focusing their efforts at the promised blessings of this era to create the next technology of communique structures. The underlying concept is to scale up the wide variety of antennas at the bottom station (BS) via as a minimum orders of significance. The quit effects of indefinitely increasing the quantity of antennas are small fading results and additive noise. In a multiuser MIMO situation, Massive MIMO opens the opportunity to persuade many spatial streams to dozens of pieces of consumer gadget (UE) within the identical cellular, on the same frequency, and on the equal time. Mobile networks are presently going through rapid visitor's growth from both smartphones and capsules. Sequential improvements of carrier fine set the new undertaking of increasing wireless network ability approximately one thousand times in the next decade, however no current wireless get right of entry to technique can provide a big development in ability. A viable method to cope with this kind of capability demand is thru community densification by using adding small cells (SCs) (pico-cells and femtocells) that function at high frequencies (e.g. 60 GHz) inside the macro cellular region.

SCs that utilize the equal band spectrum can increase the capacity of a mobile network from 10 to 100 times, depending at the range of SCs and frequency reuse approach. The power performance of big MIMO and SC has been studied. The authors proved that huge MIMO has better energy performance while the variety of SCs is low, while SC gives better overall performance when the wide variety of SCs is excessive.

However, a globally premier exchange-off between huge MIMO and SC performance is hard to acquire because of dynamic network conduct. A possible solution can be observed by way of converging big MIMO, SCs, and tool-to-device (D2D) communications right into a single cloud-controlled heterogeneous community (Het-Net), as proven in discern 1.

In this paper we discussed introductory part in section 1 and related work discuss in section 2. System model and results discussion and conclusion describe the section 3, 4 and 5 respectively.

II. RELATED WORK

In this section we describe the literature of different methodologies related to massive MIMO, MIMO detection and MIMO-OFDM.

[1] This paper proposed that the non-regenerative big multi-input-multioutput (MIMO) non-orthogonal multiple access (NOMA) relay systems are introduced by means of this take a look at. The simulation results additionally illustrate that: i) the transmitter antenna, averaged electricity cost and consumer range show the wonderful correlations at the potential and sum fee performances, whereas the relay number presentations a poor correlation at the performance; ii) the blended huge-MIMO-NOMA scheme is able to attaining better ability overall performance as compared to the conventional

MIMONOMA, relay assisted NOMA and large-MIMO orthogonal more than one get right of entry to (OMA) scheme.

[2] This paper Make development closer to the 5G of Wi-Fi networks, the bit-consistent with-joule strength performance (EE) turns into a crucial layout criterion for sustainable evolution. In this regard, one of the key enablers for 5G is massive a couple of-input more than one-output (MIMO) technology, wherein the BSs are prepared with an extra of antennas to obtain a couple of orders of spectral and energy efficiency profits over current LTE networks.

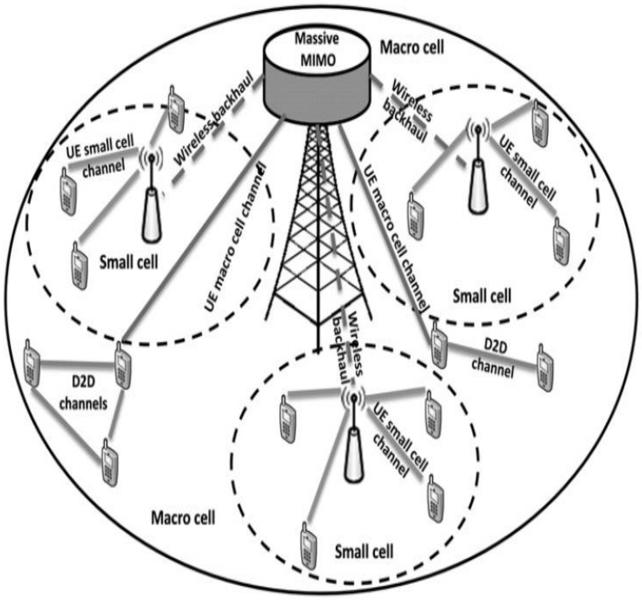

Figure 1 Architecture of HET-NET

[3] This paper offered that the overall-size a couple of-input a couple of-output (FD-MIMO) technology, that's currently an lively location of studies and standardization in wireless communications for evolution closer to Fifth Generation (5G) mobile structures. FD-MIMO makes use of an lively antenna system (AAS) with a two-dimensional (2D) planar array shape that now not best lets in a massive wide variety of antenna elements to be packed inside viable base station shape elements however also gives the capability of adaptive electronic beamforming within the 3 dimensional (3D) space. Exploiting the quasi-static channel covariance matrices of customers, the hassle of determining the ideal down tilt weight vector for antenna ports, which maximizes the minimal signal to- interference ratio of a multi-person a couple of-enter-unmarried-output gadget, is formulated as a fractional optimization hassle. A quasi-ideal answer is received via the software of semi-particular relaxation and Dinkelbach's technique. Finally, the user-organization specific elevation beamforming state of affairs is devised, which offers giant overall performance profits as showed through simulations. These consequences have direct application within the analysis of 5G FD-MIMO systems.

[4] This paper supplied that the Non-orthogonal a couple of get admission to (NOMA) has been taken into consideration as a particularly efficient verbal exchange era in the fifth technology (5G) networks with the aid of serving multiple customers concurrently via non-orthogonal sharing verbal exchange sources. To lessen the relaying complexity in CNAR system, a simplified-CNAR (S-CNAR) system is proposed as an alternative NOMA enabled relaying approach. Numerical effects show that our antenna choice and consumer scheduling algorithms reap similar overall performance to existing strategies with reduced complexity. Under excessive target charge, CNAR obtains higher performance over other transmission techniques and S-CNAR reaches similar performance with the aid of simplified relaying scheme.

[5] In this paper, a practical novel TDD layout principle is proposed for massive multiple-enter a couple of-output (MIMO) heterogeneous networks (Het-Nets) that leverages the inherent capabilities of a bendy TDD design to mitigate each the beam formed interference as a result of the pilot infection impact and B2B interference. The layout is based on the key remark that the transmission direction chosen for education via the non-massive MIMO base stations plays a crucial role in the interference behavior of the community, and the statistics slots need to be configured for this reason. We recommend TDFLEX, a low-complexity heuristic answer that follows those design recommendations. Performance assessment outcomes display big profits when our layout is in comparison to the usual TD-LTE.

[6] Presented look at, the authors propose an advanced more than one comments successive interference cancellation (IMF-SIC) algorithm and an ordered IMF-SIC (OIMF- SIC) set of rules for close to-finest a couple of-enter more than one-output (MIMO) detection. To improve the accuracy of a choice, the authors advocate a progressed MF approach where the shadow area situation is checked recursively. Further, the authors additionally advocate an OIMF-SIC algorithm wherein the log probability ratio based totally dynamic ordering is utilized for ordering the detection series. Simulation results validate superiority of the proposed algorithms over the alternative SIC primarily based detection strategies. In addition, to validate robustness of the proposed algorithms, BER performance is computed and compared beneath channel nation statistics mismatch.

[7] The design has been carried out for 2.6 GHz TDD band, and subject trials have been conducted for overall performance validation with sensible inter-mobile interference in commercial network. The trial consequences display that this 3-D-MIMO design can meet

the spectral performance requirement of 5G e-MBB services. The overall performance advantage of 3D-MIMO varies with the visitors load. When the visitors load is heavy, 3-d-MIMO can decorate the cell throughput via 4~6.7 instances. When the site visitor's load is low, the overall performance gain of this 3-D-MIMO layout decreases. The effects from field trial additionally show that the overall performance of three-D-MIMO degrades in mobility eventualities, where further enhancement on obtaining immediate channel reputation information are essential to improve the robustness of 3-D-MIMO to mobility.

[8] The large MIMO method has played the maximum important role in 5G wireless communique. It is predicted that the new strategies employed in large MIMO will no longer simplest enhance height service statistics fees notably, but additionally enhance potential, coverage, low-latency, efficiency flexibility, compatibility and convergence, hence assembly the focusing demands imposed through most desirable detection. This paper presents the most excellent detection of records symbol in huge MIMO for 5G wireless conversation. Based at the frequency non-selective fading MIMO channel, we take into account 3 distinction detectors for recovering the transmitted information symbols and examine their performance for Rayleigh fading and additive white Gaussian noise (AWGN). At the results, we display that the possibility of mistakes rate (PER) overall performance of the detectors are notably mentioned.

[9] This correspondence investigates the fundamental tradeoff among the spectral performance (SE) and energy efficiency (EE) for the massive MIMO structures with linear precoding and transmit antenna choice, wherein each the circuit power intake and the big-scale fading are taken into consideration. The EE and SE are optimized with admire to the number of transmit antennas and transmit electricity, and therefore we formulate the EE-SE tradeoff as a blended-integer-non-stop-variable multi objective optimization (MOO) problem. Using the derived EESE members of the family, the houses of the Pareto the front for the EE-SE tradeoff are analyzed. To remedy the complicated MOO trouble, we increase algorithms: the weighted-sum particle swarm optimization (WS-PSO) set of rules and the regular-boundary intersection particle swarm optimization (NBI-PSO) algorithm. Simulation consequences show that the 2 algorithms can obtain the Pareto most suitable EE-SE tradeoff, and NBI-PSO provides extra lightly distributed solutions than WS-PSO.

[10] In this paper, suggest a hybrid confined remarks with selective eigenvalue facts (HLFSEI), which adopts the man or woman quantized remarks and the codebook-primarily based comments together. In HLFSEI, we feedback most effective selective eigenvalue factors for power allocation by person quantized remarks and the precoding matrix through codebook-based comments. Furthermore, we take a look at the greatest comments bit allocation of the aforementioned comments methods to limit the throughput loss with the feedback-hyperlink capacity constraint. Specifically, the remarks bits are allotted according to the houses of the throughput loss in high- and occasional-sign-to-noise regimes. Both the BS–RS communications and the BS/RS–user-gadget communications in mobile systems are taken into consideration. Finally, we compare the overall performance of the proposed HLFSEI strategy by using simulation and show its performance benefit in comparison with conventional feedback strategies.

III. SYSTEM MODEL

MIMO systems are not sufficiently capable to cater the need of growing data rate necessities of next generation wireless communications. Also due to technical and design constraints user equipment's cannot have much more antenna elements. To overcome this problem Massive-MIMO can be used as leading technique in which huge antenna arrays are used at base station with maximum possible separation among antenna elements. It consists of all the advantages of MIMO systems with many fold increased data throughput. It is a low cost and low power communication system.

Multiple antenna systems combined with multi-carrier systems gives tremendous performance for a wireless communication system. MIMO-OFDM using different kind of FFT algorithms is practically very much useful in 4G communication systems. With improved features of conventional OFDM systems integrated with large scale MIMO named as Massive-MIMO-OFDM is one of the most capable techniques for wireless communication systems of future generation (like 5G).

MIMO-OFDM Model:

The combination of MIMO with OFDM results in increased throughput due to MIMO systems and flat fading is achieved due to OFDM. Frequency selective MIMO channel can be expressed mathematically as,

$$\begin{aligned}\boldsymbol{\overline{Z}(t)} &= \boldsymbol{H(0)\overline{S}(t) + H(1)\overline{S}(t-1) + H(2)\overline{S}(t-2)} \\ &\quad \boldsymbol{+ \cdots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots} \\ &\quad \boldsymbol{+ H(L-1)\overline{S}(t-L+1)} \\ &\quad \boldsymbol{+ \overline{n}(t)}\end{aligned}$$

Where,

$$\boldsymbol{\overline{S}(t) = T_x\ vector\ at\ time\ (t)}$$

$$\boldsymbol{\overline{S}(t-1) = T_x\ vector\ at\ time\ (t-1)}$$

$$\begin{aligned}&\boldsymbol{H(L)} \\ &\boldsymbol{= Channel\ matrix\ corresshponding\ to\ tap\ L.(N} \\ &\boldsymbol{\times M\ Matrix); and\ \overline{n}(t) = noise.}\end{aligned}$$

In a MIMO channel, Inter Symbol Interference (ISI) occurs between current and previous transmitted symbol vectors. To overcome this problem, IFFT operation is performed for each transmit antenna in a MIMO-OFDM system. MIMO-OFDM system converts a MIMO frequency selective channel into a set of multiple parallel flat fading MIMO channels. The N-parallel flat fading MIMO channels can be expressed mathematically as;

$$\overline{\boldsymbol{Z}}(\boldsymbol{0}) = \overline{\boldsymbol{H}}(\boldsymbol{0})\,\overline{\boldsymbol{S}}(\boldsymbol{0})$$

$$\overline{\boldsymbol{Z}}(\boldsymbol{1}) = \overline{\boldsymbol{H}}(\boldsymbol{1})\,\overline{\boldsymbol{S}}(\boldsymbol{1})$$

$$\overline{\boldsymbol{Z}}(\boldsymbol{N}-\boldsymbol{1}) = \overline{\boldsymbol{H}}(\boldsymbol{M}-\boldsymbol{1})\,\overline{\boldsymbol{S}}(\boldsymbol{M}-\boldsymbol{1})$$

In general,

$$\overline{\boldsymbol{Z}}(\boldsymbol{k}) = \overline{\boldsymbol{H}}(\boldsymbol{k})\,\overline{\boldsymbol{S}}(\boldsymbol{k})$$

Where,

$$\overline{\boldsymbol{Z}}(\boldsymbol{k}) = \boldsymbol{Rx1\ receive\ vector\ corresponding\ to\ subcarrier\ (k)}$$

$$\overline{\boldsymbol{H}}(\boldsymbol{k}) = \boldsymbol{flat\ fading\ channel\ matrix\ corresponding\ to\ subcarrier\ (k)}$$

$$\overline{\boldsymbol{S}}(\boldsymbol{k}) = \boldsymbol{Tx1\ transmit\ vector\ corresponding\ to\ subcarrier\ (k)}$$

Each of $\overline{\boldsymbol{Z}}(\boldsymbol{k})$ can be processed by a simple MIMO-ZF receiver or a MIMO-MMSE receiver for detection of vector $\overline{\boldsymbol{S}}(\boldsymbol{k})$.

AMP for Massive MIMO Detection: The Massive MIMO architecture is to serve tens of users by employing hundreds of antennas,

$$\boldsymbol{y} = \boldsymbol{Hx} + \boldsymbol{w}$$

Where the channel $H \in \mathbb{C}^{m\times n}$ has its element sample from $N_C\left(0,\frac{1}{m}\right), m \gg n$,

- **$y \in \mathbb{C}^{m}$ is the received signal,**
- **AWGN noise components ω_i are i.i.d with $N_C(0,\sigma^2)$;**
- **Regarding the transmitted x, We only assume that it is zero mean and finite variance σ_s^2.**

Before incorporating the AMP algorithm, we should be well aware of two facts:

1) Directly using maximum a priori (MAP) $\mathbf{arg\,max}\,\boldsymbol{p(x|y)}$ or MMSE estimation $\boldsymbol{E_{p(x|y)}(X)}$ to work with the exact prior degrade the necessity of employing AMP, because achieving a full diversity requires an extremely large set of constellation points, in which AMP works slowly while doing the moment matching process, not to mention problems about its inability to converge to the lowest fixed point.
2) In the CDMA multiuser detection theory [Verdu98, etc.], their "MMSE" detector does not mean the one working with exact prior , but rather the one assuming a Gaussian prior.

So we use a proxy prior for detecting x, i.e. assuming that $\boldsymbol{x_i \sim N_C(0,\sigma_s^2\,)}$**,** even though it may be inexact. In this occurrence, we have the signal power $\boldsymbol{\sigma_s^2 = 2}$ **in QPSK,** $\boldsymbol{\sigma_s^2 = 10}$ **in 16QAM,** etc. So the target function becomes**:**

$$\boldsymbol{min\ ||y - Hx||^2, s.t.\, x_i \sim N_C(0,\sigma_s^2)}$$

The AMP algorithm to solve the above problem only require three line as depicted below;

$$\boldsymbol{r^t = y - HX^{t-1} + \frac{n}{m}\frac{\sigma_s^2}{\sigma_s^2 + \alpha^{t-1}} r^{t-1}}$$

$$\boldsymbol{\alpha^t = \sigma^2 + \frac{n}{m}\frac{\alpha^{t-1}\sigma_s^2}{\sigma_s^2 + \alpha^{t-1}}}$$

$$\boldsymbol{X^t = \frac{\sigma_s^2}{\sigma_s^2 + \alpha^t}(H^* r^t + X^{t-1})}$$

- Where the initialization is to let $\boldsymbol{r^0 = 0, x^0 = 0, \alpha^0 = \sigma_s^2}$.
- In terms of complexity, it only costs $\boldsymbol{2mn \times (\#Iteration)}$.
- Also according to the second equation of the algorithm, it is converging extremely fast.
- On the contrary, MMSE has complexity $0(mn^2)$.
- It is noteworthy that known approximation methods to MMSE, such as Richardson's method or Newman series approximation, both fall behind the complexity performance trade-off of AMP according to our simulation.

IV. SIMULATION RESULTS

Flow Chart for Simulation of the Proposed Optimization: Simulation refers to the imitation of the operation of a real-world process or system. Simulation involves the development of a model using efficient software that closely represents the physical world system/ process under study. This illustrates the simulation of the compressive sensing scheme using MATLAB platform.

Steps involve in this proposed optimization for simulation as follows:

1) Generate the signal for transmission, signal noise and receive signal at different node.
2) Define the number of receive antenna and number of user.
3) Set SNR range and iteration done by monte iteration method and calculate the signal variance and noise variance of the transmission signal.
4) Apply approximate message passing for massive MIMO channel model.
5) Iteration done by the AMP iteration method.
6) Estimate the channel performance matrices i.e. SER, BER, MMSE.

We consider an uplink multiuser MIMO system with n = 16 independent users each UE equipped with a single antenna, and the receiver equipped with m = 64 receiving antennas. We use QPSK and 16QAM as modulation schemes. We generate a random channel matrix H and a random transmit vector x. We assume the channel model is a flat fading channel and the symbols in the random vector are uncorrelated. At the receiver the signal undergoes additive white Gaussian noise. We use the AMP algorithm for detection.

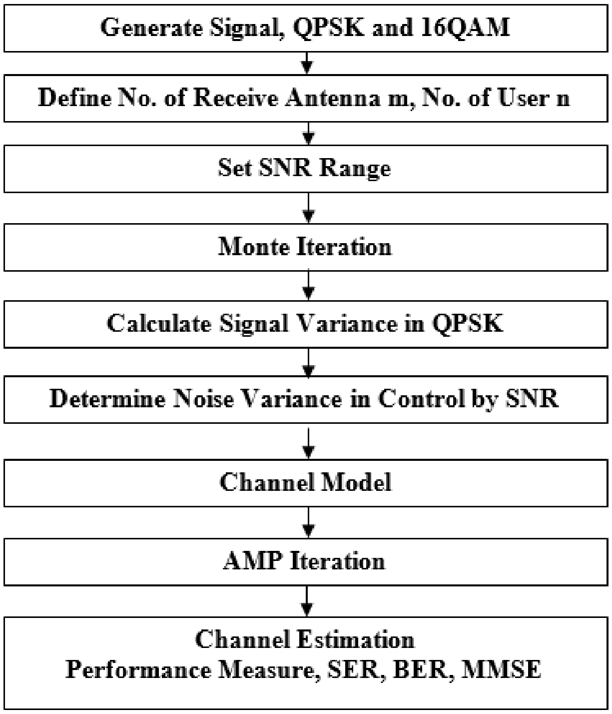

Figure 2: Flow Chart for Simulation of the Proposed Optimization

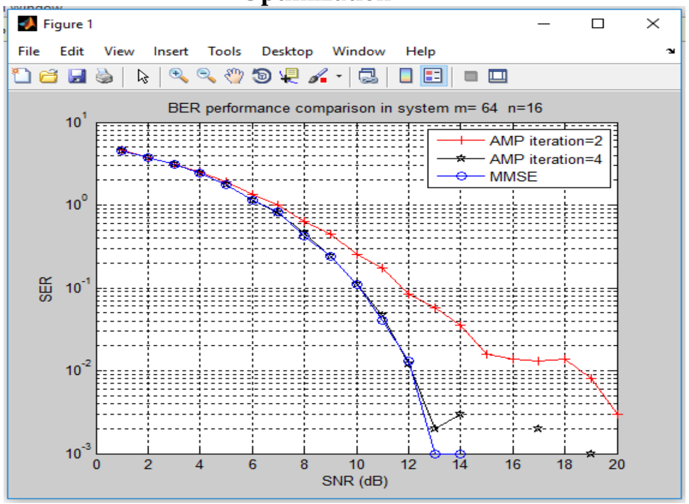

Figure 3: Shows the BER performance comparison in system m=64, n=16

We consider an uplink multiuser MIMO system with n = 16 independent users each UE equipped with a single antenna, and the receiver equipped with m = 128 receiving antennas. We use QPSK and 16QAM as modulation schemes. We generate a random channel matrix H and a random transmit vector x. We assume the channel model is a flat fading channel and the symbols in the random vector are uncorrelated. At the receiver the signal undergoes additive white Gaussian noise. We use the AMP algorithm for detection.

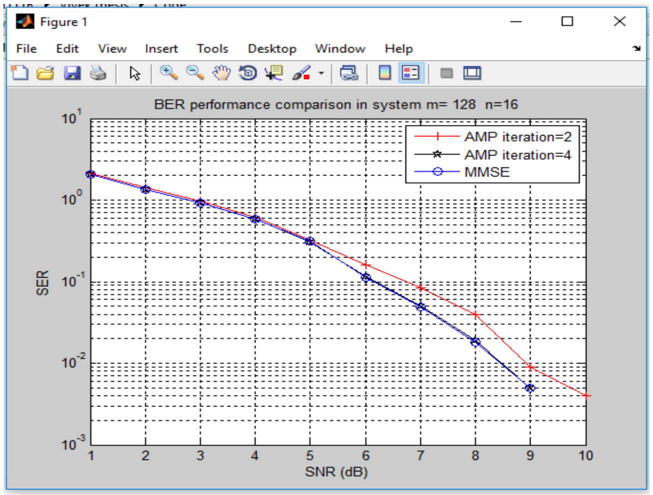

Figure 4: Shows the BER performance comparison in system m=128, n=16

Above these figure 3 and figure 4 depicted that the BER performance comparison between AMP iteration = 2, AMP iteration = 4, and MMSE. We run the simulation at the maximum number of iterations of the AMP algorithm, 20 iterations per trial, 1000 trials per given SNR value. The maximum SNR is 20 dB for (QPSK m=64, n=16), and 10 dB for (QPSK m=128, n=16).

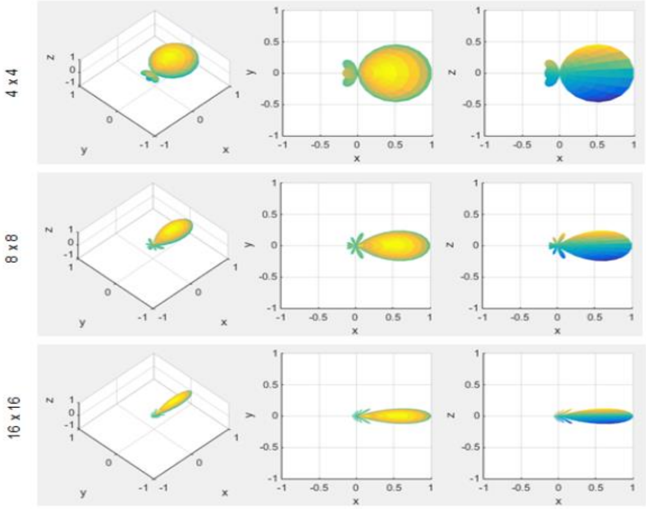

Figure 5: Comparison of beam of different array antenna

Above depicted figure 5 shows the comparison of beam of different array antenna, concluded that narrower the beam width become as the number of antenna in the array get larger.

V CONCLUSION

We consider an uplink multiuser MIMO system with n = 16 independent users each UE equipped with a single antenna, and the receiver equipped with m = 64 and m = 128 receiving antennas. We use QPSK and 16QAM as modulation schemes. We generate a random channel matrix H and a random transmit vector x. We assume the channel model is a flat fading channel and the symbols in the random vector are uncorrelated. At the receiver the signal undergoes additive white Gaussian noise. We use the AMP algorithm for detection.

In addition to growing the received power, Massive MIMO offers several different advantages as well. According to "Massive MIMO for Next Generation Wireless Systems", the potential (benefit) of Massive MIMO is described as follows;

[1] Massive MIMO can boom the capability 10 instances or more and simultaneously, improve the radiated energy efficiency inside the order of 100 instances.

[2] Massive MIMO can be built with cheaper, low energy intake.

[3] Massive MIMO permits a large reduction of latency on the air interface (due to robustness towards fading) Massive MIMO simplifies the a couple of get admission to layer Massive MIMO increases the robustness both to accidental manmade interference and to intentional jamming.

It is the truth that maximum of energy transmitted from the antenna array consciousness on very narrow area. It approach the beam width get narrower as you operate extra antenna. Following plot might come up with an example for the effect of bandwidth narrowing with the expanded quantity of antenna. Advantage would be that there may be much less interference among beams for different customers since every of the beam could be targeted in very small vicinity and the disadvantage could be that you have to put into effect very sophisticated algorithm to find exact area of the user and directing the beam to the consumer with excessive accuracy.

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