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Maximizing LTE Performance through Precoding with Low Complexity for MIMO Optimization

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ABSTRACT

In Multiple-input multiple-output (MIMO) technology has been successfully integrated in a series of well-established wireless communication standards. Linear precoding techniques can achieve near optimal capacity due to the special channel property in downlink massive MIMO systems, but involve high complexity since complicated matrix inversion of large size is required. A low-complexity linear precoding technique based on the Gauss-Seidel (GS) method. The proposed scheme can achieve the capacity and performance of the classical linear precoding schemes in an iterative way without complicated matrix inversion and can be reduce the overall complexity by the order of magnitude. The performance guarantee of the proposed GS-based precoding is analysed from the following three aspects. Therefore, network operator's new technologies such as LTE generate more throughput from existing bandwidth. While LTE can provide increased capacity using standard antenna techniques to widespread deployment and optimization of MIMO (Multiple-Input Multiple-Output) antenna techniques can multiplicative effect on LTE's data throughput. MIMO techniques, in turn, present their own unique challenges, requiring a new approach to network measurement and optimization.

Keywords: Multiple-input–multiple-output systems, linear precoding, Gauss-Seidel (GS) method, low complexity, spatial modulation (SM), spatial multiplexing (SMX), transmit precoding (TPC).

1. INTRODUCTION

MIMO technology has its roots in more widely deployed in the antenna techniques. MIMO builds on Single-Input Multiple-Output known as receive diversity as well as Multiple-Input Single-Output, also called transmit diversity. SIMO techniques for decades, while MISO is most advanced cellular networks today. Both of these techniques are boost signal-to-noise ratio in order to compensate signal degradation. As a radio frequency signal are passes from Tx to Rx and its gradually weakens, and interference from other RF signals also reduces SNR. The RF signal frequently encounters objects hich will alter its path signal. Multiple-antenna systems are compensate for some of the loss of SNR due to multiple path conditions are combining signals that have different fading characteristics, since the path from each antenna slightly different. SIMO and MISO systems are achieve SNR gain by combining signals that take multiple paths for Tx and Rx in a constructive manner each signal 3. Because different antennas receive and transmit the same signal are achieve SNR gains even in line of sight situations. The boost in SNR can then be used to increase the range of the connection by using a modulation scheme is 16QAM rather than QPSK. MIMO can combination of SIMO and MISO techniques for resulting in even greater SNR gains boosting coverage and data rates. However, when SNR is high for additional throughput gains are minimal and there is little benefit from further boosting SNR. To achieve throughput gains where SNR is already very high. LTE optimized MIMO technique called spatial multiplexing. In spatial multiplexing, each Tx sends a different

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data stream for multiple Rx. These data streams are reconstructed separately by the UE. It may seem counterintuitive that two signals for same time and frequency within the same sector can result in increased throughput rather than interference. The spatial multiplexing are compared to conventional spectrum re-use, where signals are transmitted for same frequency in different cells. For spectrum re-use in the cells must be far enough apart that is, they must occupy different space and in order to avoid interference. With spatial multiplexing, the signals, instead of occupying a completely different cell, different space-time in the same cell. Good multipath conditions create the signal orthogonality a single cell into multiple cells for respect to the amount of data that can be sent on a particular frequency band.

Multipath conditions, spatial multiplexing are depends on high SNR to produce large throughput gains. The spatial multiplexing is even though multiple data streams are transmitted, the total power of the transmission remains same. Therefore spatial multiplexing are distributes to total SNR between these multiple data streams, each lower power level. The result is each data stream contains a lower SNR than would be possible with single data stream. Because there are diminishing returns for additional SNR when SNR is already high, each multiple data streams may be capable of transmitting nearly as much data as a single stream. The increased data capacity results are sharing SNR between multiple data streams means that, while spatial multiplexing may be used to encode same data differently and boost SNR are recombined data streams, it can also be used to completely different data through Tx. In LTE, each set of data sent through the antennas in a spatial multiplexing operation is known as layer. Under ideal conditions, each layer of a spatial multiplexing transmission will contain as a single-Tx LTE transmission. The result is that spatial multiplexing can theoretically multiple throughput in the transmission rank. This multiplicative effect on throughput means that MIMO technology is essential for full benefits of LTE. With the 2×2 (2 Tx and 2 Rx) antenna configuration expected to be deployed by effective use of MIMO nearly double throughput both for individual users and for each cell as a whole.

The throughput gains are depend on three factors: maximizing rich scattering conditions within a cell configuring eNodeB to properly match MIMO settings to real-world conditions, and ensuring that UEs can take full advantage are multipath conditions are present. Scanning receivers that can provide accurate real-world measurements of multipath conditions and potential throughput are essential for evaluating the performance of all three of these factors. The measurements are using mobile operators can maximize the data rates and reliability of LTE networks.

More recently, spatial modulation (SM) has been conceived for implicitly encoding information in the index of the specific antenna activated for the transmission of the modulated symbols, offering a low-

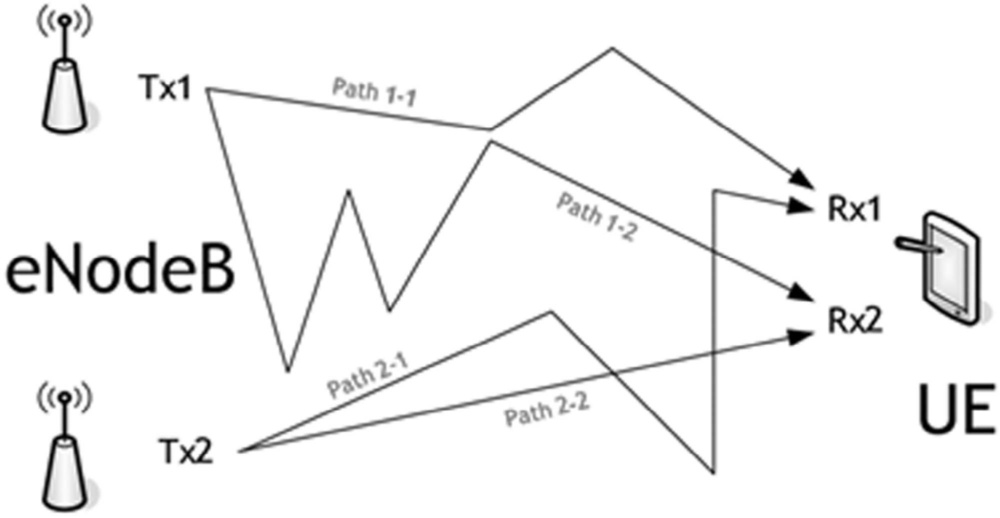


Figure 1: Multiple Paths from eNodeB to UE in 2×2 MIMO

complexity design alternative [2]. Its central benefits include the absence of inter antenna interference (IAI) and the fact that it only requires a subset (down to one) of radio-frequency (RF) chains compared with SMX. Accordingly, the inter antenna synchronization is also relaxed. The design of receiver algorithms for minimizing the bit error ratio (BER) of SM at low complexity. The work spans from matched filtering as a low complexity technique for detecting the antenna index used for SM [11] to the maximum likelihood (ML) [10] with a significantly reduced complexity compared with classic SMX ML detectors, including compressive sensing approaches [9] and performance analyses. Reduced-space sphere detection has also been proposed for SM in [5] for further complexity reduction where a generalized SM transmission was also explored. In addition to receive processing, recent work has also proposed constellation shaping for SM. Specifically, the work on this topic has focused on three main directions: shaping and optimization of the spatial constellation, i.e., the legitimate sets of activated transmit antennas (TAs), modulation constellation shaping for the SM and space shift keying transmission, where the constellation of the modulated bits is optimized, and joint spatial and modulation constellation shaping, in the form of optimizing the received constellation.

2. MIMO USING SPATIAL MULTIPLEXING SYSTEM

MIMO technology are widely deployed antenna techniques. MIMO builds on Single-Input Multiple-Output also called receive diversity or Multiple-Input Single-Output also called transmit diversity. SIMO techniques around for decades. The MISO is advanced cellular networks today. Both of these techniques shown boost signal-to-noise ratio compensate for signal degradation. A radio frequency (RF) signal passes from Tx to Rx, it gradually interference from other RF signals also reduces SNR. The RF signal frequently encounters objects which will alter its degrade signal. Multiple-antenna systems are compensate for loss of SNR due to multipath conditions by combining signals for different fading characteristics of the path from each antenna will be slightly different. SIMO and MISO systems are achieve SNR gain combining signals that take multiple paths to the Tx and Rx in a constructive manner best piece of each signal. Because different antennas receive or transmit the same signal for systems can achieve SNR gains are line sight situations. The boost in SNR can then be used to increase the range for boost data rates are using modulation scheme such as 16QAM or 64QAM rather than QPSK.

During each symbol period, R bits are de-multiplexed into M different bit streams and modulated independently using constellation S. Note that the number of bits per sub stream is R/M so that R bits are transmitted irrespective value M. The spatial multiplexer produces a symbol vector s_k at symbol period k where1 sk = $[sk, 1, sk, 2, \ldots, sk, M]^T$ For convenience we assume that $E_s s^k s^H{}_k$ = EsMIM where IM is the M × M identity matrix. Notice that sk, and thus the constellation that the entries of sk are chosen from, are normalized so that the total transmit power is EsSHksk = Es irrespectively of M. Throughout, it is assumed that M ≤ Mr. The symbol vector sk is precoded by a Mt × M precoding matrix WM, p $\in$ W(M, Mt) where

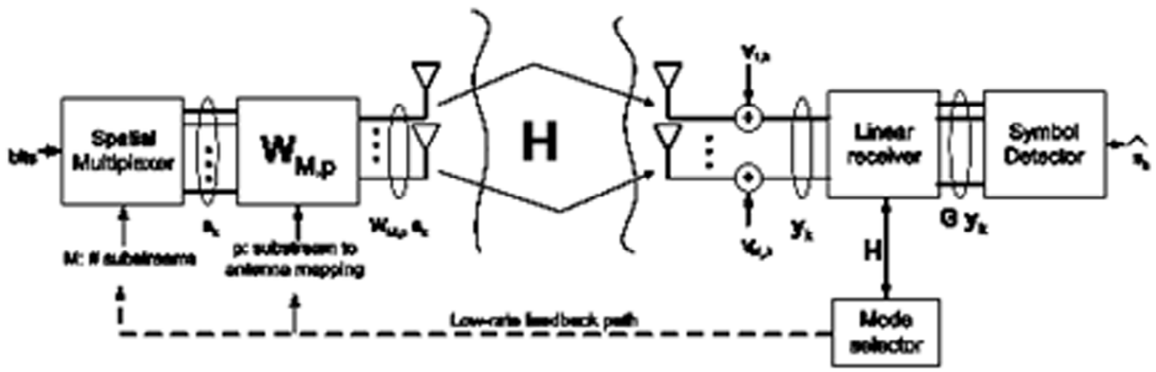


Figure 2: A spatial multiplexing system with feedback

WM,p is the pth entry in W(M, Mt), the ordered set of Mt ×M matrices constructed by combinations of M columns in the identity matrix IMt. It is shown that |W(M, Mt)| = Mt M. Essentially W(M, Mt) is the set of size M subsets of Mt transmit antennas while M is the number of data streams. For example, for Mt = 2,

$$w(1,2)=\left\{\begin{bmatrix}1\\0\end{bmatrix},\begin{bmatrix}0\\1\end{bmatrix}\right\},w(2,2)=\left\{\begin{bmatrix}1&0\\0&1\end{bmatrix}\right\}$$

The parameters M and p are determined on feedback from the receiver. Thus as mentioned before this framework includes antenna subset selection as a special case but is even more general. Assuming there are no symbol timing errors and frequency offsets for the Mr × 1 received signal vector after matched filtering and sampling can be written as

$$y_k = HW_{M,p}S_k + V_k$$

Where H is the channel matrix and vk is the noise vector. We assume the entries of H are i.i.d. according to CN (0, 1) and the entries of vk are i.i.d. according to CN (0, N0). We refer to HWM,p as the equivalent channel. The channel is constant across frame of data but varies independently from frame to frame. The subsequent notation we assume that frame with a single symbol, thus we let k = 1 and suppress the k subscripts.

At the receiver, y is multiplied by an M × M matrix and then each entry of the resulting vector is detected independently. For a ZF linear decoder *G* = ($HW_{M,p}$) while for the MMSE linear decoder

$$G=\left[W_{M,p}^{H}H^{H}HW_{M,p}+\gamma_0^{-1}I_M\right]^{-1}W_{M,p}^{H}H^{H}$$

Where γ0 = Es/MNo. The receivers are easily implemented because single-dimensional ML detection is required. This computational savings comes at the expense of increasing the error rate.

3. MULTI-MODE TRANSMISSION

In this paper propose a variation of standard antenna subset selection where both the number of sub streams for antenna optimally chosen. This allows the freedom to assume any antenna selection scheme is single antenna is full spatial multiplexing. In various optimal and suboptimal selection criteria based on the error rate as well as an Eigen mode analysis.

3.1. Multi-Mode Selection from Error Probability

The multi-mode antenna receiver must select both the number of data streams M is optimal precoding matrix within W (M, Mt). Therefore total number of distinct feedback possibilities is

$$\sum_{m=1}^{M_t}\binom{M_t}{m}=2^{M_t}-1$$

Which can be implemented using Mt bits on a feedback control channel. The number of bits of feedback that are required scales linearly with number of transmit antennas. Therefore quantizing the channel and conveying the quantized coefficients back to transmitter. If k bits used to quantize each real or imaginary component, a total of 2MtMrk bits feedback. The sign (one bit per coefficient) still requires 2MtMr bits. Thus quantizing the channel matrix incurs a factor penalty compared with multi-mode antenna. The optimal fixed rate selection metric are perfect channel choose the mode that minimizes the probability of error. The following theorem guarantees diversity order performance in Rayleigh fading channels for this case.

Theorem 1 Selection for optimal M∗ and p∗ such that WM∗, p∗ ∈□ W(M∗, Mt) minimizes conditional probability of error provides diversity advantage. Selection of diversity provides full diversity advantage on the order of MtMr. The selection diversity included among the subsets, optimal selection only be better than single-antenna selection diversity for all channel realizations.

To obtain a close, but computable, approximation to optimal selection we rely on the nearest neighbor union bound (NNUB) to obtain a form of optimal selection does not require significant numerical integration. Therefore SNRk(M, p) be the SNR of the kth substream with effective channel HWM,p, Ne(M, R) be the average number neighbors in the R/M bit substream constellation, and dmin(M, R) be the minimum distance in the R/M bit substream constellation.

4. OPEN-LOOP AND CLOSED-LOOP SPATIAL MULTIPLEXING

Open-Loop and Closed-Loop Spatial Multiplexing are keys to SU-MIMO's great leap in throughput potential. Different data each antenna modes come close to multiplying peak throughput by the transmission rank, the number of data streams or layers are transmitted. LTE supports rank-2 transmissions for 2 × 2 or 4 × 2 antenna configurations rank-4 for 4 × 4 antenna configurations. Therefore gains are Closed-Loop and Open-Loop rank-2 transmissions. The spatial multiplexing modes, are require rich scattering of multipath signals and high SNR. Therefore data streams can be successfully decoded. Under the right conditions UE can separate into signals from two Tx, identified by reconstruct two separate data streams in the same frequency block.

Spatial multiplexing are creating separate data streams on multiple antennas. The eNodeB divides into sent to a given UE on a given sub-channel into data streams, called layers. Transmission rank is determined by channel conditions at the UE considerations such as available resources at the eNodeB. In the simplest type spatial multiplexing, a rank-2 spatial multiplexing transmission on a 2 × 2 MIMO antenna will transmit each Tx. Each layer reaches each Rx along different path. The UE reconstructs to layers using both antennas. With multiple-layer transmissions, data arrives from higher level code words, as shown in Figure 4. Each code word is then mapped onto one or more layers. In 2 × 2 MIMO, each code word corresponds directly to layer. Each layer is then mapped into antennas using precoding matrix. When the UE detects a similar SNR from Tx and precoding matrix will map layer into a single antenna. When one Tx is high SNR and low SNR, the precoding matrix will divide the layers between Tx for effort to equalize SNR between the layers. The paths 1-1 and 1-2 in Figure 1 would not represent a single layer but data streams are contain information from both Layer 1 and Layer 2. The maximum throughput using given modulation scheme increases for linearly low SNR but logarithmically at high SNR, increasing the SNR layer at expense of the high-SNR layer increases total throughput. At a basic level, however, goal is to ensure that each layer decoded for acceptable error rate allowing the UE to take advantage is spatial multiplexing.

MIMO is combination of SIMO and MISO techniques, resulting in even greater SNR gains for boosting coverage and data rates. Therefore SNR is high, additional throughput gains are minimal, and there is little benefit from further boosting SNR. To achieve throughput gains where SNR is already very high, LTE uses a MIMO technique is called spatial multiplexing. The spatial multiplexing, each Tx sends a different data stream to multiple Rx. It may seem counterintuitive that two signals sent same time and frequency within the same sector can result in increased throughput rather than interference. The spatial multiplexing can be compared to conventional spectrum re-use, where signals are transmitted in the same frequency for different cells. For spectrum re-use, the cells must be far enough apart—that is, they must occupy different in order to avoid interference. With spatial multiplexing, the signals, instead of occupying a completely different cell. The multipath conditions create the signal orthogonality a single cell into multiple cells are respect to the amount of data particular frequency band.

In addition to good multipath conditions, spatial multiplexing depends on high SNR to produce large throughput gains. Even though multiple data streams are transmitted, the total power of the transmission remains the same. Therefore spatial multiplexing distributes the total SNR between these multiple data streams of a low power level. Each data stream contains a lower SNR than would be possible with a single data stream. There are diminishing returns for additional SNR, multiple data streams are capable of transmitting nearly as much data as a single stream. The increased capacity are results from sharing SNR between multiple data streams, while spatial multiplexing may be used for encode the same data differently boost SNR is recombined data streams, it can be used to send different data through Tx. In LTE, each data sent through the antennas in a spatial multiplexing operation is known as layer. Under ideal conditions, each layer of a spatial multiplexing transmission is single-Tx LTE transmission. The spatial multiplexing can be theoretically multiply throughput for transmission rank. This multiplicative effect on throughput are MIMO technology is essential for achieving benefits of LTE. The 2×2 (2 Tx and 2 Rx) antenna configuration expected to deployed. Effective use of MIMO could nearly double throughput for individual users and for each cell. These throughput gains are depend on three factors: maximizing rich scattering conditions within a cell, configuring for eNodeB properly match MIMO settings to real-world conditions, and ensuring that UEs can take full advantage for multipath conditions are present. Scanning receivers that can provide real-world measurements for multipath conditions are potential throughput are essential tools for evaluating the performance of all three of these factors. Therefore measurements, mobile operators are maximize the data rates and reliability of LTE networks, their LTE equipment investments while improving customer satisfaction.

4.1. LTE Downlink Transmission Modes

The MIMO features and techniques available in LTE downlink operations. Because network conditions are UE capabilities can vary greatly MIMO systems can be highly flexible to maximize gains and throughput. Since each eNodeB can be configured to differently in terms of how it adapts transmissions in real time, to understand transmission modes available in LTE, as well as the conditions under most useful. Network operators can compare scanning receiver measurements UE-reported data logged to determine the eNodeB is effectively adapting transmissions to the RF environment.

The remaining modes are less current LTE MIMO techniques. Modes 1 and 7 represent non-MIMO based antenna techniques. Single Antenna SISO or SIMO operation is LTE networks an option when the UE or eNodeB is unable to support MIMO operations. Therefore Single Antenna Port Beamforming generally requires a different antenna configuration for MIMO operations. Modes 5 and 8 are early versions of antenna are expected to be used minimally LTE deployments, but robust versions of techniques are planned for LTE. Multi-User MIMO (Mode 5) is multiple Tx antennas send data Rx antennas are located spatially separated UEs. Dual-Layer Beamforming (Mode 8), available LTE and combines beamforming with 2×2 MIMO spatial multiplexing capabilities. Mode 8 used for either MU-MIMO or SU-MIMO. It requires deployment of beamforming antenna arrays special configuration of eNodeBs and UEs.

4.2. Mimo Using Precoding

The main difficulty in MIMO channels are separation of the data streams are parallel. Therefore precoding or pre-equalization of the transmitted signals are MIMO systems. This type of processing transmitter requires channel state information (CSI) at transmitter. In order to obtain CSI at the transmitter channel should fixed (non-mobile) or approximately constant over a reasonably large time period. The transmitter, the transmitted symbols, either for a single-user or for multiple users, at the transmitter. In this section, overview of precoding schemes for single-user and multiuser systems.

The point-to-point communication systems for multiple access channels in which the receivers are coordinated, a minimum mean-square error decision-feedback equalizer can be applied to untangle for

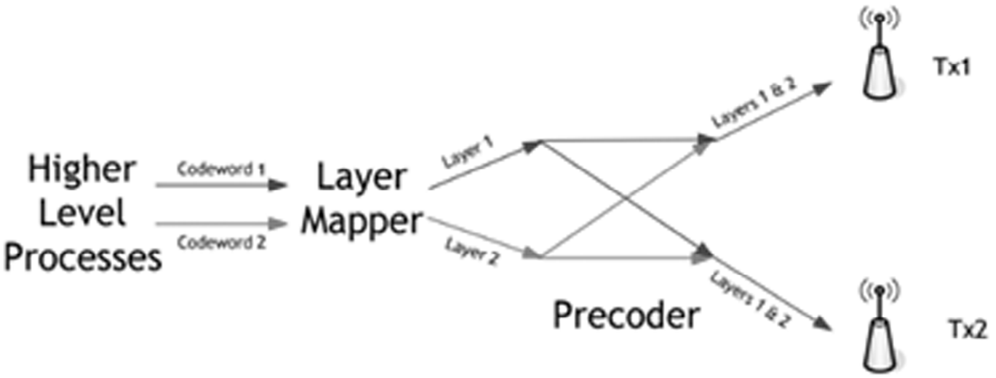


Figure 3: MIMO Precoder

interference. The structure of DFE at the receiver is shown in Figure 3.1. After each symbol is detected, it is subtracted from the received signal for next symbol is detected. A consequence error propagation may occur in these receivers. For multiple access channel, for equivalent to serial interference cancelation (SIC). The downlink channel are unlike in the other two receivers uncoordinated is impossible to implement joint processing techniques such as DFE.

However channel is known to the transmitter and the decision feedback receiver can be implemented at the transmitter as shown in Figure 3.2. A well-known example is type of “pre-equalizer” and the Tomlinson-Harashima precoder (THP), in the context equalization of ISI channels. In this work, the matrix form of THP is applied to the multi-user downlink channel (Figure 3.2). This presents the same idea as DPC. Therefore interference is known at the transmitter can be pre-subtracted prior to transmission. In this way, error propagation may be avoided. A regular subtraction at the transmitter will cause power amplification at the transmitter. Modulo-arithmetic in the form of THP is used both transmitter and receiver to minimize power amplification. If the data symbols (d) are from an M-array constellation: $\chi = \{\pm 1, \pm 3, \pm(M-1)\}$ (M even), then the operation of this modulo adder is such that the transmitted symbols, x, are constrained into the interval [–M, +M). Indeed if the result of the summation is greater than M, 2M is repeatedly subtracted until the result is less than M. If the result of the summation is less than –M, 2M is added until the result is greater than to –M.

4.3. Optimizing MIMO

The MIMO system is to achieve the highest throughput and connectivity possible in a given environment by leveraging in the multipath potential of the environment. Optimization is necessary for successful rollout MIMO systems are continued active networks helps to maintain the investment as multipath environments are change and UEs evolve. The MIMO optimization is configuration of antennas at the eNodeB is best multipath conditions possible. This altering the placement of antenna equipment. Second, MIMO optimization includes valuating UEs to ensure that the processing power and antenna configurations necessary to take advantage of multipath conditions created the interaction between environment antenna configurations. Finally, LTE MIMO systems are optimize the algorithms eNodeB uses to select the best MIMO mode are capabilities to multipath conditions. All three elements are MIMO optimization required accurate, UE-agnostic measurements are real-world multipath conditions. These measurements, operators have no way of knowing antenna configurations are produced the expected multipath conditions are throughout the sector. The UE-agnostic measurements allow operators determine the MIMO mode selection and UE capabilities for successfully throughput potential of existing multipath conditions. In real-world MIMO measurements include power and quality measurements are multipath signal, as well as indications of signal orthogonality and throughput potential of the multipath environment.

4.4. Gauss-Seidel method

The Gauss-Seidel method, we use the new values $x_i^{(k+1)}$ they are known for example, once we have computed $x_1^{(k+1)}$ from the first equation, is used in the second equation to obtain the new $x2^{(k+1)}$ and so on.

$$P_{i,inj} - jQ_{i,inj} = V_i^* \sum_{k-1}^{n} Y_{ik}V_k = V_i^* \left[Y_{i1}V_1 + Y_{i2}V_2 + \ldots + Y_{ii}V_i + \ldots + Y_{in}V_n \right]$$

4.5. Load Flow by Gauss-Seidel Method

The power flow equations are nonlinear bus power system, let the number of P-Q buses be np and the number of P-V buses ng such that n = np + ng + 1. Both voltage magnitudes and angles of the P-Q buses and voltage angles P-V buses are making a total number of 2np + ng quantities to be determined. The quantities are 2np numbers of real and reactive powers of the P-Q buses, 2ng numbers of real powers and magnitudes of the P-V buses and voltage magnitude angle of the slack bus. Therefore there are sufficient numbers are quantities to obtain a solution of the load flow problem. Therefore obtain the iterative solutions of the load flow problem.

$$V_i = \frac{1}{Y_{ii}} \left[\frac{P_{i,inj} - jQ_{i,inj}}{V_i^*} - Y_{i1}V_1 - Y_{i2}V_2 - \ldots - Y_{in}V_n \right]$$

At the beginning of an iterative method, a set of values for the unknown quantities. These are updated at each iteration. The process continues till errors between known and actual quantities are reduced to pre-specified value. In the Gauss-Seidel load flow we denote the initial voltage are i th bus and Vi(0), i = 2, ..., n . This should read as the voltage of the i th bus at the 0th iteration. The first iteration are denoted by Vi(1) . In this Gauss-Seidel load flow and voltage controlled buses are treated differently.

5. RESULTS

In above results QPSK system using MIMO frequency over bit error rate performance in MMSE.

In above results QPSK system using MIMO frequency over bit error rate performance in Spatial Multiplexing.

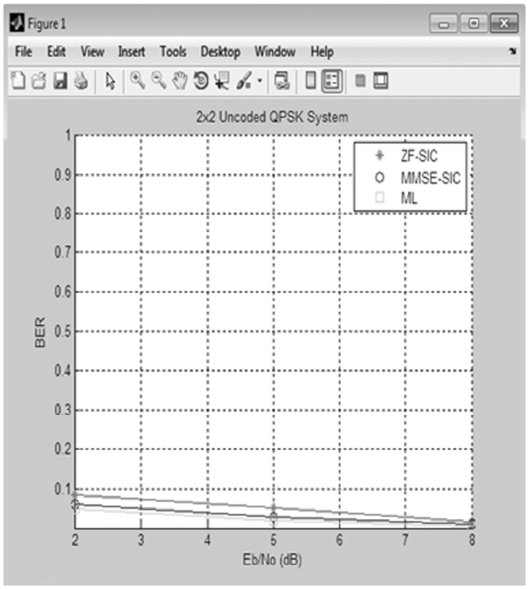


Figure 4: Precoding Bit Error Performance

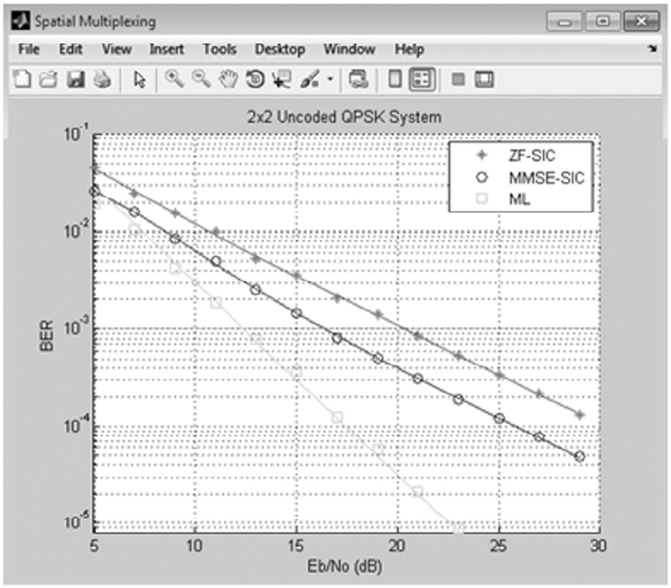


Figure 5: BER performance using Spatial Multiplexing

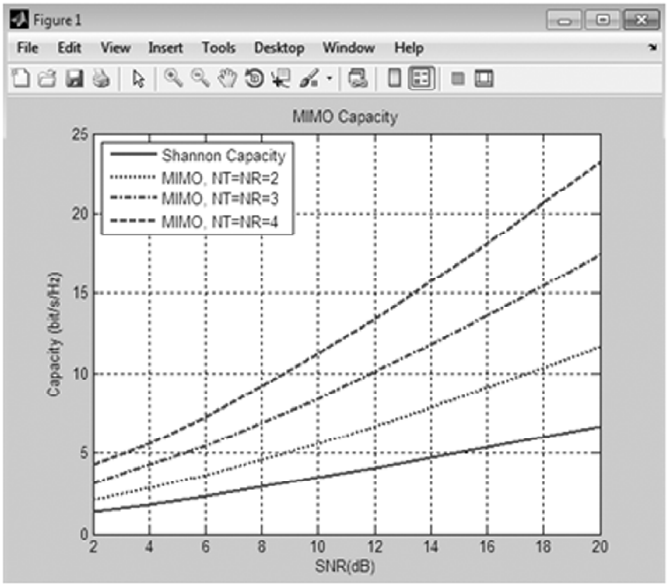


Figure 6: SNR using spatial multiplexing

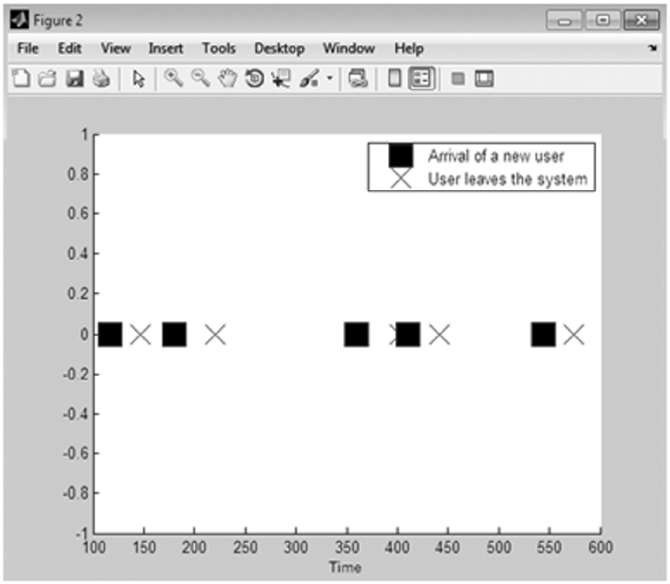


Figure 7: LTE System

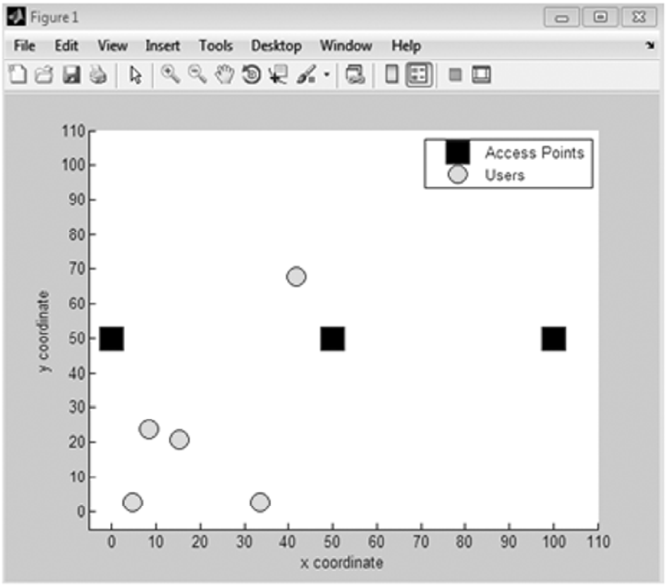
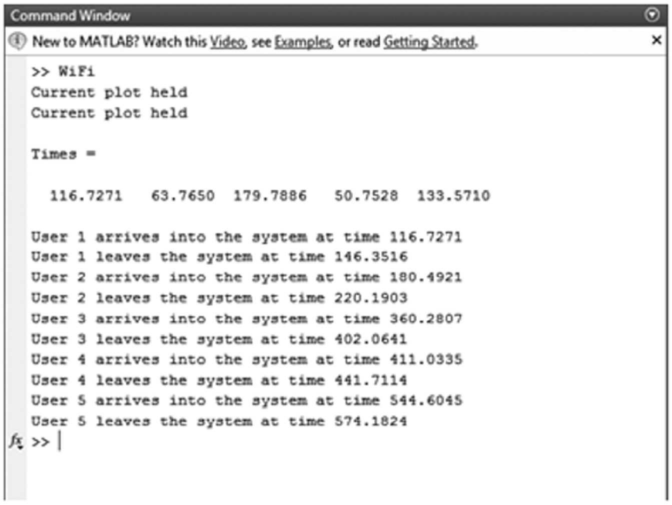


Figure 8: LTE Simulation



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>> WiFi
Current plot held
Current plot held

Times =

  116.7271   63.7650  179.7886   50.7528  133.5710

User 1 arrives into the system at time 116.7271
User 1 leaves the system at time 146.3516
User 2 arrives into the system at time 180.4921
User 2 leaves the system at time 220.1903
User 3 arrives into the system at time 360.2807
User 3 leaves the system at time 402.0641
User 4 arrives into the system at time 411.0335
User 4 leaves the system at time 441.7114
User 5 arrives into the system at time 544.6045
User 5 leaves the system at time 574.1824
fx >>
```

Figure 9: WIFI Process

In above results MIMO using Spatial multiplexing calculated in Signal to Noise ratio using channel capacity.

In above figure consists of MIMO using (WIFI) LTE. In arrival of a new user and user system are used to evaluate the long-time evaluation.

In above figure construct the nodes in x and y coordinates. In above nodes are simulated in x and y coordinates.

In above figure is WIFI process using LTE parameters. They are time and power.

6. CONCLUSION

In MIMO gains can only be realized on a fully optimized network. MIMO optimization requires a different approach to optimization, with assessment of multipath conditions playing a key role for determining the potential throughput provided by MIMO-enabled LTE network. Optimizing an LTE network for MIMO requires a new set of scanning receiver parameters and including multipath CINR measurements, CN, and CQI for all key MIMO modes. In WIFI process is optimized in the power and area. WIFI Operators can use the knowledge gained from analysing receiver MIMO data to improve conditions in the current network through antenna and eNodeB. Receiver data can also be used to evaluate the performance of UEs and eNodeB MIMO mode selection. In this work accurate data multipath conditions in existing LTE networks can be lead better planning of future MIMO-capable networks. This will become increasingly valuable as more users depend on LTE to provide the data rates. They are need for wireless applications for video streaming. Operators that maximize the performance of MIMO in their LTE networks able to provide the best service to these users with the smallest amount of infrastructure investment is advantage in both price and quality of service.

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