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Comparison in GSM& SM based ABEP analysis in Large-Scale MIMO Systems

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***Abstract**: Generalized spatial modulation (GSM) is a special case of MIMO system. The GSM system has more number of transmitting antennas where as less number of transmitting radio frequency chains. Spatial modulation (SM) is a special case of GSM where we use single number of transmitting radio frequency chain. In this paper, we have investigated GSM for large-scale multiuser MIMO communications on the uplink. Our contribution in this paper include an average bit error probability analysis for maximum-likelihood detection in multiuser GSM-MIMO on the uplink, where we derive an upper bound on the ABEP, In simulation Such as comparison of SNR gains in GSM-MIMO, SM-MIMO and conventional MIMO. In this paper we have analyzed the average bit error probability of multiuser GSM-MIMO under maximum-likelihood detection and found that the performance of Multiuser GSM-MIMO is superior than multiuser SM-MIMO and conventional multiuser MIMO systems. Effectiveness of proposed strategy has been verified through simulation study on the basis of throughput, signal to noise ratio and bit error rate.*

***Keywords**: Large-scale MIMO systems, generalized spatial modulation, GSM-MIMO receive.*

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I. Introduction

Multiple-input multiple-output technology is efficient in terms of reliability and capacity of the wireless systems. In massive MIMO, large numbers of antennas are used, that means various antennas are used in parallel in devices [1]. These systems are based on the parameters that are energy efficient, secure, robust and optimum use of spectrum [1]. If the number of antennas is more ,then the degree of freedom of channel will increase thereby improving the performance [2].MIMO technology is considered as a potential technology for future fifth generation (5G)wireless systems [13].Spatial Modulation (SM)is attractive for multi-antenna wireless communications [3]. SM-MIMO is completely different from conventional systems because in SM-MIMO based systems there will be multi transmit antennas but only one transmit RF chain. Due to the size, complexity and cost also gets reduced. If the Energy Efficient, if the power consumption is in a certain threshold then the Energy Efficient will improve, because this parameter is needed to be reviewed as in MIMO systems, the density of the Base Stations (BS) are increased [4]. Large number of terminals can always be combining very large MIMO technology with conventional time (TDM) and frequency division multiplexing (OFDM) [2].

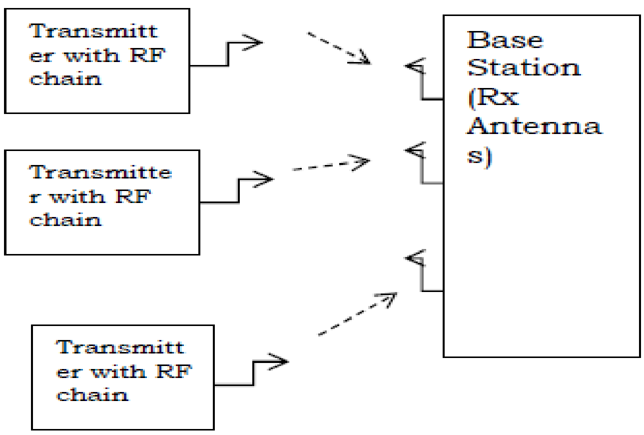

Fig 1: Massive MIMO System

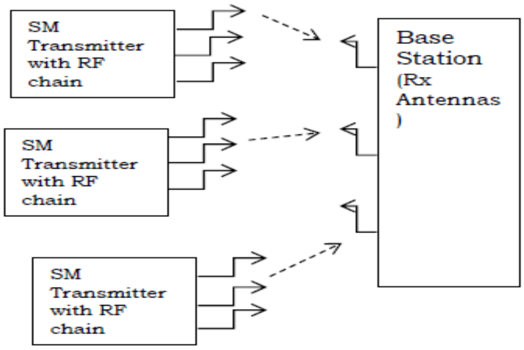

Fig 2: SM MIMO System

II. Multiuser GSM-Mimo System Model

Consider a multiuser system with transmitter, wireless channel and receiver having K uplink users communicating with a Base Station having N receiving antennas. The ratio K/N is the system loading factor. Users employ GSM for their transmission. Each user has n_t transmit antennas and n_{rf} , $1 \leq n_{rf} \leq n_t$, transmit RF chains. An $n_{rf} \times n_t$ switch connects the RF chains to the transmit antennas. In a given channel use, each user select sn_{rf} of its nt transmit antennas, and transmits n_{rf} symbols from a modulation alphabet A on the selected antennas. The remaining $n_t - n_{rf}$ antennas remain silent Fig. 3. The selection of n_{rf} active antennas is made based on information bits.

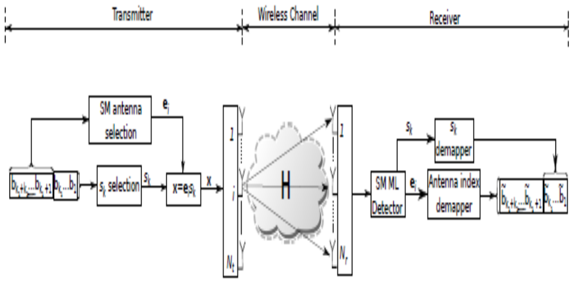

Fig 3: System model of SM Spatial Modulation

Define an antenna activation pattern to be an $n_t \times 1$ vector consisting of 1's and 0's, where a 1 in a coordinate indicates that the antenna corresponding to that coordinate is active and a 0 indicates that the corresponding antenna is silent. Note that many activation patterns possible. For example, for $n_t = 4$ and $n_{rf} = 2$, the following six activation patterns are possible: $[1\ 1\ 0\ 0]^T$, $[0\ 0\ 1\ 1]^T$, $[1\ 0\ 1\ 0]^T$, $[0\ 1\ 0\ 1]^T$, $[1\ 0\ 0\ 1]^T$, $[0\ 1\ 1\ 0]^T$.

Let $H \in C^{N\times Knt}$ denote the channel gain matrix, where $H_{i,(k-1)nt+j}$ denotes the complex channel gain from the j_{th} transmit antenna of the k_{th} user to the i_{th} BS receive antenna. The channel gains are assumed to be independent Gaussian with zero mean and variance σ_n^2 , such that $\sum_{n=1}^{K_{nt}} \sigma_n^2 = Kn_t$. The σ_n^2 model the imbalance in the received power from the K_{th} antenna, K€{1,………..,Kn_t), due to path loss etc. and σ_n^2 =1 corresponds to the case of perfect power control. Assuming perfect synchronization, the received signal at the i_{th} BS antenna is given by

$$y_i = \sum_{k=1}^{K} h_{i,}\{k\} x_k + n_i \qquad (2)$$

where $h_{i,[k]}$ is a $1 \times n_t$ vector obtained from the i_{th} row of Hand $(k - 1)n_t + 1$ to k_{nt} columns of H, and n_i is the noise modeled as a complex Gaussian random variable with zeromean and variance σ^2. The received signal at the BS antenna scan be written in vector form as

$$y = Hx + n \qquad (3)$$

Where $y = \{y_1, y_2, \ldots\ldots\ldots, y_n\}$ and $n = \{n_1, n_2 \ldots\ldots\ldots, n_n\}^T$. for this system model, the ML detection rule is given by

$$\hat{x} = \arg\min \|y - Hx\|^2$$

Where $\|y - Hx\|^2$ is the ML cost. The maximum posteriori probability (MAP) decision rule is given by

$$\hat{x} = \arg\max\ pr(x \| y, H) \quad (5)$$

III. Simulation Result

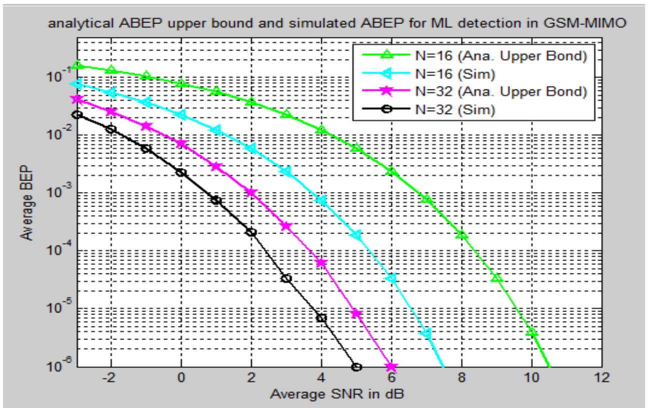

Fig.4. Comparison between analytical ABEP upper bound and simulated ABEP for ML detection in GSM-MIMO with N=16, 32, K=4, n_t=4, n_{rf}=2, BPSK, and bpcu per user analysis and simulation.

In above figure 4, we compare the analytical ABEP upper bound and the simulated ABEP of multiuser GSM-MIMO with ML detection for the following system parameter settings: N = 16, 32, K = 4, n_t = 4, n_{rf}= 2, BPSK, and 4 bpcu per user. It can be observed that the upper bound is tight at moderate to high SNRs. It is also observed that, as expected, both analysis and simulation predict that the ABEP performance improves as the number of BS antennas N is increased.

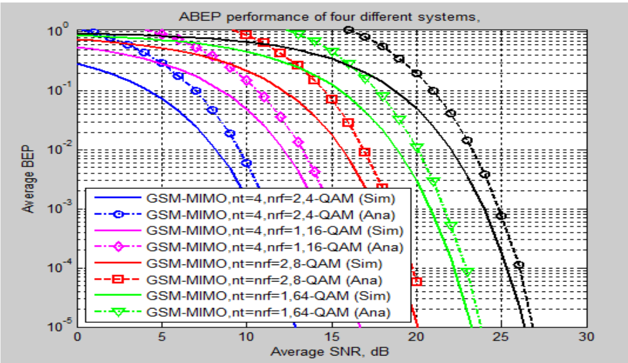

Fig.5. Comparison between the ABEP performance of four different system, all with N=8, K=2, and 6 bpcu per user: (i) conventional multiuser MIMO, n_t =1, n_{rf} =1, 64-QAM; (ii) conventional multiuser MIMO, n_t =2, n_{rf} =2, 8-QAM; (iii) multiuser SM-MIMO, n_t =4, n_{rf} =1, 16-QAM; and (iv) multiuser GSM-MIMO, n_t =4, n_{rf} =2, 4-QAM. Analysis and simulation.

In the above figure 5, we compare the ABEP performance of the following four different systems with N = 8 and K = 2: System 1—conventional multiuser MIMO with n_t = n_{rf} = 1, 16-QAM; System 2—conventional multiuser MIMO with n_t = n_{rf} = 2,8-QAM; System 3—multiuser SM-MIMO with n_t = 4, n_{rf} = 1, 16-QAM; and System 4—multiuser GSM-MIMO with n_t = 4, n_{rf} = 2, 4-QAM.

all the four systems achieve the same spectral efficiency of 6 bpcu per user. The first two systems are conventional multiuser MIMO systems where n_t = n_{rf} . System 1 uses one transmit antenna and one transmit RF chain at each user and achieves 6 bpcu per user by using 64-QAM. On the other hand, System 2 uses two transmit antennas and two transmit RF chains at each user and achieves 6 bpcu per user by using 8-QAM. System 3 is multiuser SMMIMO systems where each user uses four transmit antennas but only one transmits RF chain. Each user in this system uses 16-QAM to achieve 6 bpcu per user; 4 bits through 16-QAMmand 2 bits through indexing. System 4 is a GSM-MIMO system where each user uses four transmit antennas and two transmitter chains. This system uses 4-QAM on two streams to achieve.

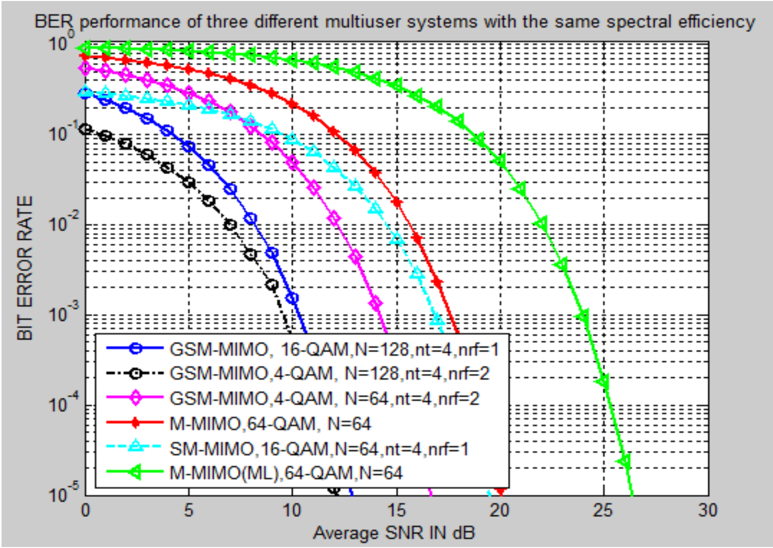

Fig.6. BER performance of three different multiuser system with the same spectral efficiency of 6 bpcu per user, K=16, N=64,128; i) M-MIMO with n_t=1, n_{rf}=1, 64-QAM, sphere decoding; ii) SM-MIMO with n_t=4, n_{rf}=1, 16-QAM, MP-GSM detection; iii) GSM-MIMO with n_t=4,n_{rf}=2, 4-QAM MP-GSM detection.

In above figure 6 present the performance of MP-GSM detection algorithm in a large-scale multiuser GSM-MIMO system with the following system parameters: K = 16, N = 64, 128, n_t = 4, n_{rf} = 2, and 4-QAM. Note that the spectral efficiency in this system is 6 bpcu per user. We compare the performance of this system with two other systems which also have the same spectral efficiency of 6 bpcu per user. These systems are: 1) conventional multiuser MIMO system with n_t = n_{rf} = 1, 64-QAM, and ML detection using sphere decoding (note that this is massive MIMO system; we abbreviate it as M-MIMO in the figures), and 2) multiuser SM-MIMO system with n_t = 4, n_{rf} = 1, 16-QAM, and MP-GSM detection. From Fig. 6, we observe that GSM-MIMO outperforms both SM-MIMO as well as conventional MIMO.

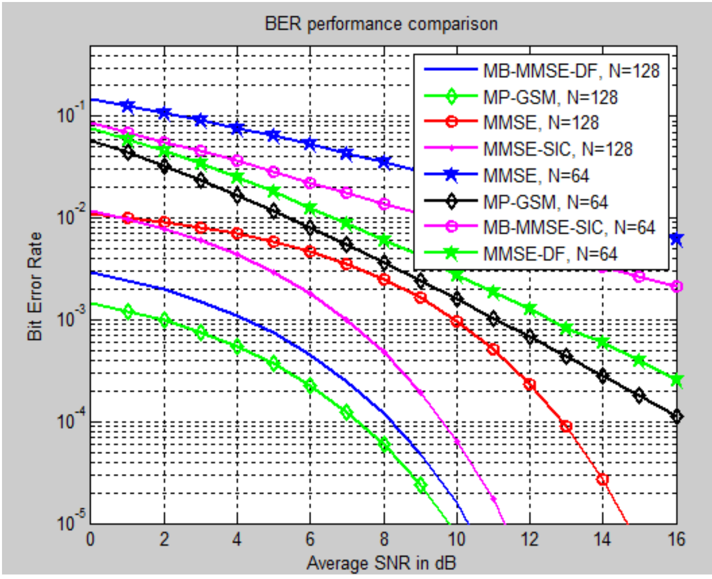

Fig.7.BER performance comparison between i) MP-GSM detector, ii) MMSE detector, iii) MMSE-SIC detector, and iv) MB-MMSE-DF detector in multiuser GSM-MIMO with K=16, N=64,128, n_t=4, n_{rf} =2, 4-QAM, and 6 bpcu per user.

In above Fig. 7, we compare the performance of MP-GSM detection with that of MMSE detection in multiuser GSM-MIMO with K = 16, N = 64, 128, nt = 4, nrf = 2, 4-QAM, and 6 bpcu per user.

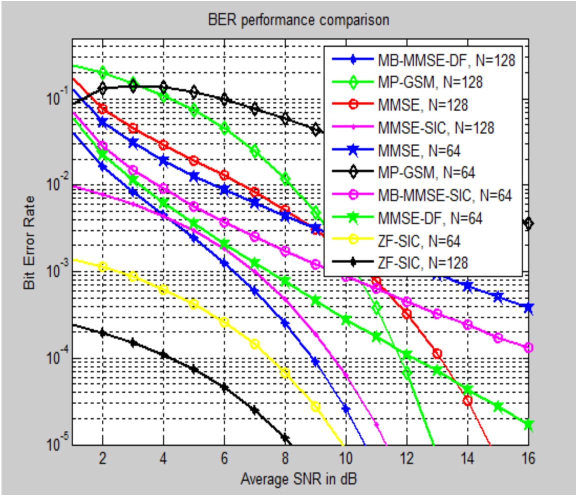

Fig.8. BER performance comparison between i) MP-GSM detector, ii) MMSE detector, iii) MMSE-SIC detector, iv) MB-MMSE-DF detector, v) ZF-SIC Detector in multiuser GSM-MIMO with K=16, N=64,128, n_t=4, n_{rf} =2, 4-QAM, and 6 bpcu per user.

IV. Conclusion

We first analyze the average bit error probability (ABEP) of multiuser GSM-MIMO under maximum-likelihood (ML) detection. We derive an upper bound on the ABEP, which is tight at moderate to high signal-to-noise ratios (SNR)

We investigated generalized spatial modulation (GSM) for multiuser communication on the uplink in large-scale MIMO systems. We derived an analytical upper bound on the average bit error probability in multiuser GSM-MIMO systems with ML detection. The bound was shown to be tight at moderate to- high SNRs. Numerical results showed that, for the same spectral efficiency, multiuser GSM-MIMO can outperform conventional multiuser MIMO by several dBs. We also proposed low-complexity algorithms for multiuser GSM-MIMO signal detection and channel estimation at the BS receiver based on message passing. The performance of these proposed algorithms in large-scale GSM-MIMO systems with tens of users and hundreds of BS antennas showed that multiuser GSMMIMO can outperform conventional multiuser MIMO. The SNR advantage of GSM-MIMO over conventional MIMO is attributed to the following reasons because of the spatial index bits, to achieve the same spectral efficiency, GSMMIMO can use a lower-order QAM alphabet compared to that in conventional MIMO.

V. Future Work

We further note that the SM concept has recently been validated with the aid of experimental activities in indoors and outdoors [7], [8]. These practical advancements in SM and the performance advantage in GSM-MIMO suggest that large-scale multiuser GSM-MIMO is an attractive technology for future wireless systems like 5G.

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