ISSN(Online): 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijircce.com

Vol. 5, Issue 12, December 2017

Review on Bit Error Rate Analysis in Multicast Multiple Input Multiple Output Systems

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ABSTRACT: In this paper we analyse the bit error rate (BER) for multicast multiple input multiple output (MIMO) systems using spatial modulation (SM), in Rayleigh fading channels. The BER is derived by calculating BER of worst receiver of each channel realization set and averaging over all possible sets. First we considering uncorrelated channel by providing tight BER upper bound and make full use of its diversity in system statistics. We perform asymptotic analysis and show that BER of multicast system can be analysed by analysing simple point-to-point SM-MIMO system with Weibull fading channels. From this we analyse impact of receiver number on BER. Now we considering correlated channels in which all receiver shares same correlation statics and analysis through framework same as uncorrelated case. We derived tight upper bound and effect of correlations is analysed.

KEYWORDS: Bit error rate; Multiple input multiple output; Rayleigh fading channel; Spatial modulation; Multicast.

I. INTRODUCTION

At the present whole information and communication technology industry contributes 2% to the global carbon emission. With the aim of reducing the carbon footprint and the operating cost of wireless networks, overall energy reduction is required in the region of two to three orders of magnitude. Meanwhile, significant increase of the network spectrum efficiency from now around 1.5 bit/s/Hz to at least 10 bit/s/Hz is needed to cope with the exponentially increasing traffic loads [8]. Due to those factors spatial modulation (SM) has recently established itself as promising transmission concept which belongs to single-RF large-scale MIMO wireless system family while exploiting multiple antenna in novel fashion compared to state-of-the-art high complexity and power-hungry classic MIMO. SM-MIMO takes advantage of whole antenna array at the transmitter, while using limited number of RF chains.

SM is unique single stream, multiple input multiple output(MIMO) transmission technique. In addition to signal modulation, in SM, antenna positions are used to carry information bits. As unique three-dimensional modulation scheme, SM enables trade-off between size of spatial constellation diagram and size of signal constellation diagram for certain spectrum efficiency. SM activates single transmit antenna and conveys single data stream at any time instance, unlike conventional MIMO schemes. SM need one radio frequency (RF) chain only. Due to this characteristic SM-type MIMO system can offer high energy efficiency (EE) than conventional MIMO techniques. Due to limited activated antennas, SM-type MIMO completely avoids inter-channel interference (ICI) [6]. This depict, SM-type MIMO system advantageous over conventional MIMO techniques.

The multicast system applications in which a single transmitter sends the common information to multiple receivers, have emerged in many wireless communication systems. By exploiting the broadcast nature of radio communications, the multicast transmission provides significant spectral efficiency improvements for group reception. This motivates extensive investigations on the theoretical limits and enhancing techniques for multicast systems using the conventional MIMO transmission. Recently, energy-efficient designs aiming to maximize the energy efficiency have

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drawn much attentions due to the increasing interests in green communications and low power transmissions. We consider SM-type MIMO a promising candidate for enhancing the multicast systems, as it targets to give a low complexity and high energy efficiency alternative to the conventional MIMO. Although the SM-type MIMO and its BER performance have already been investigated in different environments and fading channels [3] [7], the BER performance of SM-type MIMO has not been studied for multicast systems. The BER performance of the SM-type multicast MIMO system is defined by obtaining the worst BER among all receivers of each set of channel realizations and averaging over all possible sets of channel realizations. This definition shows the system BER much different from the BER acquired by simply averaging over the BER of all receivers. This work focuses on investigation of the BER performance for SM-type MIMO in multicast systems with Rayleigh fading channels and aims to establish the fundamental properties which potentially benefit future works in designs and implementations.

II. RELATED WORK

Although SM-MIMO has received widespread attention from research community only in last four or five years, it is 13-year old technology. During years 2001-2008 various researchers independently developed transmission concepts closely related to SM-MIMO scheme. The space modulation principle appeared for the first time in 2001. The scheme is called SSK modulation and it exploits differences in the signals received from different TAs to discriminate transmitted information messages. The information bits are encoded by keeping one TA active all the time while activating second TA only for one of the two possible information bits. A year later in 2002, Haas et al. proposed multiantenna modulation scheme, where number of bits that is equal to that of TA elements is multiplexed in an orthogonal fashion. A special property of encoding scheme is that only one out of available TAs is active in every channel use. Two years later in 2004, Song et al. proposed modulation scheme termed as channel hopping technique. It send two information stream, first is explicitly transmitted by using conventional PSK/QAM and second is implicitly transmitted by activating single TA of available antenna array [8].

In 2005, Mesleh et al. proposed same modulation scheme. The main aim behind is to develop an ICI-free multiantenna modulation scheme which is realised by activating one TA in every channel use and by encoding some information bits using TA switching process. Proposed scheme significantly relaxes signal processing complexity at the receiver. In 2006, Mesleh et al. further investigated proposed scheme and they used for first time terminology of spatial modulation to identify encoding mechanism. Since then research related to SM has been conducted extensively. A joint maximum likelihood (ML) detection method was proposed where the transmit antenna index and the transmitted symbol are estimated together providing an optimal detector for SM. Endeavour's were made to combine SM with space-time block coding (STBC). MIMO-orthogonal frequency division multiplexing (OFDM) is one of the most sought-after research directions. When SM confronts an OFDM system the main challenge lies on the conflict between the constraint of a single RF chain in SM and the requirement of different streams for OFDM subcarriers. Furthermore, theoretical work has been done to analyse the performance for SM in terms of bit error probability [7]. Results show that SM offers a better performance than many SOTA MIMO techniques, while achieving a low-complexity implementation.

Some variants of SM concepts have also been studied. Removing the signal modulation part from SM, space shift keying (SSK) transfers the information bits solely by antenna indices. Instead of activating a single transmit antenna, generalised spatial modulation (GSM) activates a certain number of antennas at any time instance and exploits the combinations of the active antennas to build the spatial constellation diagram. Compared with the original SM, GSM can effectively increase the spectrum efficiency when using the same number of transmit antennas [5]. Receive-spatial modulation (RSM) uses the beamforming technique in order to carry information bits through the index of the antenna receiving signals.

In 2009, J. Jeganathan, A. Ghrayeb, L. Szczecinski, and A. Ceron introduced space shift keying modulation for MIMO channels based on spatial modulation (SM) [4]. In SSK, antenna index used during transmission passes information rather than transmitted symbols. The absence of symbol information eliminates elements necessary for APM transmission and detection. Simplicity involved in modulation and reduces detection complexity compared to SM.

In 2012, A. Stavridis, S. Sinanovic, M. Di Renzo, H. Haas, and P. Grant check energy efficiency of multiantenna base station (BS) employing spatial modulation(SM) [1]. Taking advantage of single radio frequency

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(RF) chain configuration of SM they show that SM offer significant total power reduction compared to other multi-RF chain MIMO. For number of transmit antenna larger than two, SM result in higher ergodic capacity than Space-Time Block-Coding (STBC) combined with significant power saving. In 2012, Y. Chang, S. J. Lin, and W. H. Chung proposed energy-efficient communication using class of spatial modulation (SM) [10]. Energy efficient modulation design is formulated and minimum achievable average symbol power consumption is derived with rate, performance and hardware constraints. Theoretical best is achieved by energy efficient HSSK (EE-HSSK) that incorporate use of Hamming and Huffman code techniques in alphabet and bit-mapping design. EE-HSSK performs better than existing schemes in achieving near-optimal energy efficiency.

In 2012, N. Serafimovski, S. Sinanovi´c, M. Di Renzo, and H. Haas study the behaviour of spatial modulation (SM) in multiple access scenario [9]. By activating single transmit antenna for any transmission SM avoids ICI, requires no synchronization between transmit antenna and single radio frequency chain at transmitter. The ML detector is proposed which can decode incoming data from multiple simultaneous transmission. Simulation result show that interference aware detectors performs better than complexity equivalent multi-user ML-SIMO detectors.

In 2013, A. Younis, W. Thompson, M. Di Renzo used first time real world channel measurement to analyse performance of spatial modulation [2]. In this full analysis of average bit-error performance of SM using measured urban correlated and uncorrelated Rayleigh fading channel is provided. ABER performance result using simulated Rayleigh fading channel are provided and compared with derived analytical bound for ABER of SM and ABER results for SM using measured urban channels. ABER results using measured urban channels validate derived analytical bound and ABER results using simulated channels. ABER of SM is compared with performance of spatial multiplexing (SMX) using measured urban channels for small and large scale MIMO. It is shown that SM offers nearly same or slightly better performance than SMX for small scale MIMO. SM offers large reduction in BER for large scale MIMO.

III. PROPOSED METHODOLOGY

A. *Multicast SM-type MIMO system:*

In this project we consider the multicast MIMO system consisting of a transmitter and K independent receivers. Then transmitter is equipped with N_t transmit antennas and each receiver is equipped with N_r receive antennas. The SM-type MIMO is employed to convey information in the multicast MIMO system. As shown in Fig. 1. information bits are processed by the spatial modulator for conversion to the SM type signals which are transmitted in the next stage. Same SM-type signal is transmitted to all receivers.

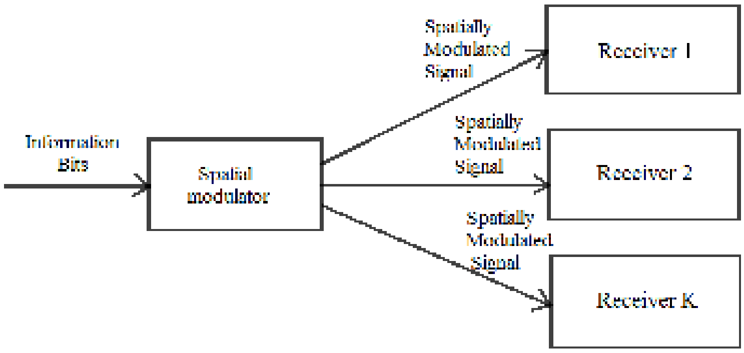

Fig. 1. Block Diagram of Multicast SM-type MIMO System

B. *BER analysis for multicast SM-type MIMO systems with uncorrelated Rayleigh fading channels:*

In this, we propose a BER upper bound for the multicast SM-type MIMO system in uncorrelated Rayleigh fading channels. We elaborate the diversity of system by using the upper bound.

C. *Asymptotic BER analysis for multicast SM-type MIMO systems with uncorrelated Rayleigh fading channels:*

The complicated expression of BER upper bound for multicast SM-type MIMO systems prevents us from obtaining deep interpretations of the performance trend with respect to critical parameters such as the number of receivers K. Therefore, we consider the asymptotic analysis to obtain the simpler expression and acquire more insights

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for the BER performance. Specifically, the BER is analyzed as K tends to infinity and the asymptotic BER can be considered as a good approximation for the multicast MIMO system with a large number of receivers.

D. *BER analysis for multicast SM-type MIMO systems with correlated Rayleigh fading channels:*

In this, we extend our analyses to multicast SM-type MIMO systems with correlated Rayleigh fading channels under the condition: the statistics of the transmit correlation for different receivers and the statistics of the receive correlation for different receivers are identical.

IV. CONCLUSIONS

We study fundamental properties of multicast SM-type MIMO system in Rayleigh fading channels and show that SM-type MIMO is advantageous over conventional MIMO systems. We propose tight BER upper bound and diversity of multicast SM-type MIMO system. To understand BER performance asymptotic analysis is performed.

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