

# Transmit Antenna Selection in Fading Mobile Telecommunication Systems

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**Abstract**—The use of multiple transmitting and receiving antennas in mobile wireless communication systems plays a great role in improving system performance. But an increase in the number of antennas used results in an increase in the system complexity. In this proposal the performance of a mobile wireless communication system with transmit antenna selection is studied. Antenna selection is applied so as to reduce the system complexity but still achieving the required goal of improved system performance. Maximum-ratio combining (MRC) is used at the receiver end. In this, a single transmit antenna which maximizes the signal-to-noise ratio (SNR) at the receiver is selected. The number of receiving antennas will be restricted to two due to the size and power limitations of hand-held mobile devices. Since much research has been done on system performance under Rayleigh fading channel, this study will be focusing on Weibull fading channel. Space-time block (STB) codes will be used due to their simplicity. Performance parameters that will be studied are the bit-error-rate (BER), channel capacity and pairwise-error-probability (PEP). The performance comparison between a full complexity multiple-input multiple-output (MIMO) system and a transmit antenna selective MIMO system will then be presented.

**Index Terms**—Maximum-ratio combining, mobile wireless communication, space-time block codes, Weibull fading.

## I. INTRODUCTION

Providing multimedia and data services at improved rates has been of great interest in mobile wireless systems over the past years. References [1] – [5] agree that the major drawback in achieving reliable communication in wireless systems is fading and multipath propagation.

Diversity and coding can be introduced into the system to improve its performance as discussed in [1] – [5]. Diversity can be divided into frequency, time and antenna diversity. The main focus in [1] – [5] was to improve the system's performance through the use of antenna diversity. In antenna diversity, several antennas are used at the transmitter and/or the receiver end. Early work on multiple antennas at the transmitter was done by Guey et al., and Tarokh et al. introduced space-time codes for multiple transmit antennas. They showed that space-time codes' performance is characterised by the coding and diversity gains. Diversity

gain is based on the fact that it is most unlikely that several antennas are in a fading dip simultaneously [7]. Within the space-time codes, Tarok et al. proposed space-time trellis (STT) codes. STT codes performed extremely well but at the cost of high complexity [5]. To address the issue of complexity, Alamouti introduced a scheme that used two transmit antennas and a generalised number of receive antennas [5]. This scheme operated at a compromised performance. Tarok et al. then generalised Alamouti scheme to any number of transmitting antennas and this gave birth to space-time block codes. Another scheme called BLAST (Bell Labs Layered Space-Time Architecture) was later developed by Foschini. The performance of different space-time codes is studied in [2].

Higher diversity can be achieved if more antennas are used. At the receiver end, the received signal can be improved by combining all the signals received by the individual antennas using diversity combining techniques, namely selective combining (SC), maximum-ratio combining (MRC) and equal gain combining (EGC), where MRC is observed to outperform all the other combining techniques [4]. In mobile wireless systems the problem is that diversity is limited. This can only be up to a specific number of antennas at the subscriber station end due to power limitations and size of current hand-held devices. Thus antenna diversity is best applicable at the transmitter end where the base station can be able to accommodate several transmitting antennas [3], [5]. Another advantage of transmit diversity is its simplicity of implementation as compared to receive antenna diversity [6]. The base station also provides several services to the mobile stations thus it would be economically viable to use antenna diversity at the base station [5].

The problem with antenna diversity is that it increases the system's complexity and cost [1], [3]. An increase in the number of transmit antennas results in an increase in the number of radio frequency (RF) chains that the receiver has to decode, leading to decoder complexity. There is a general view between [1], [3] and [8] that antenna selection can be introduced into the system to help solve the complexity problem. The idea with antenna selection is to select the best antenna(s) from all the available antennas. Antenna selection is applicable at the transmitter and/or receiver end.

Antenna selection considered in [1] is applied only at the receiver end where the receive antenna (s) with the best SNR ratio is/are selected. In this correspondence the effect of antenna selection on the PEP is investigated. Reference [9] studied the effect of antenna selection in terms of the channel capacity. It was shown that only a small loss in capacity is experienced when only the receivers with the best SNR are selected from all the available receiving antennas. In [10] antenna selection for STBCs is considered at the transmitter end. Through computer simulations they were

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able to demonstrate that the system's performance is improved by increasing the number of available transmit antenna while keeping the number of selected antennas fixed. Whereas [2] investigates the performance of a wireless system with antenna selection applied at both the transmitter and the receiver ends. The receiver (s) with the best SNR is/are selected and the transmitter with the largest transmit power is selected. The system's performance is studied in terms of the BER. The focus of this study is the performance of a transmit antenna selective MIMO system as compared to the full complexity MIMO system. The rest of the paper is organized as follows. In Section II, we provide the system model for the MIMO system. Section III provides the performance analysis.

## II. SYSTEM MODEL

Consider a MIMO communication system as shown in Fig. 1. This system uses T transmitting and R receiving antennas. For the full complexity MIMO system,  $2 \leq T \leq 4$  and  $R = 2$ .

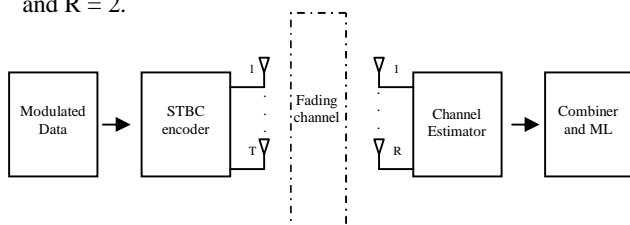


Fig. 1. System Model

For the antenna selective MIMO system, the same system configuration is considered. But only the single transmit antenna with the highest SNR will be selected from all the available transmit antennas. The overall transmit power is assumed to be evenly distributed to all the transmit antennas. The antennas at both the transmitter and receiver ends are sufficiently spaced so as to reduce any interference.

The details of modulation and demodulation can be ignored as the aim of this study is to compare the performance of a full complexity MIMO system and a transmit antenna selective MIMO system. It is worth noting that before transmission the modulated signal is encoded using space-time block codes.

## III. PERFORMANCE ANALYSIS

The signals are modulated using binary phase shift keying (BPSK) modulation. The channel is assumed to be static and channel state information (CSI) is available at the receiver. The equations for the SNR, BER, channel capacity and PEP for both system arrangements are to be derived. Using these and other system parameters the following performance table, Fig. 2. is constructed.

	Number of T	Number of R	Number of selected T	S N R	Channel Capacity	B E R	P E P
Full complexity MIMO	2	2	X				
	3	2	X				
	4	2	X				
Antenna selective MIMO	2	2	1				
	3	2	1				
	4	2	1				

Fig.2. Performance Table

Using the information in the table, graphs of SNR against BER, SNR against channel capacity and SNR against PEP can then be plotted for both systems. These graphs will be a presentation of the performance of the different system arrangements, and from these the necessary conclusions can be made.

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