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Performance of Massive MIMO Uplink System over Nakagami-*m* Fading Channel

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Abstract—This paper studies the performance of massive MIMO uplink system over Nakagami-*m* fading channel. The performance is measured in terms of spectral efficiency versus the number of base station antennas with different values of the parameter *m* using two schemes of linear detection; maximum ratio combining (MRC) and zero forcing receiver (ZF). The simulation results show that as *m* increases, the spectral efficiency increases slowly, but it increases significantly with the rise of the number of base station antennas. It should be also noted that the spectral efficiency with ZF is better than that with MRC.

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1. INTRODUCTION

In the wireless communications, the employment of multiple antennas at both the transmitter and receiver sides enables the so-called multiple-input multiple-output (MIMO) technologies to greatly improve the link reliability and increase the overall system capacity. MIMO has been used in various wireless communication standards, such as the third generation (3G), fourth generation (4G), and fifth generation (5G) wireless systems. While most current MIMO systems utilize 2–8 antennas, the recently proposed large MIMO (or massive MIMO) systems [1] aim to exploit the potentially large capacity gains that would arise in larger arrays of antennas.

Massive MIMO, also known as "Large-Scale Antenna Systems", "Very Large MIMO", "Hyper MIMO", and "Full-Dimension MIMO", is an emerging technology that scales up MIMO by an order of magnitude compared to the current state-of-the-art systems. Massive MIMO refers to a very large multiuser MIMO technology, which uses many antenna arrays that simultaneously serve many single antennas (in general, they may be equipped with multiple antennas) terminals in the same time-frequency resource.

The basic premise behind massive MIMO is to reap all the benefits of conventional MIMO, but in a much greater scale. Overall, massive MIMO is an enabler for the development of future broadband (fixed and mobile) networks, which will be energy efficient, secure, robust, and will use the spectrum efficiently. Extra antennas help by focusing energy into ever-smaller regions of space to bring huge improvements in throughput and radiated energy efficiency. Other benefits of massive MIMO include the extensive use of inexpensive low-power components, reduced latency, simplification of the media access control (MAC) layer, and robustness to intentional jamming.

As such, it is an enabling technology for the future digital society infrastructure that will connect the Internet of people and Internet of things, with clouds and other network infrastructure. Due to its great benefits and its wide applications, recent publications have discussed the massive MIMO system [2–11].

2. SYSTEM MODEL

The model of massive MIMO system considered here consists of uplink system model, channel model (Nakagami-*m* fading channel), and the linear detection schemes. These three parts are discussed in detail in the next sections.

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