



Determining the difficulties of massive mimo technology for next generation wireless systems

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Abstract

Next generation wireless communications systems are emerging as new requirements for spectral efficiency and energy efficiency. Many multiple-input multiple-output (MIMO) systems, with dozens or even hundreds of antennas, can provide significant improvements in spectral efficiency, energy efficiency and system reliability. Realistic channel models are indispensable for the design, performance evaluation and optimization of Massive MIMO wireless systems. With this technique, many improvements will be possible. However, Massive MIMO also has some difficulties such as signal processing complexity, size of antenna arrays, etc. for next generation wireless systems. For this reason, this paper is to determine coming challenges and research directions of the intended Massive MIMO system.

Keywords: MIMO; massive MIMO; next generation wireless communication systems.

1. Introduction

Wireless communication technology which is continuously evolving since development of the theory of electromagnetic waves has demonstrated a visible breakthrough recently. This breakthrough comes from 1st generation (1G) used in 1970s to 5th Generation (5G) technology which is planned to ready to use in 2020 [1]. Starting to use the 5G technology is considered as soon as possible. Because, more than 50 million devices are expected to be connected via cloud computing in 2020 [1]. In addition, achieving of data exchange with each of these devices at any time in anywhere will pave the way for making significant improvements in data transfer rate. So, 5G technology will be an important issue in this context.

One of the problems encountered in wireless technology is scarcity of electromagnetic spectrum.

2. Massive MIMO

Massive MIMO which is increasingly used in wireless communication technology in recent years is known a system that communication is performed via multiple antennas at the transmitter and the receiver sides. There is no limitation on the number of antennas. Moreover, this situation also allows to perform studies on comparisons of differences in the number of transmit and receive antennas. Various

Because, amount of transferred data increases day by day, but electromagnetic spectrum size will never increase [2]. The other issue is targeting higher data rates, which is also related spectrum usage. Because, Internet of Things technology will need higher data rates eventually. Consequently, it is necessary to access to higher data rates and to provide more efficient and good quality of service. Furthermore, studies about energy efficiency and reducing costs are also required. Thus, field of future works will be on behalf of these areas which are increasing data rates, energy and spectrum efficiency and reducing costs. Massive MIMO systems are expected to provide some solutions in these areas. Massive MIMO's advantages about these issues are indicated in [3].

works about issues such as Massive MIMO's design, analysis, and functions have focused on more. In [4], theoretical studies about network design and signal processing and coding of Massive MIMO is presented. In addition, difficulties and performance limits of this system and some algorithms for these systems have been mentioned. Another study presents to eliminate some notions caused by

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deficiencies because of high mobility and low SNR for multi-user MIMO [5]. Furthermore, the benefits of the HetNet system which is formed by combining Massive MIMO with mmWave is mentioned in [6]. A study is available which is performed with the help of various analysis to determine how the number of antennas do need for Uplink and Downlink Massive MIMO cellular network [7]. In addition, various comparative studies about Frequency Division Duplex (FDD) and Time Division Duplex (TDD) techniques for Massive MIMO systems are also

available [8]. In [9], the comparison of the general technical features of FDD and TDD techniques are available. Status of Massive MIMO overall impression in the downlink and uplink system is expressed in [2] as Figure 1 (a) and (b), respectively. Moreover, a study about number of antennas for Massive MIMO in uplink and downlink cellular systems is also available in [7]. In [5], it is specified that a system that have number of antenna is more efficient than without MIMO system.

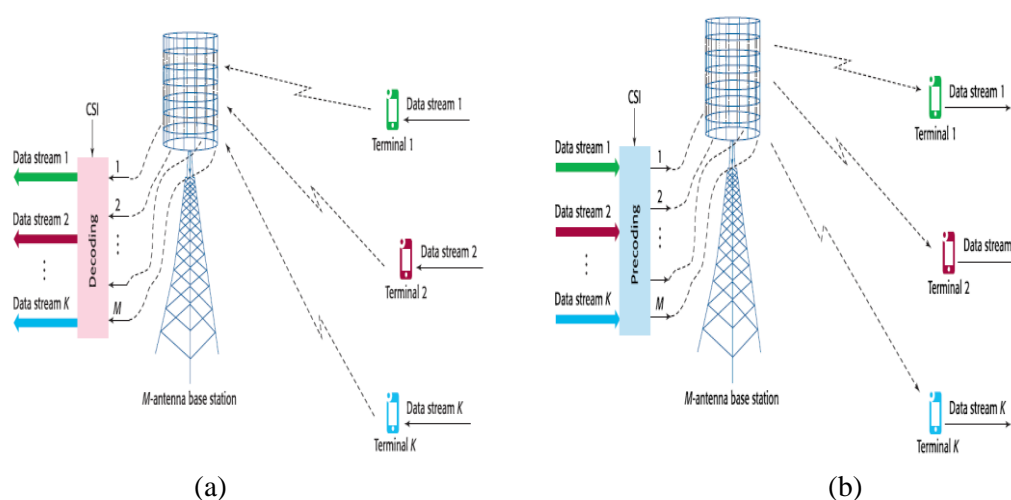


Figure 1. Operation of Massive MIMO in Downlink (a) and Uplink (b) [2].

3. Difficulties of massive MIMO

Although Massive MIMO provides some possible advantages, there are some difficulties that need to be addressed.

3.1. Reciprocal antenna coupling and spatial correlation

In theory, Massive MIMO systems are thought to provide very improvement as efficiency of capacity, spectrum and energy with thousands of BS antennas. The reason of the spatial correlation and antenna coupling is the imminence of the signal basis of the antenna elements. [10]. Researches on such antenna arrays are being investigated with various simulations and experiments so as to efficiently

perform thousands of antennas in a restricted area and to achieve the required performance. The novel antenna sequence, said parabologram, has been recommended to decrease the spatial correlation that is many times encountered with square and circular arrays [11]. In study [12], 36 sub-sector antenna sequence using mm-wave is presented, since it is feasible to mount thousands of antennas in a little region because of the short wavelength. The low reciprocal coupled antenna array consisting of bipolar antenna with four irradiation square patches is proffered [13]. Figure 2 shows how the antenna mutual coupling affects the performance of BER in Massive MIMO compared to the SNR.

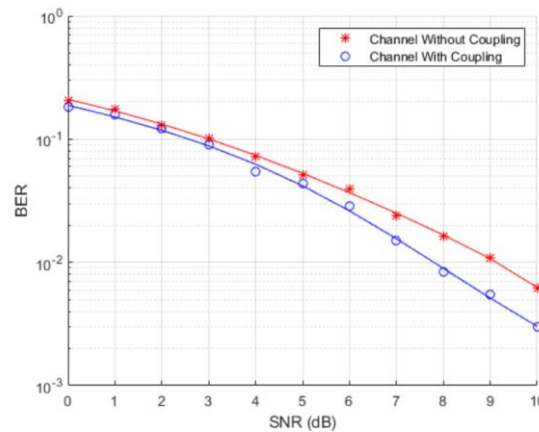


Figure 2. Massive MIMO BER performance according to channel coupling or without coupling.

3.2. Challenges of hardware impairments

The effect of hardware impairments on Massive MIMO systems is further enhanced by lower cost components as they produce lower quantization noise. [14] has indicated that hardware failures can influence to performance of system. The effect of power constraints per antenna has been examined in [15] and [16] have been emphasized, but limited to signal processing models instead of actual transceiver applications. So, the interior power consumption, comprise the cost of hardware for baseband processing must be surveyed [13]. In [28], some challanges were emphasized about Massive MIMO.

3.3. Accurate channel estimation with low complexity

To perform effective detection and precoding, the BS must obtain accurate channel state information (CSI) through channel estimation. In a conventional MU-

MIMO system, BS first sends pilots to all UEs; the UEs then estimate the channel and send the CSI back to the BS. However, such a process may not be possible for Massive MIMO because the time allocated for transmitting pilot symbols is proportional to the number of BS antennas. The time spent for channel estimation can be quite long. A time-division duplex (TDD) system that uses channel reciprocity to avoid transmitting downlink pilots is discussed in the literature in the most extreme. Besides, the majority of existing cellular systems are based on frequency division duplex (FDD) processing. Therefore, effective solutions are needed to reduce the channel estimation burden in FDD systems.

In addition, Figure 3 shows OFDM channel estimation using LS, LMMSE and lower complexity LMMSE methods [17].

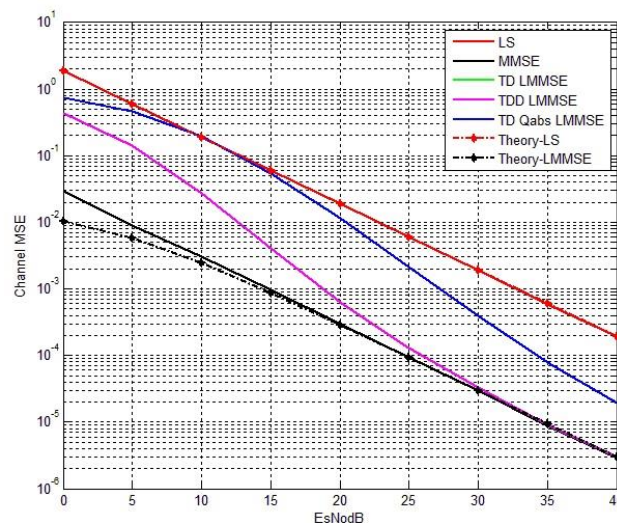


Figure 3. Channel estimation with lower complexity.

4. Why using massive MIMO in next generation wireless system such as 5G?

The most important improvements that is expected by 5th Generation (5G) technology as mentioned in the previous section are speed, energy and cost efficiency and spectral efficiency. This fact is not denied by anyone. As defined in [18], three most important technologies that will make a major contribution to 5G technology are Heterogeneous Networks, Millimeter Wave and Massive MIMO. So, Massive MIMO technologies will play an important role in 5G. Developments which support this inference that are listed below is Massive MIMO features [19]:

- Massive MIMO can increase energy efficiency at up to 100 times as well as improving the capacity 10 or more times.
- Systems which are less expensive and consume less power can be installed with Massive MIMO.
- Latency that occurs in the air can be reduced with this system.
- Massive MIMO can increase the robustness against to interferences.

4.1. Data rate for 5G

Massive MIMO will contribute to increase the data rate by enabling transmission through channels which will occur thanks to the antenna at the transmitter and receiver parts. Massive MIMO studies have begun in order to achieve the high data rate in Multi-node / Multi-antenna technology [[19]. In addition, the reason is that why Massive MIMO is being able to provide access opportunities high bit rate for 5G, it can be spatially multiplexed plurality of data streams to obtain a higher bit rate [21]. A large number of antennas at the transmitter and receiver side can provide opportunity for a desired high data rate. Because it is performed to improve the data rate through channel is formed transmit and receive antennas [22]. According to [4], it can be used maximum only 8 antenna ports in the base stations for 4G (LTE). If the number of antennas is increased, better data rate performance is provided. This information emphasizes importance of Massive MIMO on this issue. In addition, Massive MIMO system which uses a high frequency band has reached a higher bit rate [23].

4.2. Latency for 5G

Latency is an important issue for most real-time applications. Massive MIMO is an effective method in order to enable uninterrupted communication without disconnection. Because significant robustness against fading is created with combining the signals from the plurality of antennas used in

Massive MIMO [1]. Thus, the latency is also reduced through the same method.

4.3. Energy and cost efficiency for 5G

Energy and cost is one of the biggest challenges that causes a problem for developing technology. The energy of beam can be focused to a small area where the terminals in the desired location by controlling radio waves transmitted by the antennas [22]. Hundreds of lower cost amplifiers of which output power in mW level can be used with Massive MIMO instead of currently used expensive amplifiers about 50 W levels [19]. In terms of transmission power, Massive MIMO which has over 20 GHz large beam 256 transmitter antenna can keep total transmit power below of 30 dB [23]. According to this information, it is understood that a significant improvement in energy efficiency is possible. When examined in terms of Massive MIMO's feasibility, it is emphasized that equipped with lower power, lower cost a module system is potential for the realization with the semi-autonomous operation of each antenna [24]. It seems to be possible to energy efficiency up to 3 times through the system is installed with various algorithms with regards to bit / J in Massive MIMO [25]. In addition, it can also be reached a study examining large antenna arrays for Massive MIMO and offering efficient design of these arrays in terms of energy and cost [26]. PAPR is an important parameter for MIMO systems, which can affect the energy efficiency [27]. Because, PAPR is one of the disadvantages of multi-carrier systems such OFDM which is likely to be used in 5G wireless communication. In addition, OFDM is a common technique used in MIMO systems. In this regard, various algorithms must be enhanced to reduce the levels of PAPR for MIMO systems. This is also an important issue for 5G waveform.

4.4. Spectrum efficiency for 5G

The necessity of increasing the utilization efficiency of the frequency band has encouraged the construction of new studies on this subject. Massive MIMO make an important contribution to spectrum productivity due to many terminals service using the same frequency. 5G is expected to make efficient use of the spectrum with Massive MIMO. It is emphasized that Massive MIMO can significantly perform spectrum efficiency [4]. In addition, study on [19], it is stated that spectral efficiency reaches high value as 1000 b / s / Hz. Two times more improvement in the spectrum efficiency is possible with Massive MIMO system in Bits/s/Hz [25]. It is

possible to get more from spectrum by means of reusing the same frequency band by both uplink and

downlink in system which is accomplished by using Full-duplex Massive MIMO cellular system [22].

5. Conclusion and future studies on massive MIMO for next generation wireless systems

This study is about the specification of open problems to be addressed in the field of MIMO, thus emphasizing the points to be taken into account in achieving the achievements promised by MIMO technology As can be understood from the above

difficulties, various complexities need to be removed for implement Massive MIMO systems. The huge increase in traffic market for mobile data services has enabled Massive MIMO to be used in fifth generation (5G) core technologies.

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