International Journal Of Core Engineering & Management
Volume-5, Issue-7, October-2018, ISSN No: 2348-9510

MASSIVE MULTIPLE-INPUT MULTIPLE-OUTPUT (MIMO) FOR 5G WIRELESS NETWORKS: AN OVERVIEW

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Abstract

Massive multiple input multiple output (MIMO) structure employ few hundred antennas to simultaneously offer service to many wireless broadband workstations. The traffic expansion of wireless transmission networks gives rise to insufficient network capacity. Massive MIMO can improve the spectrum efficiency together with the energy efficiency and has a competent scheme for the 5G wireless transmission system. Consequently, the fundamental issues related to massive MIMO systems need to be better understood before their deployment. This paper provides a detailed overview of the massive MIMO system, highlight key network components, pros, and cons.

I. INTRODUCTION

The next generation wireless transmission system requires much higher data rate (throughput) since the universal demand for wireless data traffic is continuously rising. The high throughput of the system without additional bandwidth (BW) and base stations (BS) can be accomplished if the spectral efficiency (bit/s/Hz/cell) is enhanced. The Massive-MIMO wireless transmission system, where multi-antenna base stations spatially multiplex a multitude of user terminals over the entire bandwidth, is well-suited for this purpose. Massive-MIMO technique for 5G wireless transmission system has the potential to increase both energy efficiency and spectral efficiency [1, 2]. The upcoming wireless propagation structure has ensured to offer superior quality and coverage. Furthermore, the system is suitable for diverse scenario; provide good power and BW efficiency. However in most cases, the wireless channel undergoes attenuation due to destructive and constructive addition of multipath in the propagation media and to interference from other users.

The wireless network data traffic has doubled every 2.5 years. To cop up with the quick traffic expansion, a key purpose of the 5G technologies is to enhance the area throughput. The area throughput of a wireless system is measured in bit/s/km^2 and can be given as:

Area throughput (bit/s/km^2) = Bandwidth (Hz) x Cell density (cells/km^2) x Spectral efficiency (bit/s/Hz/cell):

The increments in area throughput in previous generations have significantly resulted from cell densification and allocation of more bandwidth. The present networks of metropolitan cities however are facing the utmost traffic demands. Auxiliary cell densification is surely feasible, but it probably sure that we are attaining a saturation point. Furthermore, the main important frequency bands are below 6 GHz due to the face that it can offer fine system coverage and quality, whereas upper bands might only suitable for short range line-of-sight environments. The vast country like Sweden, the wireless network has been owed more than 1 GHz of bandwidth (BW) in frequency range below 6 GHz and thereby cannot have any key BW enhancements either. Consequently, the spectral efficiency (SE) has not done any major enhancements in prior wireless networks [3]. Therefore, it might be issue that can be significantly enhanced in the future and perhaps become the prime way to attain high area throughput in 5G networks.

II. MULTI-USER MASSIVE MIMO SYSTEM

With the system of numerous antenna arrays, the classic signal processing schemes like maximum likelihood detection become extremely complex because of large signal dimensions. This necessitates the technique to obtain significant multiplexing gain with low complexity and low-cost signal processing. The massive MIMO structure however have multi-user MIMO (MU-MIMO) arrangements [4] in which large number of antennas are deployed into base stations (BS). Hence, massive MIMO scales up conventional MIMO by an order or two in magnitude. Massive MIMO systems or large-scale antenna systems have been proposed in [5-6], where every BS is provided with orders of magnitude more antennas. The typical massive MU-MIMO structure is shown in Fig. 1.

The channel capacity of this MIMO system with an average received signal SNR at receiving antenna can be obtained as:

$$C = \log_2[\det(IN_r + p/N_t * HH)]$$

Where I is identity matrix

H* is Hermitian (complex conjugate transpose) of H

H=Nr*Nt normalized matrix

Capacity of massive MIMO can be calculated by using Channel capacity theorem as below:

$$C = \log_2(1 + p/N_t)$$

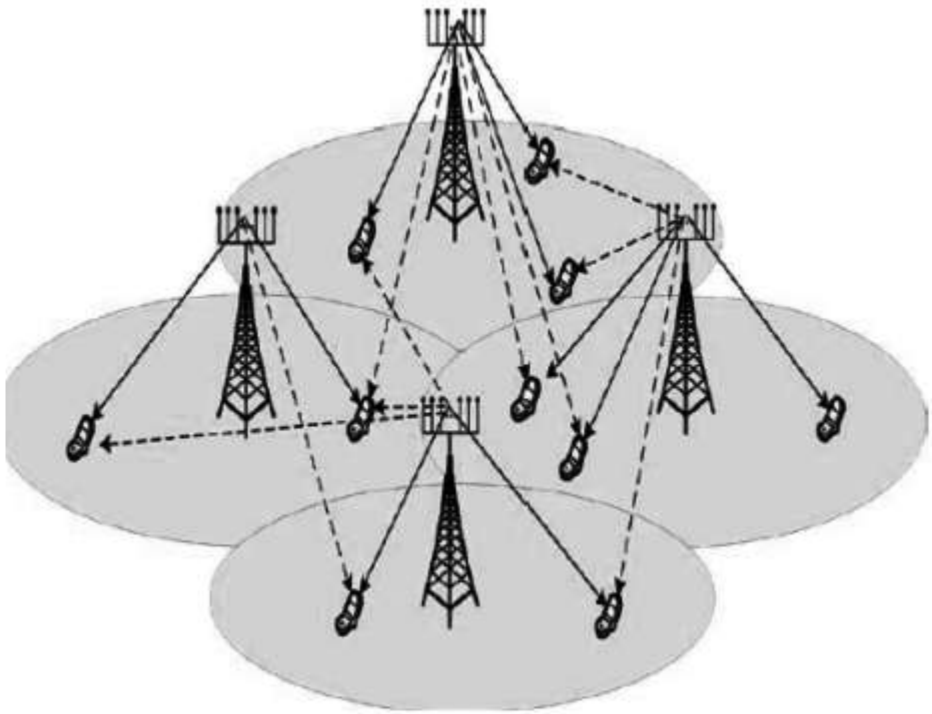

Fig. 1 Illustration of Massive MU-MIMO systems

In massive MIMO, each antenna will be surrounded in a low-cost unit with simplex processing and power efficient amplifier. Some potentials of massive MIMO technique are as follows [7]:

- Massive-MIMO can raise the system capacity 10-times or more. It improves the energy efficiency (EE) approximately 100-times. The system capacity of Massive-MIMO rise due to aggressive spatial multiplexing.
- Massive-MIMO structure is implemented with low cost, low power modules. In massive-MIMO, expensive amplifiers implemented in classic systems are replaced by hundreds of low cost amplifiers.
- Massive-MIMO is robust against both unintended interference and jamming.
- Massive-MIMO provides a major drop of latency on the air interface.
- Massive-MIMO simplifies the multiple access layers.

The above mentioned potential of massive MIMO, it can be concluded that it is the most appropriate contender in technologies for next generation of wireless transmission systems. However some of the disadvantages of massive-MIMO are:

- Pilot contamination: In the MIMO structure, the equipment is operated with narrow quantity of orthogonal pilot sequence. The constraint is determined by the period of the coherence space divided by the channel delay spread and amount of orthogonal pilot string is restricted to approximately 200 with coherence period of 1 m-sec [7]. However, the cause of the pilots reprocess from one group to other results pilot contamination. Typically, the consequence of pilot contamination is of less significant in conventional MIMO however has noteworthy in Massive MIMO.
- Sensitive to beam alignment.
- Poor broadcast channel.

III. POINT TO POINT AND MU MIMO

1) Point-to-point MIMO structure has 'BS' equipped with multiple antennas converses with single client equipment having multiple antennas.
2) Multi-user MIMO, where a BS with multiple antennas communicates with multiple user terminals, each having one or multiple antenna.
3) In point to point MIMO both the BS and user had multiple antennas but only one user could be served at one time although it was an incredible invention but there were limitations on it as it was not scalable due to the unfavorable propagation, time required for training was proportional to the system size, and the multiplexing gains were not large enough at the cell edges. The Multiuser MIMO was found to be far more superior [8] when BS was equipped with an antenna array while there were many single antenna users. The propagation was always favorable but it was also not scalable because it required DPC and decoding which was a complex technique, another problem was that CSI was required at both BS and the user end.

IV. RELATED WORK

Massive MIMO systems have gotten much consideration because of their effective ability to give higher date rates, improved connection unwavering quality for future 5G frameworks [8]. Most of the previous work on MIMO channels considers small-scale fading only. For instance, in [9, 10], the authors' have chosen Rayleigh-fading channels to investigate the asymptotic performance of MIMO systems. Similarly, in [11, 12], the focus of the authors was on Rician fading channels to derive ergodic capacity of MIMO systems. All of these works focus on the capacity of the system and do not analyze or address the outage probability under the stated channel conditions.

In [13], the authors focus on the impacts of large-scale fading on the uplink of massive MIMO systems from the perspective of ergodic capacity considering generalized-K fading channels. K-fading channels are composite fading channels in which the small-scale fading is modeled via Nakagami-m distribution and the large-scale fading via the gamma distribution [13, 14]. The approximation of lognormal shadowing by a gamma distribution helps in the performance evaluation of composite fading channels by providing closed-form expressions for the PDF of the composite channel which otherwise does not exist in a closed-form. In [15], exact lower bounds have been derived for the capacity of linear receivers in massive MIMO systems operating under composite fading environment, but these bounds do not incorporate the PDF of lognormal distribution, instead, the lognormal shadowing is averaged out by performing Monte-Carlo simulations, which limits the analysis of such systems operating under shadowing environments.

V. CONCLUSIONS

This paper broadly describes the massive-MIMO system for 5G wireless transmission. The technology provides much potential like energy efficiency, spectral efficiency, robustness, and reliability. Meanwhile, some cons of this technique are also covered in this paper. From the potential and literature, it is concluded that the massive-MIMO technology has proven to be efficient technology for next generation wireless transmission.

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