Impact of Hardware Distortion Correlation on Massive MIMO Spectral Efficiency

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Abstract

To achieve a high data rates (DR) in the fifth generation (5G), the adaptation of Massive Multiple Input Multiple Output (m-MIMO) systems with Small Cells (SCs) is required to improve the performance for Spectral Efficiency. m- MIMO provides high spectral efficiency through the deployment of a large number of antenna elements say tens to hundreds at the base station compared to a number of User Terminals (UTs) served in the same time-frequency resource with no severe inter-user-interference. The small-cell (SC) concept has emerged to obtain the lower latency, reduced energy and high achievable data rate, which are the key requirements for 5G. In this project, we develop the m-MIMO system with SCs considering the imperfect channel state information by achieving DR in the lower bound by reusing the pilot sequences in time division duplex. (TDD). The energy efficiency of cellular networks can be improved by employing massive MIMO at the BSs or overlaying current infrastructure by a layer of SCAs. We provide promising results showing that the total power consumption can be greatly reduced by
combining Massive MIMO and small cells. Most of the benefits are also achievable by low-complexity Beam-Forming, such as the proposed Multi-flow RZF beam-forming. From the theoretical analysis, the Spectral Efficiency and Optimal Energy Efficiency is achievable depending on a fixed number of users and number of antennas utilized by SCs.

Introduction: In recent years, the need for Wireless Power has increased dramatically as numbers of wireless devices and new mobile users have been on the increase. The performance is based on bandwidth (Hz) and specimen efficiency (bits/s/Hz). Either bandwidth or spectral efficiency must be improved if the throughput is to be increased. As increasing the bandwidth is an expensive element, it is necessary to take spectral efficiency into account. The transmitter and receiver can be expanded by numerous antennas. Multiple-Input Multiple-Output (MIMO) antennas improve the dependability of communications as well as communication capacity (by sending different information to various groups)
concurrently service many individual antenna user terminals at the same frequency and time. The massive MIMO system, in which BS is equiped with many antennas and supports several single antenna user terminals, is one of the designs suggested for 5G wireless communication as depicted by Fig1.1.

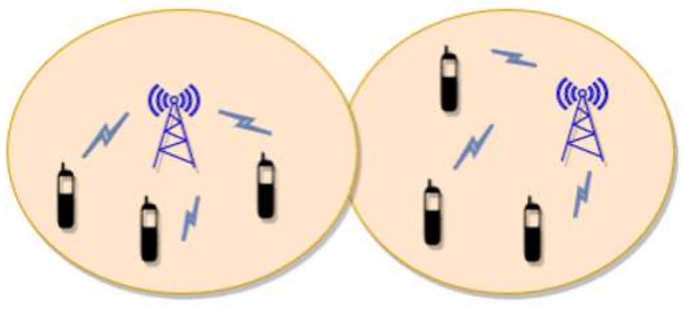


Figure 1.1: Multi-cell Massive MIMO System

Proposed Model:

Massive MIMO (m-MIMO) is an extension of MIMO technology where we are deploying large number of antenna elements say tens to hundreds at the base station compared to User Terminals (UTs) served in the same time-frequency resource with no severe Inter-User-Interference .

The adaptation of m-MIMO systems with the small cells is required to enhance the performance of data rates, channel capacity, power consumption, spectral efficiency, wireless devices connectivity with a huge amount of decrease in error rates and inference.

The base station estimates the reciprocal forward and reverse link channels with the use of Time division duplex (TDD) operation combined with reverse link pilots which achieves the perfect CSI.

With the use of a large number of antennas, gain of antenna and directivity of radiating beam (signal) increases.
For Uplink : Base Station needs to separate received signals from all the users
For Downlink : There always exists some interference among the users (MUI) as BS sends the signal on the same channel.
By having CSI at AP or BS , BS knows about MUI. Thus, MUI can be mitigated by Intelligent Beam-forming ie., Pre-coding technique. Pre-coder create beams that focus energy for each user by weighting the phase and amplitude of the antennas.
This work provide promising simulation results presenting how the spectral efficiency along with optimal energy

Fig 1.2 Transmitter

efficiency to a great extent enhanced by combining massive MIMO and small cells;
this is promising with both optimal pre-coding and low complexity beam-forming techniques.

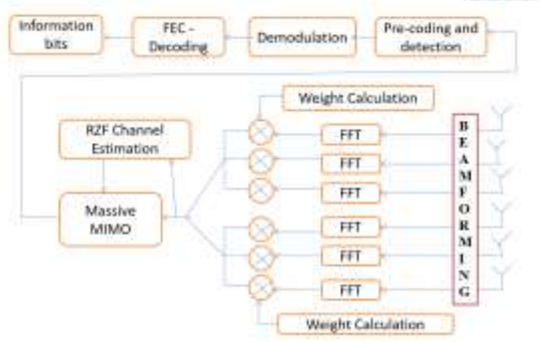


Fig 1.3 Receiver

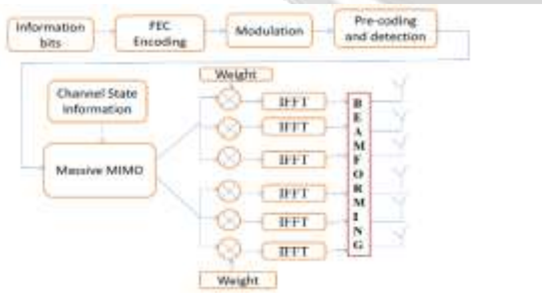
System Model:

Consider a Massive MIMO system that consists of a BS with M antennas and K users each having a single antenna system. Assume that each user's channel is slowly varying, spatially uncorrelated, and flat.

Data scheduler to optimize the spectrum efficiency of K users and a Regularized zero-forcing pre-coder to facilitate the QoS constraints.

Each time the BS schedules users, feedback is assumed to be received from all K users. Each of the K users selects Hk^[0] to quantize Hk[0] from a B-bit finite set, which is called a codebook and is known to both the BS and all the users, and feeds back the selected codeword index.

The scheduler selects M users out of K users to maximize the sum-rate by using an estimated SINR for the (K



M) possible combined channel matrices H[0].

S be the selected user set which contains power related information of User equipments and SCA base station's.

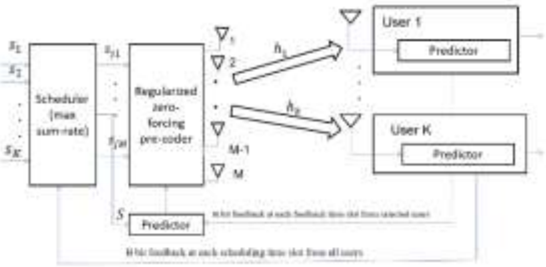


Figure : Operation of Regularized Zero forcing pre-coder with Massive MIMO system

Cont…

The transmitted signal is given by

$$x[n] = \sum_{j \in S} v_j[n]\, s_j[n]$$

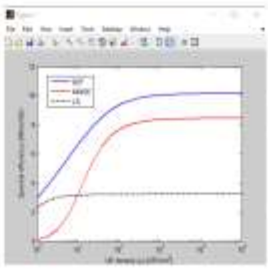
where $v_j[n]$ = linear pre-coding vector
$s_j[n]$ = data signal for the jth user

The received signal at the k th scheduled mobile user is

$$y_k[n] = h_k^H[n] \sum_{j \in S} v_j[n]\, s_j[n] + z_k[n]$$

where $z_k[n]$ = normalized additive noise
$h_k^H[n]$ = Hermition channel matrix

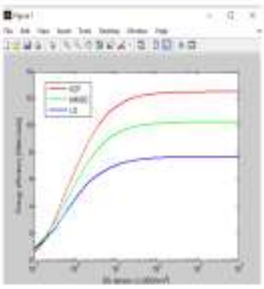
Simulation Outputs :



Spectral efficiency Vs User density

SE = data rate / channel Bandwidth

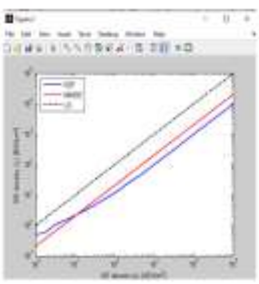
Technique	UE density in square km	Spectral Efficiency (Mbits/sec/Hz)
LS	Initially 10^1 to 10^5	2 3
MMSE	Initially 10^1 10^2 10^5	0 2 7 Approx 8
RZF	Initially 10^1 10^2 10^5	3 7 9 Approx 10



Energy Efficiency Vs BS density

EE = emitted power/total consumed power

Technique	BS density in square km	Energy Efficiency
LS	Initially 10 10000	1 6 7.5
MMSE	Initially 10 10000	1 9 10
RZF	Initially 10 10000	1 11 13



Technique	UE density in square km	BS density (BS/squarekm)
LS	Initially 10^5	1 10^5
MMSE	Initially 10^5	1 10^4
RZF	Initially 10^5	1 <10^4

Conclusion : Reuse of pilot in TDD and reciprocity are used to increase the efficiency and to achieve better channel state information. Better spectral efficiency and energy efficiency are achieved**.** RZF beam forming increases directivity and gain of antenna by suppressing noise

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