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Minimization of power consumption in massive MIMO

Syed Azhar Ulhaq* and Aashish Patidar**

**PG Student, VITM Indore, (Madhya Pradesh), India*
***Assistant professor, VITM Indore, (Madhya Pradesh), India*

(Corresponding author: Syed Azhar Ulhaq, azharulhaq_786@yahoo.co.in)
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ABSTRACT: As in today life 5Gtechnology with technology enhancement are our greatest need as this 5g technology includes C-RAN,GFDM, massive MIMO, Device to device (D2D) communication and so on,. Here we will discuss about massive MIMO technology and its use in to days life is not very general but in future there will be a requirement of it. Here we will see what massive MIMO is and out of different aspect we discuss about minimization of power consumption per subcarrier.

Keywords: massive MIMO, power consumption, antennas, base station, SCA.

I. INTRODUCTION

As the field of communication becomes very rich and and there is continous development and mutation from 1 generation to next powerful one, Technology enhancement from 1Gto 5G.
Massive MIMO allow faster data transfer and great distance communication as compared to SISO, so, Communication Systems named MIMO (Multiple –Input Multiple Output) will exploit the spatial dimension of the propagation channel, based on multiple antennas in transmission and/or reception usage.
There is almost no limit to the number of base station antennas in massive MIMO. These systems aim to exploit a large number of existing antennas relay or deployed specifically to transmit simultaneously multiple data stream in wireless communication systems.

Technology	Origin	Speed	Signal	Features	Drawbacks
1G	1980's-90's	2.4kbps,	analog	Voice call in 1 country	Poor voice quality, battery life, no security, limited capacity, poor handoff reliability
2G	Finland 1991	64kbps	digital	Sms, mms, better quality and capacity	Strong digital signal, unable to handle complex data like video
2.5G	Early2000	64-144kbps	digital	Call, web browsing,	Not specific but yes complex data handling
3G	2000's	144-2 mbps	digital	High band width, data rate, high speed net.	Security purpose, congestion control
4G	Late 2000's	100-1gbps	digital	High capacity, speed, security, low cost per bit	Security, speed, power consumption all can be improved
5G	Late 2010's	In gbps	digital	High speed, capacity, hd quality, clarity in call and video	Still need to use publically on large scale

Benefits of massive MIMO are numerous like:
The first approach: is to deploy large-scale antenna arrays at existing macro base stations (BSs). This enables precise focusing of emitted energy on the intended users, resulting in a much higher energy efficiency.

The second approach: is to deploy an overlaid layer of small-cell access points (SCAs) to offload traffic from BSs,thus exploiting the fact that most data traffic is localized and requested by low-mobility users. This approach reduces the average distance between users and transmitters, which translates into lower propagation losses and higher energy efficiency.

Here in this massive mimo as we are talking about total power consumption and it is modeled with static and dynamic part. Where dynamic part is proportional to emitted signal power and static part is depend on hardware parts. Basically we use sectorization in cell communication system but here the whole cell area is being divided into small SCA as we will see in the diagram.

Units: units that we are going to use in this paper.

mW: used to measure variance

bits/s/Hz: information rates

km or m: distance

GHz or MHz:frequency

dBm: noise,losses, power consumption

For better understanding let us take an example and understand the process of power minimization.

System model :

We consider a single-cell downlink scenario where a macro BS equipped with N_{BS} antennas should deliver information to K single-antenna users. In addition, there are S> 0 SCAs that form an overlay layer and are arbitrarily deployed. The SCAs are equipped with N_{SCA} antennas each, typically $1< N_{SCA} <4$, and characterized by strict power constraints that limit their coverage area). In comparison, the BS has generous power constraints that can support high QoS targets in a large coverage area.

The number of antennas, N_{BS}, is anything from 8 to several hundred—the latter means that $N_{BS} >K$ and is known as massive MIMO. This scenario is illustrated in Fig. 1.

In fig1.BS has NBS number of antennas. and SCA has NSCA number of antennas ,k=single antenna user can be served by any combination of transmitter (non coherent).circle indicate coverage area.

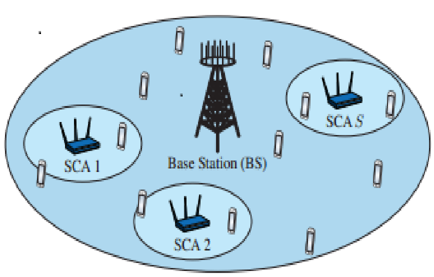


Fig. 1. Illustration of a downlink macro-cell overlaid with S small cells.

Channel to user k are modeled as block fading, the channels are represented in the baseband by $h_{k,0}^{H} \in C^{1\times N_{BS}}$ and $h_{k,j}^{H} \in C^{1\times N_{SCA}}$ for the BS and jth SCA, respectively.

The received signal at user k is

$$yk = h_{k,0}^{H}\ x_0 + \sum_{j=1}^{S} h_{k,j}^{H}\ X_j + n_k$$

where x_0; x_j are the transmitted signals at the BS and jth SCA, respectively. The term $n_k \sim$ CN $((), \sigma_k^2)$ k) is the circularly symmetric complex Gaussian receiver noise with zero-mean and variance σ_k^2 measured in milliwatt (mW).

The information symbols from the BS and the jth SCA to user k are denoted $x_{k,0}$ and $x_{k,j}$, respectively, and originate from independent Gaussian codebooks with unit power (in mW); that is, $x_{k,j} \sim$ CN (0 , 1) for j = 0 , ….. S. These symbols are multiplied with the beam forming vectors $w_{k,0} \in C^{N_{SCA}\times 1}$ and $w_{k,j} \in C^{N_{SCA}\times 1}$ to obtain the transmitted signals.

$$x_j = \sum_{k=1}^{K} w_{k,j}\ x_{k,j},\ ,\ j = 0........S.$$

There are different approaches for beam forming to direct beam in particular direction towards receiver.

In this paper our aim is to minimize the total power consumption, by maintaining quality of service. QOS constraints specify the information rate [bits/s/Hz] that each user should achieve in parallel. These are defined as $\log_2(1 + SINR_k) \geq \gamma k$, where γk is the fixed QoS target and

$$SINR_k = \frac{|h_{k,o}^{H}\ w_{k,0}|^2 + \sum_{j=1}^{S} |h_{k,j}^{H}\ w_{k,j}|^2}{\sum_{\substack{i=1 \\ i\neq k}}^{K} |h_{k,o}^{H}\ w_{j,0}|^2 + \sum_{j=1}^{S} |h_{k,j}^{H}\ w_{k,j}|^2 + \sigma_k^2}$$

is the aggregate signal-to-interference-and-noise ratio (SINR) of the kth user. The information rate $\log_2(1 + SINR_k)$ is achieved by applying successive interference cancellation on the own information symbols and treating co-user symbols as noise.

Now The power consumption (per subcarrier) can be modeled as $P_{dynamic} + P_{static}$ with the dynamic and static terms

$$P_{static} = \frac{\eta_0}{C} N_{BS} + \sum_{j=1}^{S} \frac{\eta_j}{C} N_{SCA}$$

$$P_{dynamic} = \rho_0 \sum_{k=1}^{K} \| w_{k,0} \|^2 + \sum_{j=1}^{S} \rho j + \sum_{k=1}^{K} \| w_{k,j} \|^2$$

This total power consumption static and dynamic terms both and its summation has to minimize.

Dynamic term is the aggregation of the emitted powers, $\sum_{k=1}^{K} \| w_{k,j} \|^2$ each multiplied with a constant $\rho j \geq 1$ accounting for the inefficiency of the power amplifier at this transmitter.

The static term, P_{static}, is proportional to the number of antennas and $\eta j \geq 0$ models the power dissipation in the circuits of each antenna (e.g., in filters, mixers, converters, and baseband processing). P_{static} is normalized with the total number of subcarriers $C \geq 1$.
Here we need to minimize power consumption by maintaining QOS and power constraint.

$$\min_{w_{k,j} \forall_{k,j}} imize \quad P_{dynamic} + P_{static}$$

Subject to $\log_2(1 + SINR_k) \geq \gamma k \ \forall\, k$, ….. (1)

$$\sum w_{k,j}^{H} Q_{j,l}\, w_{k,j} \leq q_{j,\ell} \quad \forall j, \ell$$

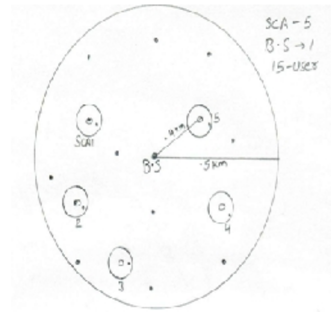
Now. for non coherent coordination we need to minimize (1). To achieve a convex reformulation of (1),we use notation $W_{k,j} = w_{k,j}\, w_{k,j}^{H} \ \forall k, j$. This matrix should be positive semi-definite, denoted as $W_{k,j} \succeq 0$, and have rank($W_{k,j}$) ≤ 1. Note that the rank can be zero, which implies that $W_{k,j} = 0$. By including the BS and SCAs inthe same sum expressions, we can rewrite (1) compactly as …..

$$\min_{W_{k,j} \succeq 0 \forall_{k,j}} imize \sum_{j=0}^{S} \rho_j \sum_{k=1}^{K} tr(W_{k,j}) + P_{static}$$

Consider the optimal solution $\{W^{*}_{k,j} \forall_{k,j}\}$. For each user k there are three possibilities:

1. It is only served by the BS (i.e.,$W^{*}_{k,j} = 0$, $1 \leq j \leq S$).
2. It is only served by the j th SCA (i.e. $W^{*}_{k,0} = 0$ and $W^{*}_{k,i} = 0$ for $i \neq j$);
3. It is served by a combination of BS and SCA's where of at least one transmitter j has an active power constraint $\ell (i.e. \sum_{k=1}^{K} tr(q_{j,\ell}\, W^{*}_{k,j}) = q_{j,\ell})$.

The BS and SCAs are fixed, while the 15 users are randomly distributed in figure:



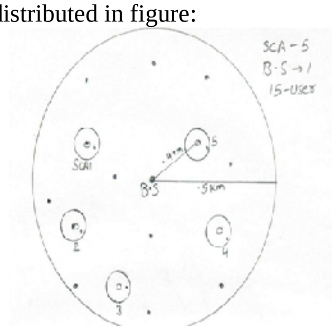


TABLE I
HARDWARE PARAMETERS IN THE NUMERICAL EVALUATION

Parameters	Values
Efficiency of power amplifiers	$\frac{1}{\rho_0} = 0.388,\ \frac{1}{\rho_j} = 0.052\ \forall j$
Circuit power per antenna	$\eta_0 = 189$ mW, $\eta_j = 5.6$ mW $\forall j$
Per-antenna constraints	$q_{0,\ell} = 66,\ q_{j,\ell} = 0.08$ mW $\forall j, \ell$

Numerical evaluation: This figure shows a circular macro cell overlaid by 5 small cells. There are 15 active users in the macro cell, whereof 10 users are uniformly distributed in the whole cell and each SCA has one user uniformly distributed within 40 meters. channel parameters are shows in Table 2.
We first analyze the impact of having different number of antennas at the BS and SCAs: NBS ∈ (10,20, 30; : : : ; 100)

Table 2

Parameters	Values
Macro Cell radius	·5 Km
Carrier freq.ⁿ / No. of SubCarrier	F= 2GHz / C=600
Total Band Width / SubC B.W	10 MHz / 15 Hz
Small Scale fading	$h_{kj} \sim CN(0, R_k)$
Standard deviation of long-normal Shadowing	7dB
Path & penetration loss at d (km)	$148.1 + 37.6 \log_{10} d$
Noise Variance σ^2	-127 dBm

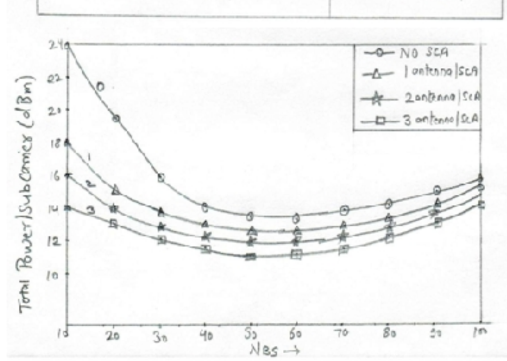


Fig. 3

Fig. 3 demonstrates that adding more hardware can substantially decrease the total power consumption $P_{dynamic}$ + P_{static}.means $P_{dynamic}$, decreases due to energy focusing and less propogation loss, it is clear P_{static} will increase from extra circuitry, massive mimo brings large energy efficiency but same power consumption can be achieved with half number of BS station by deploying few single antenna SCA with active user ,more improvement can be done by having multi antenna SCA.

In the figure 3 or the graph we saw it shows power consumption for different number of base station antennas, on using different number of antennas for each SCA as we are seeing in plotted graph on increasing number of base station antennas at around 50 the power consumption is minimum around 12dBm on the use of 3 antennas per SCA. All the calculations are based on static and dynamic power consumption formulas.

II. CONCLUSION

Now here we can conclude this paper that power minimization can be achieved by deploying different number of base antenna, and multi antenna SCA as we had already saw in above figure and plotted graph. And this using multiple numbers of antennas reduces signal distance to travel that helps in minimize propagation or path loss, and problem of hand off also remove as small SCA also takes the responsibility of transrecieving. And beam forming process also helps in case of wastage of energy in omni directional antennas. But there are different techniques of beam forming.

REFERENCES

[1]. Qualcomm. The Evolution Mobile Technologies 1G, 2G, 3G, 4G LTE.June2014.

[2]. M. E. Sahin *et al.*, “Handling CCI and ICI in OFDMA Femtocell Networks Through Frequency Scheduling,” *IEEE Trans. Consumer Electronics*, vol. **55**, no. 4, Nov.2009, pp. 1936–44.

[3]. S. Park *et al.*, “Beam Subset Selection Strategy for Interference Reduction in Two-tier Femtocell Networks,”IEEE Trans. Wireless Commun., vol. **9**, no. 11, Nov.2010, pp. 3440–49.

[4]. NOKIA,” looking ahead to 5G”.

[5]. Ejder Ba¸stu g_, Mehdi Bennis and Mérouane Debbah_,Alcatel Lucent Chair - SUPÉLEC, Gif-sur-Yvette, France Centre for Wireless Communications,University of Oulu, Finland

[6]. {ejder.bastug,merouane.debbah}@supelec.fr, bennis@ee.oulu.fi Living on the Edge: The Role of Proactive Caching in 5G Wireless Networks », 23 May 2014

[7]. Ejder Bastug, Mehdi Bennis3, Marios Kountouris2 and M_erouane Debbah1, « Cache-enabled Small Cell Networks: Modeling and Tradeoffs »

[8]. Jonathan Primeau , “Les futurs réseaux cellulaires 5G”, 1 aout 2014.

[9]. Federico Boccardi, Vodafone Robert W. Heath Jr., University of Texas at Austin Angel Lozano, Universitat Pompeu Fabra Thomas L. Marzetta, Bell Labs, Alcatel-Lucent Petar Popovski, Aalborg University « Five Disruptive Technology Directions for 5G ».

[10]. Erik G. Larsson, ISY, Linköping University, Sweden Ove Edfors, Lund University, Sweden Fredrik Tufvesson, Lund University, Sweden Thomas L. Marzetta, Bell Labs, Alcatel-Lucent, USA, « Massive Mimo For Next Generation Wireless Systems », 23 January 2014.