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PERFORMANCE ANALYSIS FOR 5G WIRELESS COMMUNICATIONS USING MASSIVE MIMO ANTENNAS

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***ABSTRACT:** After about a decade of intense research, spurred by both economic and operational considerations, and by environmental concerns, energy efficiency and data transfer has now become a key pillar in the design of communication networks. With millions more base stations and billions of connected devices, the need for energy-efficient and high speed data rate system design and operation will be even more compelling. To improve the data rate and cellular energy efficiency we analyze a combination of two densification approaches, namely Massive Multiple-Input Multiple-Output (MIMO) base stations antennas and small-cell access points. we present resource-aware energy-saving technique with a low-complexity algorithm based on classical regularized zero-forcing (RZF) beam forming is proposed and compared with the optimal solution and we analyze spectrum of 5g wireless communication by using the IDMA modulation scheme and bit error rate performance analysis, and comparison with OFDM Schemes .The main work is to reducing the energy efficiency and radiated power and analyze the performance for better data rate with high throughput and efficiency. Comparison of the data rate transmission and energy variations with various frequency levels by using the massive mimo antennas (Microtik Radio Frequency device) Furthermore, we provide promising simulation results showing how the total power consumption can be greatly improved by combining massive MIMO and small cells and BER comparison of IDMA with OFDMA*

***INDEX TERMS:** Energy efficiency, Data Rate, IDMA, OFDMA, 5G, resource allocation, dense networks, massive MIMO, small cells networks, mmWaves, RZF Beamforming, Base stations, small cell access points.*

I.INTRODUCTION

Today's mobile users want faster data speeds and more reliable service. The next generation of wireless network promises to deliver that, and much more. With 5G, users should be able to download a high-definition film in u second (a task that could take 10 minutes on 4G LTE). And wireless engineers say these networks will boost the development of other new technologies, too, such as autonomous vehicles, virtual reality, and the Internet of Things. As the number of mobile users and their demand for da 5G must handle far more traffic at much higher speeds than the base stations that make up today's cellular network To achieve this, wireless engineers are designing a suite of brand-new technologies. Together, these technologies deliver data with less than a millisecond of delay (compared to about 70 ms on today's 4G networks) and bring download speeds of 20 gigabits per second (compared to 1 Gb/s on 4G) to users. At the moment, it's not yet clear which technologies will do the most for 5G in the long run, but a few early favorites have emerged. The f runners include millimeter waves, small cells, massive MIMO, full duplex, and beamforming.

ENERGY consumption has become a primary concern in the design and operation of next generation wireless communication systems. Indeed, while for more than a century communication networks have been mainly designed with the aim of optimizing performance metrics such as the data-rate, throughput, latency, etc., The vision is to have a connected society in which sensors, cars, drones, medical and wearable devices will all use cellular networks to connect with one another, interacting with human end-users to provide a series of innovative services such as smart homes, smart cities, smart cars, telesurgery, and advanced security. Clearly, in order to serve such a massive number of terminals, future networks will have to dramatically increase the provided capacity compared to present standards. It is estimated that the traffic volume in 5G networks will reach tens of Exabyte's (10006 Bytes) per month. In order to avert the energy crunch, new approaches to wireless network design and operation are needed. The key point on which there is general consensus in the wireless academic and industry communities, is that the 1000_ capacity increase must be achieved at a similar or lower power consumption as today's networks [6], [7]

II. SYSTEM MODEL

1) 5G Technology Key Factors:

In this part we analyze the 5 Key factors named Millimeter waves, small cells, Massive MIMO, Beamforming and Full Duplex that makes a basement for 5G Wireless system

2) Network Planning and Deployment:

In order to hope with the many number of connected devices, several potentially disruptive technologies have been proposed for the planning, deployment, and operation of 5G networks. From that several technologies we use optimal soft cell coordination using Massive MIMO BS and Soft Cell Access points

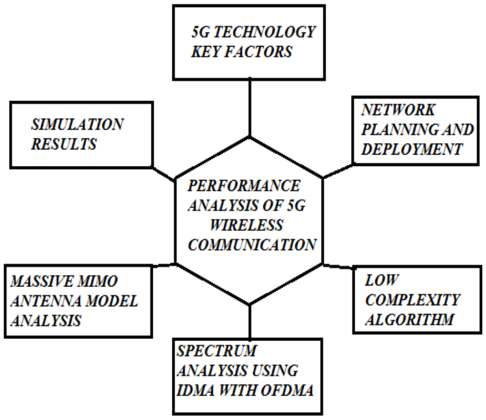


Figure: 1 Performance Analysis factors in 5G

3) Low Complexity Algorithm:

This section derives algorithms for solving the optimization problem (7). The QoS constraints in (7) are complicated functions of the beamforming vectors, making the problem non-convex in its original formulation.

4) Spectrum analysis using IDMA, OFDMA:

In this section that we analyze the available modulation schemes beginning from the present, evolving into the future. Section IV characterizes the mm wave, outlining on its objectives' and obstacles'.

5) Massive MIMO Antenna Model Analysis:

This part Examines the massive MIMO with example of Microtik SX-T Radio Frequency Antenna model with varies range of frequency level and various transmission and receiving data rates

III. SYSTEM ANALYSIS

1) 5G TECHNOLOGY KEY FACTORS:

A) Millimeter Waves:

Millimeter waves are broadcast at frequencies between 30 and 300 gigahertz, compared to the bands below 6 GHz that were used for mo devices in the past. They are called millimeter waves because they vary in length from 1 to 10 mm, compared to the radio waves that serv smartphones, which measure tens of centimeters in length. Until now, only operators of satellites and radar systems used millimeter waves for real-world applications. Now, some cellular provider begun to use them to send data between stationary points, such as two base stations. But using millimeter waves to connect mobile users nearby base station is an entirely new approach. There is one major drawback to millimeter waves, though—they can't easily travel through buildings or obstacles and they can be absorb foliage and rain. That's why 5G networks will likely augment traditional cellular towers with another new technology, called small cells.

B) Small Cells:

Small cells are portable miniature base stations that require minimal power to operate and can be placed every meters or so throughout cities. To prevent signals from being dropped, carriers could install thousands of these in a city to form a dense network that acts like a relay team, receiving signals from other base stations and send to users at any location. While traditional cell networks have also come to rely on an increasing number of base stations, achieving 5G performance will require an even greater infrastructure. Luckily, antennas on small cells can be much smaller the traditional antennas if they are transmitting tiny millimeter waves. This size difference makes it even easier to stick cells on light poles a buildings. In addition to broadcasting over millimeter waves, 5G base stations will also have many more antennas than the base stations of today's networks—to take advantage of another new technology: massive MIMO.

C) Massive MIMO:

This technology is called massive MIMO. It all starts with MIMO, which stands for multiple-input multiple-output. MIMO describes wireless systems that use two or more transmitters and receivers to send and receive more data. Massive MIMO takes this concept to a new level by featuring dozens of antennas on a single array. MIMO is already found on some 4G base stations. But so far, massive MIMO has only been tested in labs and a few field trials. In early time has set new records for spectrum efficiency, which is a measure of how many bits of data can be transmitted to a certain number of users per second. Massive MIMO looks very promising for the future of 5G. However, installing so many more antennas to handle cellular traffic also cause interference if those signals cross. That's why 5G stations must incorporate beamforming.

D) Beamforming:

Beamforming is a traffic-signaling system for cellular base stations that identifies the most efficient data-deliver to a particular user, and it reduces interference for nearby users in the process. Depending on the situation and technology, there are several ways for 5G networks to implement it. Beamforming can help massive MIMO arrays make more efficient use of the spectrum around them. The prima challenge for massive MIMO is to reduce interference while transmitting more information from many more any once. At massive MIMO base stations, signal-processing algorithms plot the best transmission route through the each user. Then they can send individual data packets in many different directions, bouncing them off buildings and other objects in a coordinated pattern. By choreographing the packets' movements and arrival time, beamforming allows many users and antennas on a m MIMO array to exchange much more information at once. Besides boosting data rates by broadcasting over millimeter waves and beefing up spectrum efficiency with massive MIMO, wireless engine are also trying to achieve the high throughput and low latency required for 5G through a technology called full duplex, which modifies the antennas deliver and receive data.

E) Full Duplex:

Today's base stations and cellphones rely on transceivers that must take turns if transmitting and receiving info over the same frequency, or operate on different frequencies if a user wishes to transmit and receive information at same time. With 5G, a transceiver will be able to transmit and receive data at the same time, on the same frequency. This technique is known as full duplex, and it could double the capacity of wireless networks at their most fundamental physical Picture two people talking at the same time but still able to understand one another—which means their converge could take half as long and their next discussion could start sooner. Some militaries already use full duplex technology that relies on bulky equipment. To achieve full duplex in personal devices, researcher design a circuit that can route incoming and outgoing signals so they don't collide while an antenna is transmitting and receiving data at time.

2) NETWORK PLANNING AND DEPLOYMENT:

In order to cope with the sheer number of connected devices, several potentially disruptive technologies have been proposed for the planning, deployment, and operation of 5G networks. From that several technologies we use optimal soft cell coordination using Massive MIMO BS and Soft Cell Access points

Optimal Soft Cell Co-Ordination Method:

We consider a single-cell downlink scenario where a macro BS equipped with NBS 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 NSCA antennas each, typically 1 ≤ NSCA, ≤ 4, and characterized by strict power constraints that limit their coverage area (see below). In comparison, the BS has generous power constraints that can support high QoS targets in a large coverage area. The number of antennas, NBS, is anything from 8 to several hundred the latter means that NBS >>K and is known as massive MIMO. This scenario is illustrated in Fig. 2.

The channels to user k are modeled as block fading. We consider a single flat-fading subcarrier where the channels are represented in the baseband by a $\mathbf{h}_{k,0}^{H} \in \mathbb{C}^{1\times N_{BS}}$ & $\mathbf{h}_{k,j}^{H} \in \mathbb{C}^{1\times N_{SCA}}$ for the BS and jth SCA, respectively. These are assumed to be perfectly known at both sides of each channel; extensions with robustness to channel uncertainty can be obtained as in [8]. The received signal at user k

$$y_k = \mathbf{h}_{k,0}^{H}\mathbf{x}_0 + \sum_{j=1}^{S} \mathbf{h}_{k,j}^{H}\mathbf{x}_j + n_k \qquad (1)$$

where x_0, x_j are the transmitted signals at the BS and jth SCA, respectively. The term is the circularly symmetric complex Gaussian receiver noise with zero-mean and variance σ_k^2, measured in mill watt (mW).

The BS and SCAs are connected to a backhaul network that enables joint spatial soft-cell resource allocation but only linear non-coherent transmissions; that is, each user can be served by multiple transmitters but the information symbols will be coded and emitted independently. We call it spatial multiflow transmission [9] and it enables users barely covered by a SCA to receive extra signals from the BS or other SCAs.

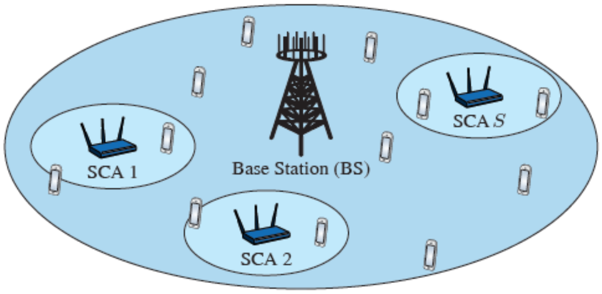


Fig. 2. Illustration of a downlink macro-cell overlaid with S small cells. (The BS has NBS antennas and the SCAs have NSCA antennas. The K single antenna users (e.g., smartphones) can be served (non-coherently) by any combination of transmitters, but the circles indicate typical coverage areas.)

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 beamforming vectors $w_{k,0} \equiv C^{Nbs*1}$ and $W_{k,j}$ $\in C^{NSCA*1}$ to obtain the transmitted signals

$$\mathbf{x}_j = \sum_{k=1}^{K} \mathbf{w}_{k,j} x_{k,j}, \quad j = 0, \dots, S. \tag{2}$$

The beamforming vectors are the optimization variables in this paper. Note that wk;j 6= 0 only for transmitters j that serve user k. This transmitter assignment is obtain automatically and optimally from the optimization problem solved herein.

3) LOW COMPLEXITY ALGORITHM FOR RESOURCE ALLOCATION:

This complexity is relatively modest, but the algorithm becomes infeasible for real-time implementation when NBS and S grow large. In addition, Theorem 1 provides a centralized algorithm that requires all channel knowledge to be gathered at the BS Theorem 1 should be seen as the ultimate benchmark when evaluating low-complexity algorithm.

1) Each transmitter $j = 0, \dots, S$ computes

$$\mathbf{u}_{k,j} = \frac{\left(\sum_{i=1}^{K} \frac{1}{\sigma_i^2} \mathbf{h}_{i,j}\mathbf{h}_{i,j}^H + \frac{K}{\bar{\gamma}_k q_j}\mathbf{I}\right)^{-1}\mathbf{h}_{k,j}}{\left\|\left(\sum_{i=1}^{K} \frac{1}{\sigma_i^2} \mathbf{h}_{i,j}\mathbf{h}_{i,j}^H + \frac{K}{\bar{\gamma}_k q_j}\mathbf{I}\right)^{-1}\mathbf{h}_{k,j}\right\|} \quad \forall k,$$

$$g_{i,k,j} = |\mathbf{h}_{i,j}^H \mathbf{u}_{k,j}|^2 \ \forall i, k, \quad Q_{j,\ell,k} = \mathbf{u}_{k,j}^H \mathbf{Q}_{j,\ell} \mathbf{u}_{k,j} \ \forall \ell, k.$$

2) The jth SCA sends the scalars $g_{i,k,j}, Q_{j,\ell,k}\, \forall k, i, \ell$ to the BS. The BS solves the convex optimization problem

$$\begin{aligned} \underset{p_{k,j} \geq 0 \ \forall k,j}{\text{minimize}} \quad & \sum_{j=0}^{S} \rho_j \sum_{k=1}^{K} p_{k,j} + P_{\text{static}} \\ \text{subject to} \quad & \sum_{k=1}^{K} Q_{j,\ell,k} p_{k,j} \leq q_{j,\ell} \quad \forall j, \ell, \\ \sum_{j=0}^{S} p_{k,j} g_{k,k,j} \left(1 + \frac{1}{\bar{\gamma}_k}\right) & - \sum_{i=1}^{K} p_{i,j} g_{k,i,j} \geq \sigma_k^2 \quad \forall k. \end{aligned} \tag{9}$$

3) The power allocation $p_{k,j}^* \ \forall k$ that solves (9) is sent to the jth SCA, which computes $\mathbf{w}_{k,j} = \sqrt{p_{k,j}^*}\mathbf{u}_{k,j} \ \forall k$.

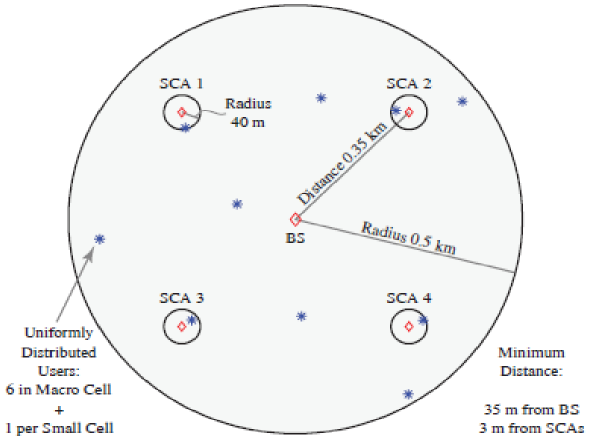


Fig. 3. The single-cell scenario analyzed in Section IV. The BS and SCAs are fixed, while the 10 users are randomly distributed as described above

This algorithm applies the heuristic RZF beamforming (see e.g., [2]) to transform (7) into the power allocation problem which has the same low complexity irrespectively of the number of antennas. The algorithm is non-iterative, but some scalar parameters are exchanged between the BS and SCAs to enable coordination. In practice, only users in the vicinity of an SCA are affected by it, thus only a few parameters are exchanged per SCA while all other parameters are set to zero.

4) SPECTRUM ANALYSIS USING IDMA, OFDMA:

Due to its good performance and low complexity, IDMA is believed to be an important technique for future radio access (FRA). However, its performances are highly affected by the interleaver design. In this paper we propose two contributions to improve the performance of the IDMA. First, we propose a new interleaver design, called "NLM interleaver", which improves the computational complexity, reduces the bandwidth consumption and the memory requirements of the system.

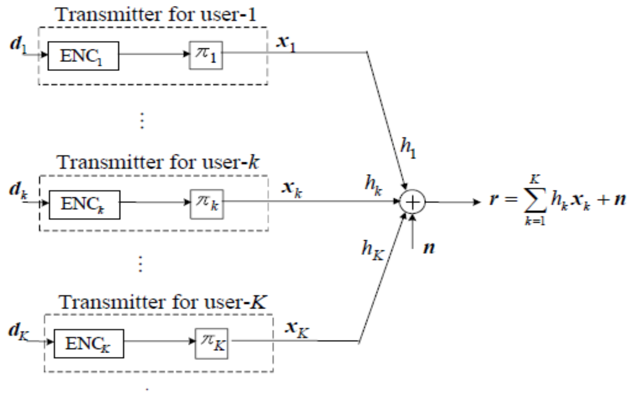


Fig 4: IDMA System Model

It also provides infinite sets and quasi-orthogonal spreading codes and interleavers based on only one parameter. Second, we propose a new user grouping algorithm based on the correlation function to improve the resources (codes and interleavers). In fact, all users are divided into several equal-size groups where each group's data are transmitted at the same time, with the same frequencies and the same interleaver. The simulation results indicate that the proposed scheme achieves better performances compared to the existing algorithms. Various multiple access techniques are proposed to satisfy 4G requirements. Among these techniques, we can find MCCDMA (Multicarrier-CDMA), OFDMA (Orthogonal FDMA), SC-FDMA (Single Carrier FDMA), and IDMA (Interleave Division Multiple Access). They deliver high data rates transmission and reliable coverage for broadband wireless access with high efficiency (6)

Benefits of IDMA:

Interleaving in IDMA does not incur rate loss, but spreading in CDMA incurs rate loss.The optimal approach is to consider two constraints jointly. A sub-optimal approach is to handle one constraint at a time using an iterative process. **Complexity:** 6 additions and 6 multiplications per chip per iteration per user. Complexity (per user) is independent of user number *K. Comparison:* To achieve good performance, the cost for MMSE -CDMA multi-user detection is $O(K2)$ due to matrix operations.

5) MASSIVE MIMO ANTENNA MODEL ANALYSIS:

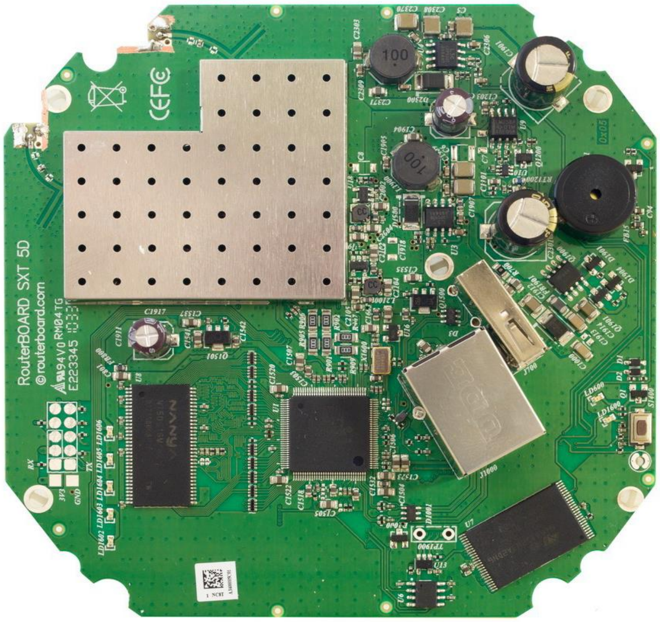
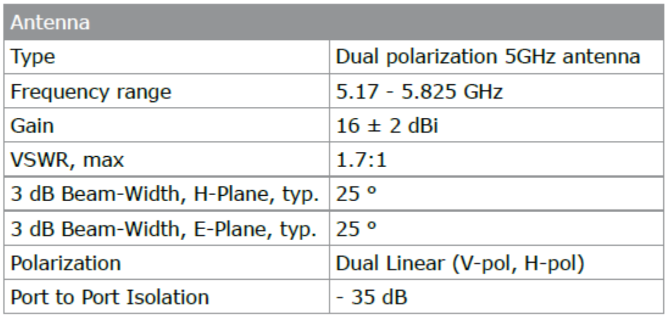


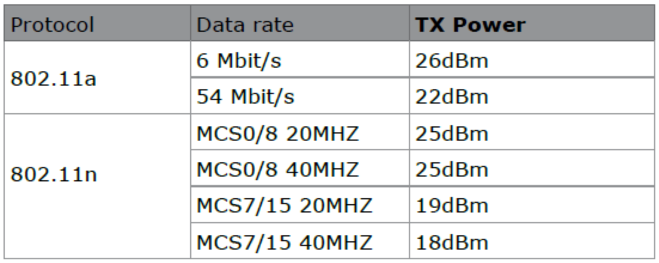
Fig:5 Microtik-SXT-Board View

This RouterBOARD model has a built-in 802.11a/n 5GHz wireless device based on the **AR9280** Atheros chipset. It doesn't support turbo mode. There is no antenna connector, as the wireless part is directly connected to the built-in antenna. The SXT 5HnD has a built in dual polarization PCB type antenna... SXT is a low cost, high speed MIMO 5GHz outdoor wireless device, available as a High Power or Lite version. SXT Lite5 provides the best price-performance ratio on the Wireless CPE market. Unit is equipped with powerful 600MHz CPU, 64MB RAM, 16dBi dual polarization antenna, poe, power supply and mounting kit. SXT-5HPnDr2 is the high power version (30dBm TX power).

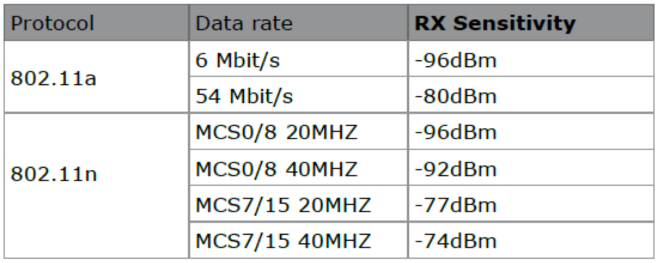
Antenna Specifications:



Antenna	
Type	Dual polarization 5GHz antenna
Frequency range	5.17 - 5.825 GHz
Gain	16 ± 2 dBi
VSWR, max	1.7:1
3 dB Beam-Width, H-Plane, typ.	25 °
3 dB Beam-Width, E-Plane, typ.	25 °
Polarization	Dual Linear (V-pol, H-pol)
Port to Port Isolation	- 35 dB



Protocol	Data rate	**TX Power**
802.11a	6 Mbit/s	26dBm
	54 Mbit/s	22dBm
802.11n	MCS0/8 20MHZ	25dBm
	MCS0/8 40MHZ	25dBm
	MCS7/15 20MHZ	19dBm
	MCS7/15 40MHZ	18dBm



Protocol	Data rate	**RX Sensitivity**
802.11a	6 Mbit/s	-96dBm
	54 Mbit/s	-80dBm
802.11n	MCS0/8 20MHZ	-96dBm
	MCS0/8 40MHZ	-92dBm
	MCS7/15 20MHZ	-77dBm
	MCS7/15 40MHZ	-74dBm

IV. NUMERICAL EVALUATION AND SIMULATION RESULTS:

ENERGY EFFICIENCY SIMULATION :

Table I shows the hardware parameters that characterize the power consumption and is based on [6, Table 7] and [11]. Table II for all channel model parameters. We first analyze the impact of having different number of antennas at the BS and SCAs: N_{BS} belongs to {20; 30; : : : ; 100}

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 $\forall j, \ell$

TABLE II
CHANNEL PARAMETERS IN THE NUMERICAL EVALUATION

Parameters	Values
Macro cell radius	0.5 km
Carrier frequency / Number of subcarriers	$F = 2$ GHz / $C = 600$
Total bandwidth / Subcarrier bandwidth	10 MHz / 15 kHz
Small-scale fading distribution	$\mathbf{h}_{k,j} \sim \mathcal{CN}(\mathbf{0}, \mathbf{R}_{k,j})$
Standard deviation of log-normal shadowing	7 dB
Path and penetration loss at distance d (km)	$148.1+37.6\log_{10}(d)$ dB
Special case: Within 40 m from SCA	$127+30\log_{10}(d)$ dB
Noise variance σ_k^2 (5 dB noise figure)	-127 dBm

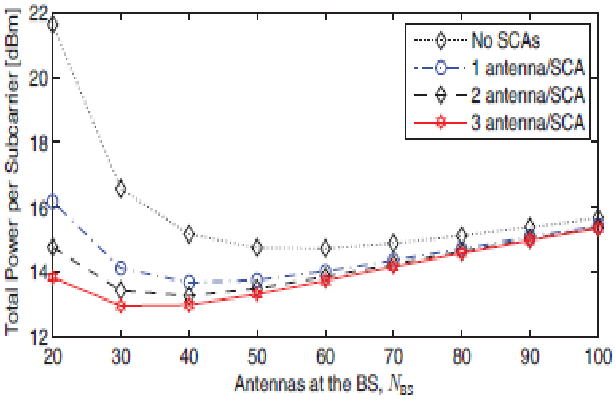


Fig. 6. Average total power consumption in the scenario of Fig. 3. Weconsider different NBS and NSCA, while the QoS constraints are 2 bits/s/Hz.

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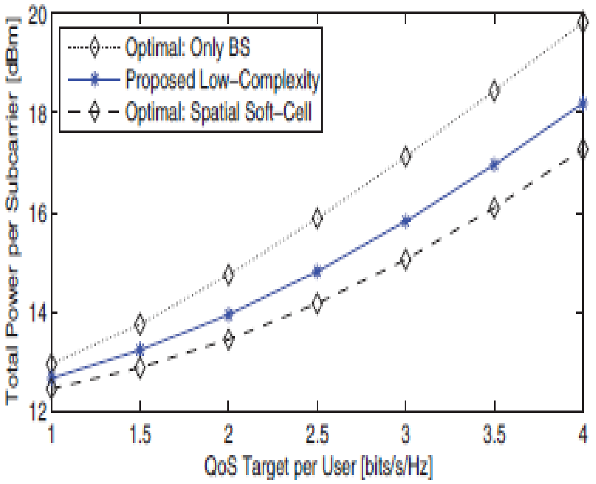

Fig. 5. Average total power consumption in the scenario of Fig. 3 with NBS = 50 and NSCA = 2. We consider different QoS constraints and beamforming.

As in the previous figure, we observe great improvements in energy efficiency by offloading users to the SCAs. The proposed Multiflow-RZF beamforming gives promising results for practical applications, because a majority of the energy efficiency improvements is achievable by judicious low-complexity beamforming techniques.

BER COMPARISION USING IDMA Interleaver:

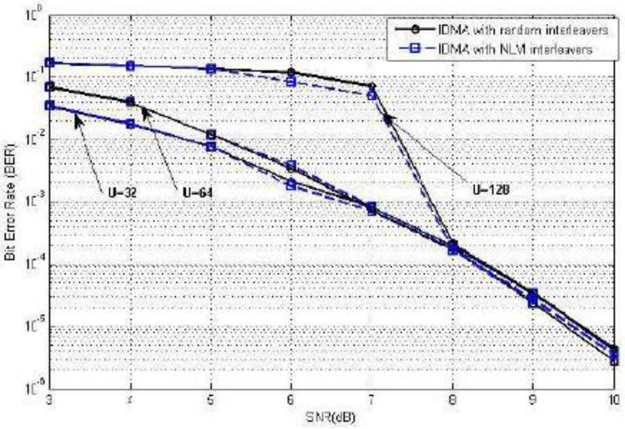

Fig:6 BER Performance comparison of NLM interleaver and Random Interleaver in IDMA system without grouping

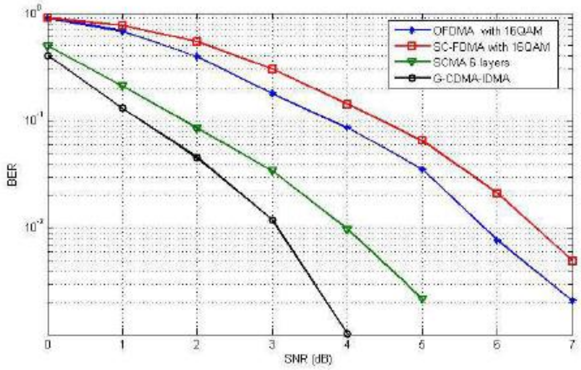

Fig:7. BER Performance comparison between G-CDMAIDMA, SCMA, OFDMA, and SC-FDMA

V. CONCLUSION:

With these and other 5G technologies, engineers hope to build the wireless network that future smartphone users, VR gamers, and autorun cars will rely on every day. Already, researchers and companies have set high expectations for 5G by promising ultralow latency and recover breaking data speeds for consumers.The energy efficiency and High Speed Data transfer of cellular networks can be improved by employing massive MIMO at the BSs or overlaying current infrastructure by a layer of SCAs. This paper analyzed acombination of these concepts based on soft-cell coordination, where each user can be served by non-coherent beamforming from multiple transmitters, Spectrum Analysing using IDMA interleaver Scheme. We proved that the power minimizing spatial multiflow transmission under QoS constraints is achieved by solving a convex optimization problem and BER Comparision of the 5G with IDMA Method.Finally We analyse the overall Performance Parameters with promising simulation results and also sample Massive MIMO antenna was Analyzed with various frequency Levels and various Traffic Data rates.

VI.FUTURE REASEARCH CHALLANGES

After having reviewed the state-of-the-art of the main 5G energy-efficient techniques, a natural question is: what are the next steps to be taken towards an energy efficient 5G? We review some of them in the following.

A. The need for a holistic approach:

A holistic approach is thus necessary, in which all energy-efficient techniques are combined. Indeed, as previously discussed, some works in this special issue go in this direction combining multiple energy-efficient techniques together.

B. Dealing with interference:

Unfortunately, 5G networks will be interference-limited, since orthogonal transmission schemes and/or linear interference neutralization techniques are not practical due to the massive amount of nodes to be served. Thus, the potentialities of fractional programming must be extended. A promising answer is represented by the framework of sequential fractional programming, which provides a systematic approach to extend fractional programming to interference-limited networks with affordable complexity

C. Dealing with randomness:

A second approach lies in the use of learning techniques, which deal with randomness by letting the devices learn from past observations of their surroundings and respond as appropriate in a self-organizing fashion. However, also in this case, very little research effort has been directed towards understanding the impact of this technique on energy-efficient network design.

D. Emerging techniques and new energy models:

In addition, new emerging technologies can also be used for energy-efficient purposes. In particular, caching and mobile computing have shown significant potential as far as reducing energy consumption is concerned. By an intelligent distribution of frequently accessed content over the network nodes, caching alleviates the need for backhaul transmissions, which results in relevant energy consumption reductions..

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