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Utilizing Multiple Inputs and Outputs for Optimal Spectrum Efficiency in the Uplink and Downlink

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***Abstract**: Attaining maximum spectral efficiency using massive MIMO in a cell network system is a promising method to expand the efficiency in the system. By means of arranging arrays of antennas at the base stations in terms of large number of dynamic components and carry out the processing of coherent transceiver techniques are improving the system performance. General guideline is that these frameworks ought to have a significant degree of magnitudes of massive N number of antennas are required in contrast to the active premeditated L number of users. In support of this reason that the users channels are probably orthogonal to each other with N/L greater than 10. The proposed work, investigate the L* number of planned users, relies upon N and some of the parameters mentioned in this framework. The spectral efficiency articulations are determined to empower the framework level assessment with power management , reuse of random generation pilot, and user arbitrary positions. The estimation of L* number of active user in the massive N system be determined inside the close structure. But experimental simulations are utilized limited number of N to demonstrate at various interference situations, with various pilot reuse issues, and for various handling process. The transmission is capable of half of block is devoted for pilots signalling and the best possible N/L is below 10 within several situations of convenient relevance for functional significance and L* relies emphatically upon the processing scheme.*

***Keywords:** Base Station, Downlink, Massive MIMO, Spectral Efficiency, Uplink, User Equipment*

I. INTRODUCTION

MIMO stands for multiple-input multiple-output. It's a new field of research that has large antenna arrays at base stations. To increase region throughput (in bits/s/km^2), one generally needs to take into account three multiplicative factors: higher cell density (more cells per km^2), more bandwidth (in Hz), and greater spectral efficiency (in bits/s/Hz/cell).The higher SE is achieved by using a closed-structure estimation of area spectral efficiency for massive MIMO in multi-cell multi-user with pilot contamination [1].

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To maximize the area spectral efficiency (ASE) and area energy efficiency (AEE), a number of key considerations are considered, such as the number of antennas, the number of users, and the optimal pilot to data power ratio. There is a tradeoffs between ASE and AEE, smaller number antennas and users at the base station are able to attain better AEE with small ASE. However required ASE can achieve by introducing more number of antennas but, increasing the number of users not constantly promising higher ASE. Substantial achievable rate for a Massive MIMO in multi cellar network with superimposed pilot (SP),by investigating the involvement of special resources of interfering [2], As a result, SP can be used to reduce pilot contamination by including additional coherent and non-coherent interventions that limit system performance. The experimental results are illustrated by optimizing length of the pilot with regular pilot (RP), the average AEE and ASE are estimated. However, SP may be able to improve the performance of the system compared with the other signal processing techniques, but such techniques require more computation to complete the ASE.A MIMO with orthogonal frequency division multiple access [3] for broadcast channel scenarios is examined for its essential relationship to AEE and ASE. In order to deal with the trade-off between EE and SE, the authors provide an algorithm that decouples the multi-carrier optimization EE problem into a set of single carrier optimization EE problems. The projected resource distribution algorithm can professionally come near the optimal trade-off of EE and SE but the EE achieved. Finally, the scheme introducing ambiguity while selecting the user and antenna, which in turn produces worst system performance while maximize the SE. Investigated the downlink SE of massive MIMO structures by means of antenna arrays in different configuration and to get better performance by means of suppressing inter user interference by non orthogonal between channel vectors [4]. Entirety SE of Massive MIMO systems in a single circular cell is considered , by way of hypothesis so as to that base station knowing the channel state information (CSI) in earlier and make use of linear pre-coding. If this scenario to extended the multiple cellular where SE mostly depends on the intra-cell interference will introduce noise into the system and degrades the system performance. Assess the trade-offs between EE-SE of Transmit Antenna Selection(TAS) using Maximum Ratio Combining technique [5].Although TAS has fewer antennas than low- to medium-SE, it is capable of delivering considerable energy reserves and Despite the number of antennas, the SE beam-forming system outperforms transmit beam-forming schemes in terms of maximum transmission ratio.

When the number of transmit antennas is increased, the results of TAS over MIMO become even better. In MIMO, the TAS scheme maximizes EE with a large SE range, but it influences spatial correlation at the receiver, which reduces the system's efficiency. The authors investigated ergodic SE, a random wireless network with multiple transmit and receive antennas, to achieve multiplexing gains using MIMO techniques[6].In order to obtain ergodic spectral efficiency, assume two types of CSI, analytical expressions, and scaling laws. According to the results, SE scaling can be reformulated as a function of both transmit streams and node density, The number of antennas scales with density according to a polynomial function. The processing technique introduces more complexity while improving the SE. The massive MIMO scheme propose the prospect of increasing the SE by one or two orders of magnitude[7], and at the same time improving the EE by three orders of magnitude. The BS will likely perform optimally with a simple linear processor like maximum-ratio combining or ZF utilizing channel estimation derived from UL pilots yet in an elevated mobility situation with training interval is half the channel coherence interval. The system will work only for Rayleigh fading with small-scale, however system not offering good performance for large-scale fading. The analog pre-coder to maximize SE for generalized spatial modulation assisted mm-Wave MIMOs [8]. A closed form estimation is used to quantify the practicable rate of the scheme. Foundation on the closed form expression, iterative algorithms were used design the analog pre-coder and simulations demonstrated the better performance with aspect of SE. By means of iterative algorithm, developing lower bound as a cost function for SE maximization with analog pre-coder gives tides work processing. When a massive MIMO network is cell-free (CF) with imperfect channel state information, network-assisted full-duplex communication (NAFD) efficiency is investigated under spatially correlated channels [9].The deterministic equivalents of the uplink sum rate for the minimum-mean-square error receiver and the downlink sum rate for zero-forcing and regularized zero-force beam-forming are presented using large dimensional random matrix theory. Results from a methodical approach have offered reliable system performance for large-scale system for a restricted number of antennas with minimal SE. With a statistical CSI at the transmitter, when transmitting massive MIMO in single cells, the EE-SE trade-off can be addressed[10]An EE-SE balance is achieved by optimizing the system resource efficiency (RE).Establish the closed-form solution for the eigenvectors of the optimal covariance matrix for multiple stations, which shows that MIMO transmission optimization in massive MIMO is favorable. The numerical results gives better performance gain to maximize RE, however it requires high transmitting power making financial burden. A generalized analysis of both small-scale (regular) and large-scale (massive) multi-input multi-output (MIMO) systems [11], in which various characteristics and parameters of radio propagation are considered, such as path loss, shadowing effects, multi-path fading, antenna correlations, antenna polarizations, and environmental cross-polarization couplings. A spectral efficiency upper bound on the MIMO channel is first established, utilizing Hadamard's determinant inequality for positive semi-definite matrices, following development of the channel model using the Weichsel Berger method. In cases where the number of transmitting antennas exceeds the number of receiving antennas, the effect of the processing scheme will be small on the SE. Efficiency of dual-hop (DH) amplify-and-forward (AF) MIMO relays in the presence of residual hardware impairments [12].The ergodic channel capacity of DH AF relay systems is characterized using results from finite-dimensional and large random matrix theory.

However It introduces more complexity to the system processing. By utilizing effective processing techniques to reduce the interference caused by the allocation of resources in networks, the systems can be improved in terms of SE and EE as per the above-mentioned literature. To increase spectral efficiency in this proposed work, resource allocation is planned per cell for several user equipments. A number of system parameters are resolved, including coherence block length, number of antennas, and pilot allocation. Utilize innovative spectral efficiency appearances which are convincing for both uplink and downlink communication, with arbitrary user locality, and manage the power that allows uniform device synchronization. A new full-pilot zero-forcing strategy that dynamically uses a combination of transmission and maximum ratio, in addition to conventional linear processing approaches, could be considered that curbs intrusions between cells in a distributed beam-forming manner.

II. PROPOSED SYSTEM MODEL

A cellular network system is considering, where loading data is sent with reusing frequency with general time. Every cell is allotted an indicator in the set R. With N number of base station antennas, each with one antenna, each UE antenna in each cell communicates simultaneously. L_{max} is the maximum number of UE's per cell.

The interest in massive MIMO geographies where N and L_{max} are fixed at greater numbers, while L is a intend parameter with every part of UEs have limitless claim for information to be communicate each other. Over the time period the subset operative UEs are changes, hence the UE of $l\in\{1,\dots,L\}$ within cell r $\in$ R is given to various UEs at various occasions. The geological position Q_{rl} of UE l within cell r is in this manner an ergodic arbitrary variable with a cell explicit dissemination[13].Using this model, the average performance of interfering UEs is revised for arbitrary rather than fixed arrangements. T_c seconds and W_c Hz are the resources of time-frequency. The transmission symbols $S = T_cW_c$ per frame. Since frame width measurement indicates that T_c is modest or the same as the coherence bandwidth for the entire UE, while W_c will be modest or equivalent to the coherence time. Consequently, every one of the channels are static inside the frame; h_{irl} signifies the channel response involving in base station i and UE l within cell r in a specified the frame. In this case, the channel response is derived from circularly symmetric zero-mean complex Gaussian functions: A random complex Gaussian variable is g = a + jb with self-governing, zero-mean parts of 'a' and 'b' are the equivalent to variance of Gaussian arbitrary variable with circularly-symmetric[14].The channel responses are represented in (1).

$$h_{irl} \sim G_C N[0; d_i(Q_{rl}) I_N] \qquad (1)$$

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Where $d_i(Q)$ a deterministic function provides the variance of channel attenuation from any UE location Q to BS i, the identity matrix I_N is N*N. Based on this design, this work can provide the consequences of both a few and a large number of BS antennas to support line of sight propagation [15]. The estimation of $d_i(Q_{rl})$ gradually fluctuates over the long time and frequency, As such, all users will be identified to their value at BS i for all systems inside r, and every user equipment will be identified to its value at its serving base station. The specific user equipment locations Q_{rl} are unidentified. The transmission frame is the time-division duplex (TDD) protocol, The UL Pilot symbols $B \geq 1$ are set aside for signaling of UL pilot in each frame ,which contains S symbols. Here no signaling of DL pilot is used and no channel status information (CSI)feedback , since the base stations can process both DL and UL signaling by means of UL channel capacity suitable, because reciprocity of channels are used in TDD systems [1][16].Assigning the residual symbols to payload data is divided among DL and UL transmission. Although the base stations are not exchanging any type of information in this scenario, the pilot distribution and communication processing can come together in a distributed manner.

III. UPLINK AND DOWNLINK PROCESS

A transmission frame can be derived $y_i \in \mathbb{C}^N$ as from (2) for the uplink signal received by a base station.

$$y_i = \sum_{r \in R} \sum_{l \in 1}^{L} \sqrt{p_{rl}}\, h_{irl} x_{rl} + n_i \tag{2}$$

where $x_{rl} \in \mathbb{C}$ is the transmitted symbol by the user equipment of l within cell r. The normalized signal energy $\mathbb{E}\{|x_{rl}|^2\} = 1$,accordingly, the user equipment transmission power is considered as $p_{rl} \geq 0$.

The additive noise is $n_i \in \mathbb{C}^N$, which is modelled with variance σ^2 as $n_i \sim G_C N[0; \sigma^2 I_N]$. Contrary to the most of preceding works on massive MIMO, are assuming predetermined UL power, but in this work power management is considered as statistic-attentive[17] ; the symbols transmit power from UE l in cell r have the $p_{rl} = \rho\ / d_r(Q_{rl})$, where ρ is greater than zero is the model parameter. the average channel attenuation $d_r(z_{rl})$ is the inversely proportional to the power-control and ensures the same overall effective channel gain for all UEs: $E\{p_{rl}\|h_{rl}\|^2\} = N\rho$. Hence, this promises a uniform experience in all the users and accumulates precious energy at UEs. With TDD, the downlink signal received from base station i can be calculated using (3) as the received signal $Q_{il} \in \mathbb{C}$ at user equipment l in cell r.

$$Q_{il} = \sum_{r \in R} \sum_{m=1}^{L} h_{ril}^T w_{rm} s_{rm} + n_{il} \tag{3}$$

In this $(\cdot)^T$represents transposition, s_{rm} represents the symbol anticipated for user equipment m within cell r, and $w_{rm} \in \mathbb{C}^M$ is the analogous pre-coding vector[2], and $\|w_{rm}\|^2$ is the assigned transmit power for downlink. The power control be able to considered in the downlink, given that the base station has way to access the estimated channel status information [18]. The UE l within cell r are modelled as with additive noise $n_i \sim G_C N[0, \sigma^2]$ with the similar variance as in the upper link.

IV. AVERAGE SPECTRAL EFFICIENCY PER CELL

This section examines the spectral efficiency of multi-cell networks with random placements of user equipment depending on their number and size.

A. Pilot-Based Channel Estimation

Based on the many antennas in the base station i, it is possible to use coherent receiving in the uplink, and transmitting pre-coding in the downlink, which is capable of amplifying preferred signals and suppressing unwanted ones. It was necessary to have knowledge of the different channels of the user's equipment; consider the instance, $\sqrt{p_{rl}} h_{irl}$ within the UL, for every one of r and l. The CSI is usually obtained through the pilot signalling, In this case, the user equipment launches well-known signals in a predetermined manner [19].As resources are shared across cells for transmission purposes in multi-cellular systems, achieving perfect CSI is difficult since the pilot signal information is certainly influenced by means of inter-cell interference. This phenomenon is known as pilot corruption and it affects the quality of the CSI that can be obtained as well as the ability to eliminate inter-cell interference. A typical approach to studying the effects of pilot corruption is to assume that the approximately similar pilot signals are used in every cell. In massive MIMO, the major properties are an arbitrary pilot, where every cell may be used as a subset of the signalling. In every frame, the pilot signals span the B symbols, while $1 \leq B \leq S$. The pilot signals have a predetermination vector $v \in \mathbb{C}^B$ of their size per symbol and are fixed in size, meaning that each admission has a unit in magnitude: if $|[v]_s| = 1$, then $[\cdot]_s$ would represent the s^{th} component in s ∈{1, ...,B}.Assuming all pilot signalling is created as a result of a fixed pilot codebook V, as described in (4).

$$V = \{v_1, v_2, \ldots, v_B\} \tag{4}$$

$$\text{where } v_{b1}^H v_{b2} = \begin{cases} B, & b_1 = b_2 \\ 0, & b_1 \neq b_2 \end{cases}$$

Because of this, the B pilot signals are orthogonal, where $(\cdot)^H$ represents the transpose of symbol in conjugate form, for instance, column matrices have discrete Fourier transforms (DFTs) indicative of signals. The pilot signals within cell r are transmitted by UE l using the signal v_{krl}, when the signal $k_{rl} \in \{1,......B\}$ indicates the index number in the pilot codebook. As a result of transmitting these upper link pilot signals over B symbols, the combined upper link signals at BS i are designated $Y_i \in C^{N \times B}$ and expressed as (5) and the $n_i \in C^{N \times B}$ includes the additive noise into those signals at the receiver.

$$Y_i = \sum_{r \in R} \sum_{k=1}^{K} \sqrt{p_{rl}}\, h_{ril} v_{krl}^T + n_i \tag{5}$$

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B. Effective power Estimation

In order to estimate effective power management in uplink channels, the minimum mean square error (MMSE) is used, which are described as $h^{eff}_{irl} = \sqrt{p_{rl}} h_{irl}$. The effective power estimate at BS *i* of the uplink channel h^{eff}_{irl} is defined using MMSE as expressed in (6), for every user equipment $l\in\{1, ...,L\}$ at all cell $r\in R$ and $(\cdot)^*$symbolized as the complex conjugate.

$$h^{eff}_{irl} = \frac{d_i(Q_{rl})}{d_r(Q_{rl})} Y_i(\phi_i^T)^{-1} v^*_{krl} \tag{6}$$

Therefore, as a result standardized covariance matrix of the signal $\phi \in C^{B\times B}$ can be described as in (7)

$$\phi_i = \sum_{r\in R}\sum_{m=1}^{K} \frac{d_i(Q_{rl})}{d_r(Q_{rl})} v^H_{krm} v_{krm} + \frac{\sigma^2}{\rho} I_B \tag{7}$$

The $C_{irl} \in C^{B\times B}$ is covariance matrix estimation error is specified in (8) and its MSE is $MSE_{irl} = tr(C_{irl})$.

$$C_{irl} = \mathbb{E}\{(h^{eff}_{irl} - \bar{h}^{eff}_{irl})(h^{eff}_{irl} - \bar{h}^{eff}_{irl})^H\} \tag{8}$$

Presently, the literature in the massive MIMO are conventionally used two important channel estimators they are: 1) for arbitrary pilot allocation supports the MMSE estimator ; and 2) the effective channels estimate together with the upper link power management. The covariance matrix in (7) discloses the reasons for errors in estimation; Contrary to that, User equipment uses similar pilot signals, which drives the noise-to-signal ratio (SNR)σ^2/ρ . Due to the interference, Assuming BS i is receiving UE *l* in cell r at a relative strength is described as the ratio as$d_i(Q_{rlm})/d_r(z_{rm})$; which is approximately UEs of neighboring cells of one cell-edge, however it is nearly zero if the cell *r* is especially far distant as of BS *i*. Though MMSE permits every one of channel vectors are possible estimate in the entire cellular network , but every BS can be able to determine B dissimilar spatial dimensions because of pilot signals are B orthogonal signals and uses each one of the B pilot signals are considered from vector *V*. To demonstrate explicitly and described the N× B matrix in the (9).

$$\bar{H}_{vi} = Y_i(\phi_i^T)^{-1}[v_1^*\cdots,v_B^*] \tag{9}$$

The estimate of the channel in the UE *l* within in the cell *r*, it uses v_{krl} pilot signal and the k_{rl} th column of $\bar{H}_{vi}$ is parallel to it ; further specifically describe $\bar{h}^{eff}_{irl}$ is as in (10)

$$\bar{h}^{eff}_{irl} = \frac{d_i(Q_{rl})}{d_r(Q_{rl})} \bar{H}_{vi} e_{krl} \tag{10}$$

In the (10) e_{krl} indicates the k[th] column in the identity matrix I_B within the in the cell *r* . The essence of the pilot contamination is; however the predicted channels are parallel, so that BSs unable to inform separately UEs so as to make use of the identical pilot signals and cannot possible to reject their corresponding interference. In the special cases like ,high level channel correlation in spatial and deliberately modifies user scheduling to partially separate the UEs a statistical prior knowledge have been employed, although this prospect is not observed here because the reason for this is the development of novel methods to suppress potential contamination during pilot propagation that can be used in any propagation environment.

V. UPLINK ATTAINABLE SPECTRAL EFFICIENCY

The channel assesses the signals from every BS to data signals arrived from the corresponding UEs are detected coherently. Specifically, imagine that BS *I* uses linearly combination of receive vector $g_{rl}= \in C^N$ to the collected signals, like $g^H_{rl}y_r$, amplify these received signals obtained from the corresponding *l*[th] UE and moreover, interference from infrastructural interference from adjacent UEs within the spatial region has also been suppressed.

To determine the feasible SE for every UE, where as the code words spread over in both the Rayleigh fading and interfering by the UEs which are located randomly. For conveniently assuming, that the aspect of the pilot reuse factor must be an integer i.e. β = B/K. Using the pilot groupings of similar K pilots within a set of L cells, while using different pilots among different sets of L cells, the L cells are fragmented into β ≥1 disjoint subsets. For any network topology with explicitly for hexagonal cells, for Gaussian codebooks the SE relies upon the combination received signals, i.e. $x_{rl} \sim G_C N(0;1)$.An arbitrary located UE *l* in cell *r*, the attainable SE is indicated as [bits/s/Hz] in the UL process is depicted in (11)

$$SE_{UL} = \alpha^{UL}\left(1 - \frac{B}{S}\right)\mathbb{E}_Q\{log_2(1+SINR^{(UL)}_{il})\} \tag{11}$$

whereas $\alpha^{(UL)}$ is considered as the fractions of UL transmission, the $\mathbb{E}_Q$ is the expectations UE positions, the base station *i* and the signal to interference and noise ratio (SINR) is the effective ratio of the signal and interference to the noise in the cell *r* in the corresponding *l*[th] user equipment[20] in the UL processing is represented as $SINR^{(UL)}_{il}$, and is described as in (12).

$$SINR^{(UL)}_{il} = \frac{P_{il}\,|\,\mathbb{E}_{(h)}\{g^H_{ik}h_{iil}\}\,|^2}{\sum_{r\in R}\sum_{m=1}^{K} P_{lm}\,|\,\mathbb{E}_{(h)}\{g^H_{il}h_{ilm}\}\,|^2 - P_{il}\,|\,\mathbb{E}_{(h)}\{g^H_{il}h_{iil}\}\,|^2 + \sigma^2\,||\,\mathbb{E}_{(h)}\{g_{ik}\,||^2} \tag{12}$$

The BS *i* the corresponding *l*[th] UE, the P_{il} is UL transmit power, the $\mathbb{E}_h$ is the expectations of the channel realizations. Three assumptions are made on the SE: 1) The desired signal component is one which is received over the effective channel means as $E\{h\}\{g^H_{il}h_{iil}\}$, 2) whereas the signal component and interference are received over the uncorrelated remaining channel which is $\{g^H_{il}h_{iil}\} - E\{h\}\{g^H_{il}h_{iil}\}$ are considered as noise, it is worst level of the Gaussian distribution in the decoding process, 3) prompting a further lower bound on the shared data.

It is required to indicate the receive combination technique in order to process these expectations, the receive combination technique is either active or passive interference suppression. The maximum ratio (MR) combination is the one of the canonical form of the passive interference suppression, which can be expressed in (13).

$$g^{(MR)}_{il} = \bar{H}_{vi} e_{kil} = \overline{h^{eff}_{iil}} \tag{13}$$

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In (13) maximizes the desired signal gain and on the other hand automatically it suppresses the interference because h_{iil}^{eff} is the orthogonal channels especially in case of larger number of N. In comparison to the active interference suppression, among the possible ways to accomplish this are to combine the received signals in orthogonal ways to the interfering channels. Using a zero-forcing (ZF) combination, which is defined as in (14) as the orthogonal channels in the intra-cell R.

$$g_{il}^{(ZF)} = \bar{H}_{vi} E_i (E_i^H \bar{H}_{vi}^H E_i \bar{H}_{vi})^{-1} e_{kil} \tag{14}$$

whereas $E_i = [e_{ki1} \ldots\ldots e_{kiL}] \in C^{B \times L}$ and the entire UEs in cell *r* in BS *i* are essentially used different pilots signaling.

VI. DOWNLINK ATTAINABLE SPECTRAL EFFICIENCY

In the DL process, the channels are additionally utilized the linear pre-coding, where inputs of the N channels are used every data signals , added up coherently in the desired UE *l* in cell *r*and also reject the interference due to other cell. These pre-coding vectors are defined in (15).

$$W_{rl} = \sqrt{\frac{q_{rl}}{\mathbb{E}_h\{\| \bar{g}_{rl} \|^2\}}} \bar{g}_{rl}^* \tag{15}$$

whereas $q_{rl} \geq 0$ is the average transmit power, and it depends on the positions of the UE, the $\bar{g}_{rl} \in \mathbb{C}^N$ is the transmission vector in the spatial directivity and it depends on the acquired CSI, the $\mathbb{E}_h \| \bar{g}_{rl} \|^2$ is the average squared norm with normalization. In the DL signalling, an arbitrary UE *l* in cell *r*, the attainable SE is illustrated in(16).

$$SE_{DL} = \alpha^{DL} \left(1 - \frac{B}{S}\right) \mathbb{E}_Q\{log_2(1 + SINR_{il}^{(DL)})\} \tag{16}$$

whereas $\alpha^{(DL)}$ is considered as the fractions of DL transmission, the $\mathbb{E}_Q$ is the expectations UE positions, the BS *i* and the corresponding l^{th} UE in the cell *r*, The effective SINR in the UL processing is represented as $SINR^{(DL)}_{il}$, and is described as in (17).

$$SINR_{il}^{(UL)} = \frac{P_{il} \dfrac{|\mathbb{E}_{(h)}\{\bar{g}_{ik}^H h_{iil}\}|^2}{\mathbb{E}_{(h)}\{\| \bar{g}_{ik}^H \|^2\}}}{\sum_{r \in R} \sum_{m=1}^{K} P_{rm} \dfrac{|\mathbb{E}_{(h)}\{\bar{g}_{rm}^H h_{ril}\}|^2}{\mathbb{E}_{(h)}\{\| \bar{g}_{rm}^H \|^2\}} - P_{il} \dfrac{|\mathbb{E}_{(h)}\{\bar{g}_{ik}^H h_{iil}\}|^2}{\mathbb{E}_{(h)}\{\| \bar{g}_{ik}^H \|^2\}} + \sigma^2} \tag{17}$$

Let the receiving combination vectors set as $g_{il}^{strategy}$ be used in the UL in UE *l* within cell r subsequently, existing a DL power control q_{rl} measure with $\sum_{r \in R} \sum_{l=1}^{L} q_{rl} = \sum_{r \in R} \sum_{l=1}^{L} q_{rl}$ designed for which $SINR_{rl}^{(DL)} = SINR_{rl}^{(UL)}$ by utilizing $\bar{g}_{rl} = g_{rl}^{strategy}$ for every cell *r* and *l*. Therefore, in the DL attainable SE in cell *r* is represented as in (18)

$$SE_{DL} = L\alpha^{DL} \left(1 - \frac{B}{S}\right) log_2 \left(1 + \frac{1}{I_r^{strategy}}\right) \tag{18}$$

whereas the $I_r^{strategy}$ is the interference, which is similar effect in the UL for all processing techniques. When the power control coefficients are chosen appropriately q_{rl} and same the performance can be achieved in both UL and DL.A similar SINR can be obtained in the DL as well as the UL. The absolute transmit power is something very similar, however it is distributed diversely over the UEs.

This is an outcome of the UL-DL duality in nature[21],This usually applies to single-cellular networks with the best CSI, which is also applicable to multi-cellular networks with massive MIMO systems with the same assessed CSI. In this work, three kinds of linear pre-coding vectors are considered: 1) Maximizes the desired signal gain using maximum ratio pre-coding by setting as $\bar{g}_{rl} = g_{rl}^{MR}$; 2) To dismisses intra-cellular impedance effectively using zero force pre-coding by setting as $\bar{g}_{rl} = g_{rl}^{ZF}$; 3) Both intra and inter-cellular interference suppress effectively using Pilot-zero force pre-coding by setting as $\bar{g}_{rl} = g_{rl}^{P-ZF}$. However P-ZF pre-coding technique is a completely appropriated in customize the beamforming in MIMO setup, because every BS just uses locally assessed CSI.

The multi-cell -MMSE (m-MMSE) scheme maximizes the SE by linearly combining the received signals. In linear schemes, interference is treated as in spatial noise as colored , which primary characteristic.

This is only optimal from the point of view of channel capacity if each pair of UEs has a sufficiently low amount of interference. By using non-linear receiver processing schemes, such as successive interference cancellation, strong interference sources require cancellation before the desired signals can be decoded according to the information theory for interference channels. It is rather impractical to implement such schemes, since they require storing large blocks of received data and required sequentially data of UEs', causing high complexity, high memory usage, and latency problems.

All combination schemes become more complex as the number of UEs and BSs antennas increases. Due to this, another schemes offer lower SEs but have the practical benefit of reducing computational system complexity and reducing channel estimation by combining the matrix of the statistically behavior of the channel. The single-cell MMSE (s-MMSE) combining scheme can be obtained with just the channels estimated from BS's of its individual UEs.

Due to this, another schemes offer lower SEs but have the practical benefit of reducing computational system complexity and reducing channel estimation by combining the matrix of the statistically behavior of the channel.

The single-cell MMSE (s-MMSE) combining scheme can be obtained with just the channels estimated from BS's of its individual UEs. ZF is expected to provide lower SEs than r-ZF since not all UEs have high SNRs in practice.

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VII. ASYMPTOTIC ANALYSIS

The term asymptotic analysis refers to the mathematical analysis of describing how the SE curve reaches its limit in UL and DL. It is described in (19) how to consider both the UL and DL feasible SE in a cell *r*.

$$SE_r = SE_r^{UL} + SE_r^{DL} \tag{19}$$

$$SE_r = L\left(1-\frac{B}{S}\right)log_2\left(1+\frac{1}{I_r^{strategy}}\right) \tag{20}$$

It is possible for this SE to be split between the DL and UL randomly by utilizing some positive fractions value of α^{DL} and α^{UL}, considering as $\alpha^{DL}+\alpha^{UL}=1$ in this paper.With out isolating the UL and DL, This is an advantageous outcome that permits to analyze the optimum SE in the entire network system. But it is difficult to achieve further understanding SE from (20) by putting constraint of an massive number of antennas

VIII. RESULTS AND DISCUSSION

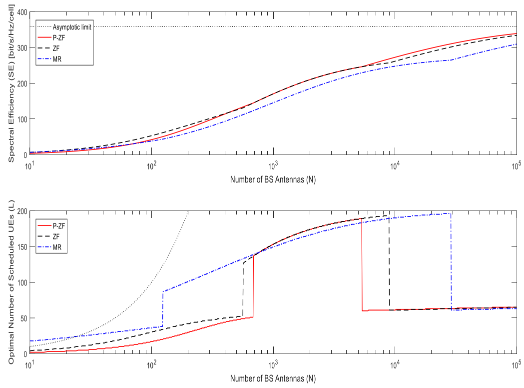
i. SE in Different Levels of Interference

The simulation is carried out to determine the SE by considering the interference[22] into the system in a randomly located cell in hexagonal cellular network system[23][24].The UEs can able to locate anywhere in the cells, however it distance is not less than 0:13ras of the assisting BS, where 'r' is the radius of the cell, to avoid reflection and bringing it into the line of sight. Given that the similar SE articulations for both UL and DL, except α^{DL} and α^{UL} fractions, this sum is reproduced based on these SEs and note that it may be split at the discretion of both the UL and DL. For both UL and DL, a linear processing strategies such as ZF, MR, and pre-coding like P-ZF and combination of all strategies are used to analyze the SE.

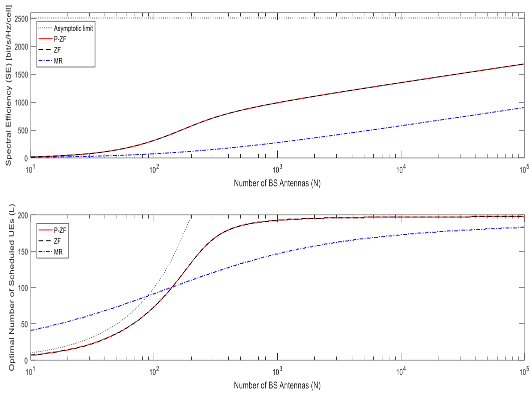
The experimental results are achieved by considering the combination of different parameter which are mentioned in the above equations. The SE optimization is obtained for each N number of antennas with regard to the number of UEs L and the arbitrary range of all reasonable integer pilot reusing factor β i.e. B =βL are searching within the available dedicated pilots. Practically consider coherence bandwidth is 200 kHz, coherence time is 2 ms, S = 400 coherence block length , path-loss exponent P = 4-6 , and SNR is/ ρ/ σ^2= 4 dB. To verify the system performances practically in this paper, three different scenarios with various inter-cell interference level are considered:

- The normal scenario: Average effect of inter-cell interference on UE locations in entire cells is uniform.
- The best possible scenario: Every single UEs are located at the edge in the other cells, which are far from the BS *i* (intended for every *i*).
- The worst possible scenario: Every single UEs are located at the edge in the other cells, which are nearer to the BS *i* (intended for every *i*).

Each cell is bounded by 120 UE, which are randomly located. The best possible scenario case is very promising because the preferably UE locations are different in the interfering cells with regarding to the other cells. Be that, it provides an upper bound of SE which is attainable by in time schedule planning in entire cells. Whereas in the normal scenario the average effect arrived due to mobility of UE, arbitrary exchanging of pilot sequences among the UEs in every cell, and coordinated scheduling in entire cells system. The most doubting scenario is worst case because the all UEs are not situated in the worst positions in cell areas, regarding any remaining cells, simultaneously. The normal scenario is illustrated in Figure 1, best possible scenario in Figure 2, and worst possible scenario in Figure 3. In (a) and (b), we show an optimized SE and its corresponding L_{max}(active).



(a) Optimization of SE per cell.
(b) Corresponding optimal number of UEs: active L
Fig 1: Based on inter-cellular interference, the optimal SE as a function of N.



(a) Optimization of SE per cell.
(b) Corresponding optimal number of UEs: active L
Fig 2: SE with best-case inter-cell interference as a function of N

The feasible SEs per cell with respect to inter-cell interference are totally different from the best possible scenario with respect to the other two different scenarios. The SEs offers by the ZF is much higher than MR in best possible scenario, Since then, interference in intracellular processes is likely to result in a high gain. The performance of P-ZF almost similar to ZF in best scenario. In The worst possible scenario the optimized SE is less in all different techniques mentioned in the Figure 3. In case of normal scenario the average effect of SEs optimized with ZF, MR, and P-ZF techniques are similar; In particular, the range of feasible antennas is 15 ≤ N ≤ 210.The biggest contrasts between all scenarios are making large differences when it comes to the SE with respect to large number of antennas, which are concerning with the logarithmic N-scales.

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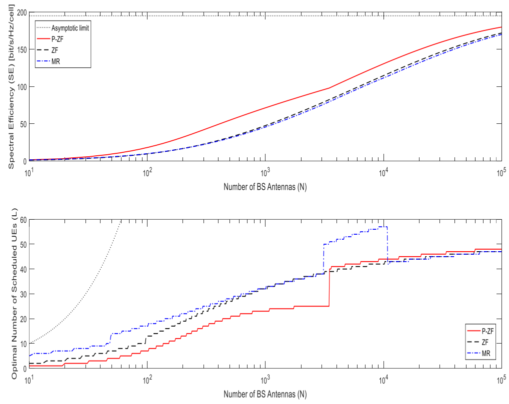
To reach SE to asymptotic limit, the minimum number of required antennas are 10^4 under the best possible scenario case of interference. Evidently, the system performance with respect to the asymptotic limits must not be consider because a large number are required in support of convergence[25].



(a) Optimization of SE per cell.
(b) Corresponding optimal number of UEs: active L
Fig 3: SE with worst-case inter-cell interference as a function of N.

The primary distinction between ZF,MR, and P-ZF as shown in Figure 1-3 are not giving the exact values for optimized SE, however the SEs are achieved by the β (pilot reuse parameter) and number of UEs L are participating in the processing scheme. The overall performance is that larger N suggests higher UEs L by way of lesser β, on the grounds that the channels turn into more orthogonal with respect to N. Given that the reuse parameter β is considered practically as an integer, involuntarily L is modifying as non-continuously as soon as pilot reuse parameter β changes; more modest β takes into consideration for larger number of L and conversely for L andβ. Scheduling for the MR scheme for larger UEs as well as changeover to a lesser β at fewer number of antennas as compared with the other schemes.

On the contrary, UEs are scheduled under the P-ZF scheme in smaller numbers ,which are most noteworthy parameters influencing large pilot reuse, because this thing suppresses most of the inter-cell interference in these scenarios. Merely telling that, the MR achieves low SEs per-user to many number of UEs i.e. sometimes it is more than N, ZF and P-ZF, on the other hand, achieve higher SEs to fewer users.

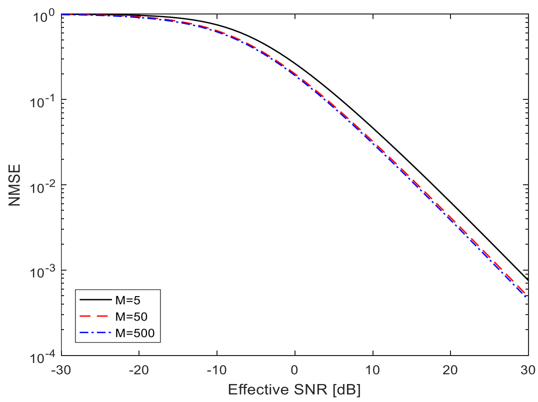


Fig 4: Estimation of the NMSE in MMSE spatially correlated channel

The MMSE estimator minimizes the MSE of the channel estimation, A normalized mean square error (NMSE) is used to compare estimation quality in different scenarios with different estimation schemes. The estimation error per antenna, as defined below, is a useful metric because it measures an antenna's relative estimation error per antennas, and as such is a suitable metric. An estimate of this value would be a value between zero i.e. perfect estimation and one which attained by the value of the variable, $h^{eff}{}_{irl}$. A plot of the NMSE versus the effective SNR is shown in Figure 4 is N = 5, N = 50, or M = 500 antennas. As the SNR increases, the results are monotonically decreasing and are averaged over different groupings of antennas, which are uniformly distributed. An estimation error variance of 0.5% percent of the channel's original variance and is observed at an SNR of 30 dB, meaning that the NMSE is 10^{-3}. SNR of 6 at nominal level can be achieved as the effective SNR. It is also interesting to note that the NMSE also decreases with the addition of more number antennas. As seen from the fact that NMSE easily estimates spatially correlated channels, this makes estimating spatially correlated channels of $1/(SNR_{eff}+1)$ is independent of N for a spatially uncorrelated channel of the arbitrary range of all reasonable integer pilot reusing factor β i.e. B =βL. Thus, spatially correlated channels are easier to estimate based on their statistical characteristics.

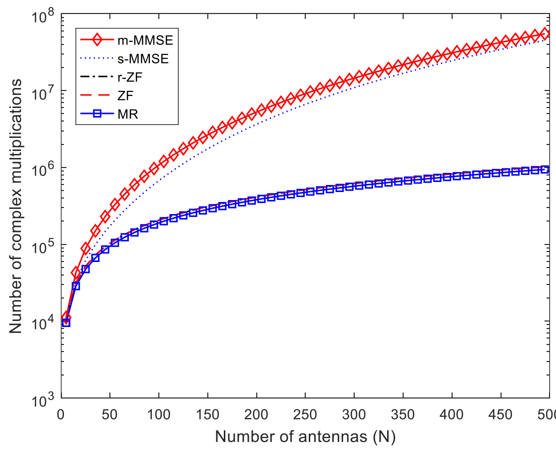


Fig 5: The system complexity of L = 20 with different N values

Let N range from 50 to 500 and L equal 20 as considered the situation as shown in Figure 5. and logarithmic scale applied to the vertical axes. In all combining schemes, system complexity increases as UEs and BSs antennas are increases. The m-MMSE and the s-MMSE have the highest complexity in the system. Figure illustrates the complexity reduction between 14 and 32 % for L = 20. The r-ZF, ZF and MR schemes invert smaller matrices than the m-MMSE and s-MMSE schemes, meaning they have a lower complexity in the system. As N is varied from 5 to 100, different values of throughput are achieved. Each scheme increases both throughput and EE simultaneously. m-MMSE enables to achieve the highest EE under any throughput value. EE is provided by schemes in slightly different ways according to the Figure 6 illustration. However, in all of these cases, the EE is a uni-modal function of the throughput and it reaches its maximum at roughly N = 30 or 40 regardless of the

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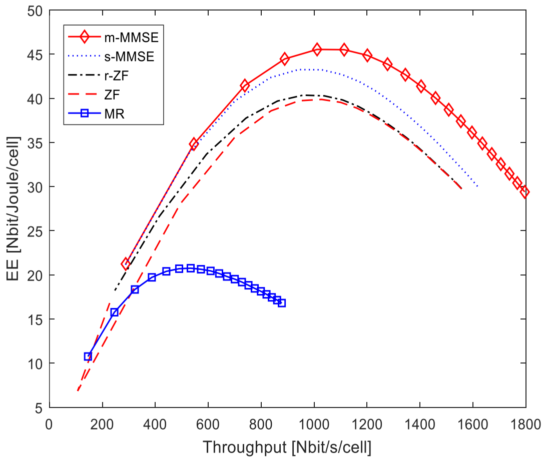

Fig 6: EE compared to throughput

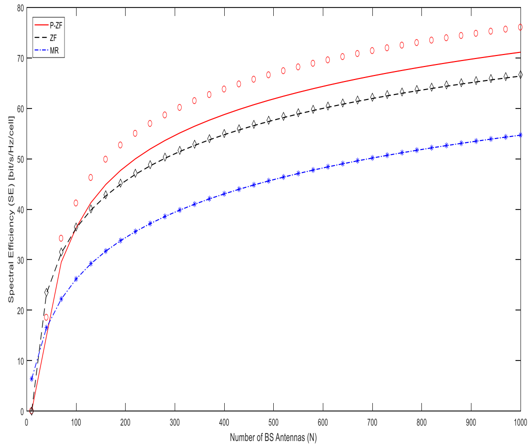

Fig 7: Per-cell SE for L = 10

system parameter value. While the antenna-UE ratios for massive MIMO are far from the range in which they are expected for maximum EE, the antenna-UE ratios which reach the highest EE are expected to be on the order of N/L = 2 or 3. Using the more energy-efficient hardware setup, we show that N increases as L increases.

Table I. Average throughput Megabits/sec by DL per cell

Method	N=5	N=10	N=50	N=100
m-MMSE	178	287	812	1267
r-ZF	164	257	801	1189
MR	156	245	789	1134
ZF	147	234	723	1089
P-ZF	172	285	808	1261

For the area transmit power to have meaning, it needs to be accompanied by a quality metric, such as the area throughput. The average throughput of DL summarizes per cell over a 18 MHz channel, L=20 is shown in table 1. The DL throughput Megabits/sec for N = 100 depending on the area throughputs.

ii.Parameters impact on System

Focusing on the normal scenario case of the average effect of inter-cell interference on UE locations, because of its practical significance, investigated and simulated the effect of parameter on system results. Considering the number of antennas N varying from 10 to 1000 and verify the accuracy of closed-form expressions by comparing them to Monte Carlo simulations.

Figure 7 shows that in the average interference case some SE is lost as a result of the interference variations between the best and worst cases with Monte-Carlo simulation is based on L = 10 UEs. A very tight relationship exists between MR and ZF. The P-ZF formula does have a few percent of variation, as a lower bound is used to get a tractable formula in order to cancel inter-cell interference. Accordingly, P-ZF will actually outperform in this paper.On Figure 8, the SEs per-cell are simulated for β values are 1 and 3, respectively, which are the highest when L = 100 and SNR = 5dB for N ≤ 1000 .Smooth curves are present around the β switching points with almost equal SEs around both values. Cell scheduling and planning can be simplified based on user load because of this robustness.

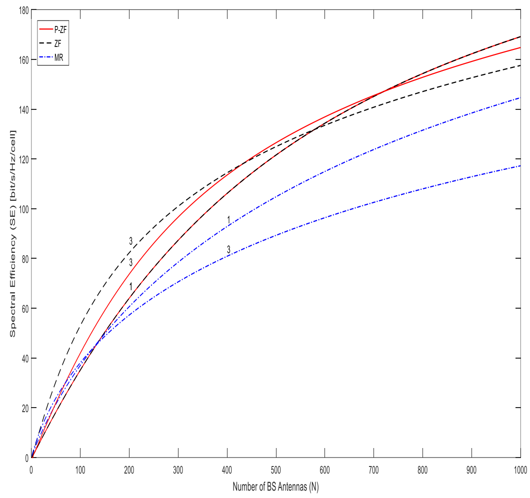

Fig 8: Systems designed for high SE per cell withchanging β.

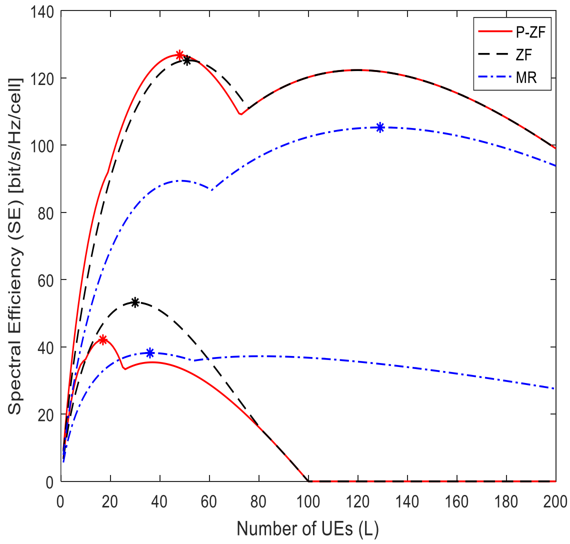

Fig 9: Possible SE per cell based on the number of scheduled UEs

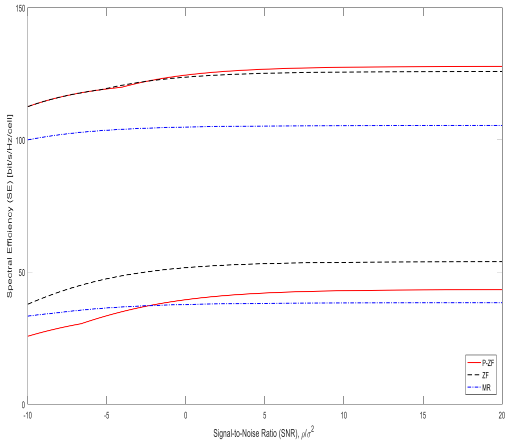

Fig 10: SNR Variation on SE

The Figure 9 shows the SE for each cell in relation to the number of scheduled UEs, because cells aren't always fully loaded at all times. Since peak numbers differ for each scheme at the same L (N=100 and 5 dB) then MR, ZF, and P-ZF will have different differences compared to the peak numbers for a given L. SE is often better in ZF and P-ZF than MR. However, MR is sometimes competitive in this regard when L is large. With N=100 and L=80. This figure illustrates how the average SNR $\sigma^2/\ \rho$ has an impact on the results.Due to the array gains from coherent processing, the SE has already reached saturation with a signal-to-noise ratio of 5 dB.Massive MIMO is also possible at lower SNRs despite performance losses.CSI estimation quality is especially critical for active interference suppression such as ZF and P-ZF since the SNR levels are high as shown in Figure 10.

IX. CONCLUSION

A fixed number of N is used in this paper to investigate how many users can be scheduled to maximize the SE per cell on massively multiuser systems. Due to the strong dependence of conventional SE expressions on UE positions, it is difficult to optimize L. Hence, power controlling and averaging over random positions of UEs, therefore, offers the possibility of obtaining SE expressions regardless of the location of the UEs at any given instant. There is no difference between the UL and DL expressions, so joint optimization is possible. In symmetric network topologies, these expressions can provide direct network-wide performance, where each cell can be represented by any other cell. By listening to neighboring cells' pilot transmissions, P-ZF,r-ZF,m-MMSE suppresses inter-cell interference through MR and ZF analysis. According to an asymptotic analysis, the SE-optimal L_{max} approaches S /2β as N approaches infinity, regardless of the processing scheme. When N is big enough, we should use half of the frame for pilot signalling since B = βL_{max} approaches to S/ 2. In spite of the asymptotic limit not being reached, the pilots should still be allocated some space: in simulations for $N \leq 1000$, and 5% to 40% of frame space should be allocated to pilots.

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