

Network efficiency enhancement by reactive channel state based allocation scheme

Umesha G. B., M. N. Shanmukha Swamy

Department of Electronics and Communication Engineering,
Sri Jayachamarajendra College of Engineering (SJCE), India

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ABSTRACT

Now a day the large MIMO has considered as the efficient approach to improve the spectral and energy efficiency at WMN. However, the PC is a big issue that caused by reusing similar pilot sequence at cells, which also restrict the performance of massive MIMO network. Here, we give the alternative answer, where each of UEs required allotting a channel sequences before passing the payload data, so as to avoid the channel collision of inter-cell. Our proposed protocol will ready to determine the channel collisions in distributed and scalable process, however giving unique properties of the large MIMO channels. Here we have proposed a RCSA (Reactive channel state based allocation) scheme, which will very productively work with the RAP blockers at large network of MIMO. The position of time-frequency of RAP blocks is modified in the middle of the adjacent cells, because of this design decision the RAP defend from the hardest types of interference at inter-cell. Further, to validate the performance of our proposed scheme it will be compared with other existing technique.

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Corresponding Author:

Umesha G. B.,

Department of Electronics and Communication Engineering,

Sri Jayachamarajendra College of Engineering (SJCE),

Mysore, Karnataka, India.

Email: umesh2719@rediffmail.com

1. INTRODUCTION

Massive MIMO is a technology where cellular BSs are having large number of antennas (NoA). It shows significantly amount of improvement in reliability and capacity of the wireless system, also it allows improve orders of magnitude in the spectral. The energy efficiency is also can be provided through relatively simple processing in massive MIMO (mMIMO), therefore it has been broadly studied from last two decades, also considered at many wireless standards. As per the random matrix theory [1], the channel vectors in between the BS and UE become the pairwise orthogonal. Therefore, it results the minimization of small-scale fading and uncorrelated noise effect as per the increment of antennas at BS in the MIMO network. Subsequently, the essential transmitted energy as per bit also can be asymptotically less without of much performance loss [2].

There are several contributions which provide insights on the energy efficient design of system; in [3], provided the optimization at downlink side of massive MIMO system using zero-forcing pre-coding scheme. Iterative prototype was considered under a true power consumption system in order to increase the energy efficiency. Though the approach aimed to get the enhanced energy efficiency at uniform rates for the every user, with considering the suitable channel state information. Moreover, a resource allocation based approach has provided in [4] to obtain the optimal energy efficiency with the BS coordination, the outcome reflected that the energy efficiency optimization difficulty was not convex but it was able to transform into

the convex fractional programming. However, the author in [5], aimed towards the theoretical investigation of energy efficiency and spectral efficiency for the multi-user type massive MIMO system. It showed some visions on the way for antennas allocation, also derived nearly expressions for the number of users that are necessary to be served in a network. However, it did not able to provide the complete structure and therefore the considered model was not much practical to use further.

Through the comparison with traditional system of MIMO [6] as shown in Figure 1, the large MIMO has many benefits such as the processing of modest linear at BS and also the antennas usage at mobile terminal. While considering the Time DD (division duplex) at large network of MIMO, the symmetrical pilots have some resources and need to utilize in adjacent cellular space, wherever the channel utilize offers grow for the channel contamination. That causes the negative impact, for example, attainable rate execution and exactness estimation at the uplink channel [1]. The author in [7] have thought about the CR-MIMO (cognitive radio), wherever the interference is occurred because of the optimal users of data transmission and therefore the essential users have affected through the channel transmission. In [8], the essential users promises the QoS in large system of MIMO through learning the impact of vast-scale essential BS on few optimal network of MIMO and through setting the best interference level in large network of MIMO. In [9], a pilot scheme for large MIMO of cognitive network has been proposed to improve the quality of channel evaluation of optimal users with reducing the negative reaction on essential network of channel estimation. In [10], propose a reciprocity which is based on large MIMO of beam-forcing method, so as the UEs (user equipment) during a network. Whereas a full spatial range sharing at large MIMO of network has been proposed [11] with the minimized overhead of preparing to reduce the PC. Likewise it utilizes 2-D DFT (Discrete Fourier Transform) for angular directional and spread of arrival estimation.

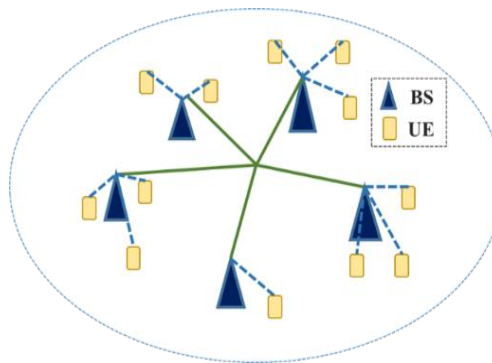


Figure 1. MIMO network diagram

Usually the cellular network assigns the dedicated resources to individual active of UE, in this manner it is vital for the BS to transmit time-frequency of resources area. The large network of MIMO allocates all assets of time-frequency to all UEs and confines them spatially in understanding to their channel sequences. There are restricted numbers of channel because of rational block size, while the concept of large MIMO [12], the important channel use again over the cellular area and it causes the channel contamination of inter cell, which leads toward the extra interference [13]. Thinking about the crowded urban situations, the number of active and inactive UEs present in the CN (cellular network) which is significantly more than the all accessible channel carrier groupings. In this way the channel can't be determined for all time with the specific UE in cell, because of this present it is needed to be deviously allocated and de-allocated so as to pursue its unpredictable recurrent information traffic design. The RAP (random access protocol) can be the best decision for this sort of channel resources allocation; however the design is additionally expected to beat the collision in dense cells immediately. In [9], proposed a technique where the UEs can ready to transmit the information under a chosen random channel from the normal pool, this reduces the entrance delays at the cost of channel collision that causes the intra-cell PC.

The collision is introduced because the graph code in [14] and also the belief propagation is taken into account to moderate the PC through applying the principle of RAC (random access code). The many SE (spectral efficiency) expressions are considered in [15] and utilized to enhance the probability of UE activation and also the channel length. Also, the asynchronous of timing UE is specified in [9] so as to determine and detect the channel collision in RAP. During this paper, we give the alternative answer, where

every of UEs required allotting a channel sequences before passing the payload data, so as to avoid the channel collision of intra-cell. These represent the thought about scenario of payload transmission within the large MIMO network [12-13]. Here, we have got targeted on the urban organizations with the help of few initial variation of the timing and propose a RAP for UEs that need to get the cellular network. Our proposed protocol will ready to determine the channel collisions in distributed and scalable process, however giving unique properties of the large MIMO channels. Here we have contributed a RCSA (Reactive channel state based allocation) scheme, which will very productively work the RAP blockers at large network of MIMO. The position of time-frequency of RAP blocks is modified in the middle of the adjacent cells, because of this design decision the RAP defend from the hardest types of interference at inter-cell.

2. LITERATURE SURVEY

A mMIMO is one of the most well-known technologies for the wireless communication and attracted the huge number of researchers due to its vast spatial diversity and high data transmission rate [16, 17]. However, in mMIMO system, the PC is a big issue that caused by reusing similar pilot sequence at cells, which also restrict the performance of network and cannot be reduced through maximizing the NoA [1]. Pilot or channel allocation is the effective process to minimize the PC [18-20]. In paper [21], proposed a pilot sequence based allocation approach in order to mitigate the consequence of PC in massive MIMO system; firstly derived the sum rate of uplink system when the BS antennas tend to infinity. In accordance to the derived expression, the contamination of pilot is only impairment with respect to the system performance. Afterwards, provided an optimized model of pilot allocation in order to increase the system sum-rate, where the outcome is obtained through all the conceivable allocations required to be examined that leads towards the higher computational complexity.

In paper [22], proposed the asynchronous scheduling approach that based upon the fractional reuse of pilot reuse, which allows the users to be free from PC at the time of uplink transmission. In according to the interference level, two groups are created from the users that can be denoted as center users, who's having the minor PC; also the edge users, who's having the simple PC and based upon this difference, a cell-centric pilot set can be reused for entire center users in cells; whereas, a set of cell-edge (CE) pilot is considered for the edge users under the adjacent cells. Therefore, the used pilots through the CE users are independent to each other, so the edge users able to transmit pilots at any period of time; nonetheless, the set of pilot for center users can be reused for entire cells, where the cell center users transmit their pilots over the non-overlapped times to evade PC.

A fair pilot allocation method has proposed in [23] for the multi-cell mMIMO, to reduce the PC effect and increase the sum rate (SR) of system with assuring the services among the users. Min Leakage algorithm (MLA) that is a heuristic algorithm is proposed to resolve the problem of optimization with lower system complexity, while considering the MLA can only deliver a suboptimal performance. Moreover, a greedy pilot allocation based User-Exchange approach is proposed to further improve the system SR and the services among users [23]. In [24], author considered the problem of resource allocation for the uplink mMIMO system, where the antennas at BS are priced and the virtualization has done across the service providers; though the mobile network provider (MNP) holds the complete infrastructure of antennas decides the price, also the Stackelberg game is considered for the maximization of net profit of MNP, whereas the minimum SR necessities of service providers are fulfilled. In order to resolve the bi-level problem of MNP, initially provided the closed-form optimal responses of service providers with respect of MNP pricing strategies. Therefore, the MNP problem can be decrease towards the single level optimization process. Afterwards, the approximations and transformations are used to cast the MNPs difficulty with the integer constraints to Signomial geometric program and, then applied an iterative approach based upon successive convex estimation in order to resolve Signomial geometric program.

Energy efficient based resource allocation approach is proposed in [25] for the multi-users mMIMO systems with the amplify-and-forward relay, where the dedicated relay guides the pairwise information interchange at several parts of single antenna UE. The energy efficiency system has theoretically examined through considering random matrix theory and huge system analysis, this results the optimal approximation for MIMO system with reasonable NoA. It also provides the some efficient approaches with different type of channel state information in order to increase the system energy efficiency through scheduling the appropriate relay antennas and, UE pairs with their corresponding transmission power. With respect to the conventional resource allocation approaches, the proposed prototype avoids the calculations of complicated matrix and the instant channel state information of the small-scale fading; so it provides efficient computation with small overhead of channel state information. Mostly of the works aimed on maximizing sum-rate of UEs but they have not considered the delay time that can decrease the all system performance for massive MIMO system.

3. PROPOSED METHODOLOGY

Here, we have considered the major four steps of RCSA approach as shown in Figure 2, where, the base station (BS) transmit the control signal and each of the UE will take use of this signal to predict its channel gain average and synchronizes itself through the BS. Afterwards, under a system initialization process and querying step, an inactive subset of UEs is considered in cell that wants to active. Each of the UE selects sequences of channel at random state from the predefined RAP channel pool, so the BS estimates its channel that has to be transmitted over. The UEs selection is similar for the RAP channels, if the collision has taken place then the BS acquires a superposition UE estimation channels. Afterwards, the BS cannot able to identify the followed collisions that similar to the situation in LTE.

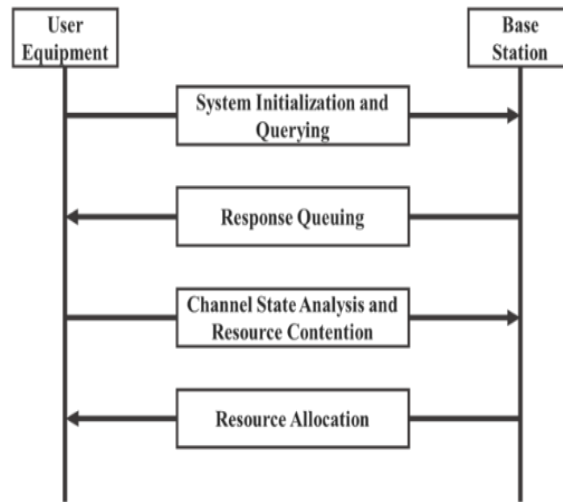


Figure 2. A proposed RCSA scheme for massive MIMO

Therefore, in reaction of queuing the BS responses through sending the downlink channels that are pre-coded through the channel estimates, which results at spatially aimed signals toward the UEs and offer the suitable RAP resource. In step 3, channel state analysis and resource contention mechanism is considered, where the probability of non-colliding channel transmission is considerably increased in RCSA approach. That allows the massive MIMO system to acknowledge UEs under the crowded scenarios, also provide the identity of UE and payload transmission request, which help to resemble the radio resource control connection followed by the demand in LTE. Whereas considering the step 4, it allows these resources by assigning a pilot sequence that further can be used at the payload blocks or to starts conflict resolution at the few cases whenever RAP collisions occurred. Therefore, the proposed RCSA approach stands for both; on its own, also for the orthodox contention resolution methods.

Each of B_0 UEs selects one of the uniformly pilots g_k at random under a RA block, b UE chooses the pilot $c(B) \in \{1, 2, \dots, g_k\}$. Moreover, UE generally like to be active at the present block with the probability of $K_x \leq 1$, which is permanent scenario based parameter that shows how the UE transmit or receive the data packets. Therefore, each of the inactive UE transmits a specific pilot sequence ψ_t with the K_x/g_k probability. The set is given be Q_t that consist the UEs indices that transmit t pilot, and ψ_t transmit sequences has a binomial distribution.

$$Q_t = \{b: c(b) = t, h_b > 0\} \quad (1)$$

$$|Q_t| \sim \delta(B_0, K_x/g_k) \quad (2)$$

Where, δ is denotes the circularly-symmetric composite Gaussian distribution. We considered that the t pilot is not in used ($|Q_t| = 0$) with the probability $(1 - K_x/g_k)^{B_0}$ and choose only one UE that is ($|Q_t| = 1$) with the $B_0 K_x/g_k (1 - K_x/g_k)^{B_0-1}$ probability. Therefore, the collision of RA ($|Q_t| \geq 2$) occurs during at arbitrary pilot with the probability of;

$$1 - (1 - K_x/g_k)^{B_0} - B_0 K_x/g_k (1 - K_x/g_k)^{B_0-1} \quad (3)$$

In a massive MIMO network [26], the collisions are needed to recognize and resolve as before of UE entering at payload blocks. Our proposed approach is a distributed process in order to resolve the collisions at UEs by utilizing the massive MIMO principle. Where the channel vectors at UE can be represented as $b \in B_0$ and the BS can be given as $d_b \in C^E$, where we consider a very general propagation model and the channels are also can be pre-assumed to satisfy these two conditions:

$$\frac{\|d_b\|^2}{E} \xrightarrow{E \rightarrow \infty} \beta_b, \quad \forall b, \quad (4)$$

$$\frac{d_b^D d_a}{E} \xrightarrow{E \rightarrow \infty} 0, \quad \forall b, a, b \neq a, \quad (5)$$

For some strictly value of β_b that is known to b UE, thus the channels can offered the asymptotic favorable propagation and channel reinforcing [27]. While considering step 1 for the RAP, the signal received through the BS is $\mathbf{F} \in C^{E \times g_k}$ from pilot transmission can be given as:

$$\mathbf{F} = \sum_{b \in B_0} \sqrt{h_b} d_b \psi_{c(b)}^T + \mathbf{L} + \mathbf{M} \quad (6)$$

where, inter-cell interference is symbolized through the $\mathbf{L}, \mathbf{M} \in C^{M \times \tau_p}$ is the self-determining receiver noise and individual distribution of element can be given as $CZ(0, \sigma^2)$ that is a complex Gaussian distribution, where the matrix $C^{E \times g_k}$ defines the interferences from the different adjacent cells. The time-frequency properties are divided into the coherence blocks of T channel and E that represents NoA. Transmit power is represented by h , C shows the complex value and transmitted pilot is represented by ψ . Through, correlating F with a normalized ψ_t pilot sequence, the BS obtains as;

$$f_t = \mathbf{F} \frac{\psi_t^i}{\|\psi_t\|} = \sum_{a=Q_t} \sqrt{h_a} \|\psi_t\| d_a + \mathbf{L} \frac{\psi_t^i}{\|\psi_t\|} + \varphi_t \quad (7)$$

$$f_t = \sum_{a=Q_t} \sqrt{h_a g_k} d_a + \mathbf{L} \frac{\psi_t^i}{\|\psi_t\|} + \varphi_t \quad (8)$$

where, $\|\psi_t\|$ is equal to $\sqrt{g_k}$, φ_t is the current receiver noise and it can be given as;

$$\varphi_t = M \frac{\psi_t^i}{\|\psi_t\|} \sim CZ(0, \sigma^2 \mathfrak{D}_E) \quad (9)$$

where, \mathfrak{D}_E denotes the $E \times E$ identity matrix. Recall that the Q_t is a UEs set which transmitted through ψ_t pilot and, the interference \mathbf{L} at inter-cell can be given as;

$$\mathbf{L} = \sum_Q L_Q \kappa_Q^T + \sum_{t=1}^{g_k} \sum_{b \in Q_t^{inter}} \sqrt{h_{t,b}} Y_{t,b} \psi_t^T \quad (10)$$

The first summation in above (10) shows the Q interfering transmission of data that carried out at neighboring cells, where, κ shows random data sequence and Y_t is the channel to the BS. In response queuing step, the BS replies towards the RAP pilots by sending the pre-coded downlink signal, which corresponds to each RAP pilots that were being used at the uplink. The reaction towards ψ_t is the sequence of channel $N_t \in C^{g_k}$ and, the downlink channel sequences can be presented as $N_1, N_2, \dots, N_{g_k} \in C^{g_k}$ that are orthogonal to each other and satisfy the condition $\|N_t\|^2 = g_k$. If the BS consider the normalized conjugate then $\frac{p_t^*}{\|p_t\|}$ as a pre-coded vector at N_t pilot sequence in downlink. Then after the signal directed to the multi-cast maximum ratio of transmission at UEs in Q_t , so the complete pre-coded downlink pilot signal \mathbf{R} can be given as;

$$\mathbf{R} = \sqrt{s} \sum_{t=1}^{g_k} \frac{p_t^*}{\|p_t\|} N_t^T \quad (11)$$

where, the downlink transmits s power and has a pre-defined value, whereas the pilot channel length is given as g_k and it is independent from the NoA. The received signal $\mathbf{U}_b \in C^{g_k}$ at the UE $b \in Q_t$ is;

$$\mathbf{U}_b^T = d_b^T \mathbf{R} + \tau_b^T + \eta_b^T \quad (12)$$

where, h_k^T shows the reciprocal downlink channel, v_k corresponds to C^{g_k} is an inter-cell interference, η_b is a receiver noise signal. Through correlating the \mathbf{U}_b receiver signal with the normalized downlink N_t pilot sequence, the UE obtain as;

$$U_b = \mathbf{U}_b^T \frac{N_t^*}{\|N_t\|} = \sqrt{s g_k} d_b^T + r_b^T \frac{N_t^*}{\|N_t\|} + \eta_b \quad (13)$$

where, the effective receiver noise $\eta_b = \eta_b^T \frac{N_t^*}{\|N_t\|} \sim CZ(0, \sigma^2)$, therefore the asymptotic favorable propagation is considered.

$$U_b / \sqrt{E} = \sqrt{s g_k} \frac{(d_b^T p_t)^*}{E} \frac{1}{\sqrt{\frac{1}{E} \|p_t\|^2}} + r_b^T \frac{N_t^*}{\sqrt{E} \|N_t\|} + \frac{\eta_b}{\sqrt{E}} \quad (14)$$

$$\xrightarrow{E \rightarrow \infty} \frac{\sqrt{h_b s \beta_b g_k}}{\sqrt{\sum_{a=Q_t} h_a \beta_a g_k + \omega_t + \sigma^2}}$$

The noise does not maximize with E , so the r_b inter-cell interference is not affected by E . Later on the assumption is made if the nearest interfering cells transmit RA pilots through assign downlink pilots in different methods, which causes the minimization at pilot contaminated interference. Considering (14), we can define the sum of interference gain and signal received at BS at uplink transmission of ψ_t pilot;

$$V_t = \sum_{a=Q_t} h_a \beta_a g_k + \omega_t \quad (15)$$

So, the function $R(\cdot)$ provides the real block of its input and based on the (14), the approximation can be given as;

$$\frac{R(U_b)}{\sqrt{E}} \approx \frac{\sqrt{h_b s \beta_b g_k}}{\sqrt{V_t + \sigma^2}} \quad (16)$$

where, we have removed the imaginary part of U_b , which contains the estimation error, interference and noise. Therefore, the b UE can use the approximation in order to estimate V_t ;

$$\hat{V}_{t,b}^{approx} = \max\left(\frac{E s h_b \beta_b g_k^2}{(R(U_b))^2} - \sigma^2, h_b \beta_b g_k\right) \quad (17)$$

where, max function will take maximum of two values and this estimator become asymptotically error-free when $E \rightarrow \infty$ (14).

In step 3 provide the channel state analysis and resource contention mechanism to resolve the channel contentions issue at the distribute manner, therefore each channel is repeated ones at one UE. UE $b \in Q_t$ is taken for the signal gain $h_b \beta_b g_k$ and, estimate $\hat{V}_{t,b}$ signal gain sum that contending UEs and inter-cell interference. The BS takes the RAP repetitive pilot transmission that followed by uplink message, BS takes the t^{th} pilot signal to predict the channel at UEs, which sent the ψ_t and decodes the corresponds message. Afterwards the successful decoding, the BS acknowledged one UEs in Q_t to provide coherent blocks of payload by allocating the pilot channel sequence. This allocation result is forwarded towards the downlink in step 4 and same for the step 2. The RCSA approach is repeated for the fixed number of interval, if the UEs were not recognised in step 4, then it's instructed to transmit via a new RAP channels.

4. RESULTS AND ANALYSIS

Here, we provide result analysis using our proposed RCSA approach that compared with the vertex graph-coloring-based pilot assignment (VGCPA) approach [28]. The proposed scheme exhibits the four major steps; system initialization and querying, response queuing, channel state analysis and resource contention, and resource allocation, which allows decreasing the delay time and failed access attempts, also increases the end-to-end success rate. In order to validate the result analysis two scenarios has been considered, where all the other parameters are same except the number of BS. The parameters are shown in Table 1, which has been applied before simulation of code. Here we will compute the three major things that cause the PC in a network such as; end-to-end success rate, delay time in mille seconds and failed access attempts.

In scenario A, we computed end-to-end success rate, delay time in mille seconds and failed access attempts at 100 number of BS. Figure 3 shows end-to-end success rate, where our proposed model got 72.83% of improvement with respect to VGCPA. Figure 4 shows delay time in msec, where our proposed model got 43.63% less average delay time with respect to VGCPA. Figure 5 shows the failed access attempts, where the mean failed access attempts from our RCSA scheme is 0.0844, whereas from VGCPA

we got 0.75. Similarly coming to scenario-B, where the considered number of BS is 200. Figure 6 shows end-to-end success rate, where our proposed model got 73.38% of improvement compared to VGCPA model. Figure 7 shows delay time, where our proposed model got 43.68% less average delay time compared to VGCPA. Figure 8 shows the failed access attempts, where the mean failed access attempt from our RCSA scheme is 0.0855, which is 88% less compared to existing VGCPA approach.

Table 1. System parameters

Serial No.	Parameters	Parameters Values
1	Monte-Carlo realizations	500
2	BS antennas	100 or 200
3	Number of UEs	1000 to 20000
4	Maximum number of attempts	10
5	Probability of retransmitting	0.5
6	RA pilot signals	10
7	Transmit power of UEs	1 dB
8	Transmit power of the BS	1 dB
9	Noise variance	1 dB
10	Standard deviation of fading	10 dB
11	Cell Radius	250 m
12	Number of active UEs in neighboring cells	10

Scenario-A

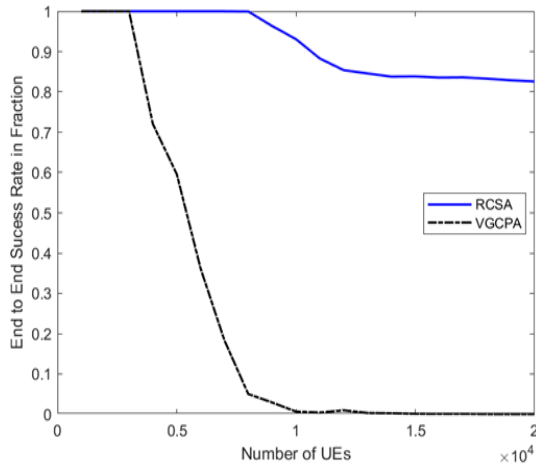


Figure 3. End-to-end success rate

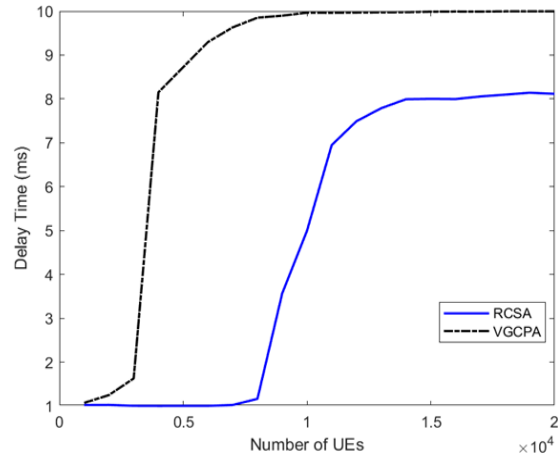


Figure 4. Delay time (ms)

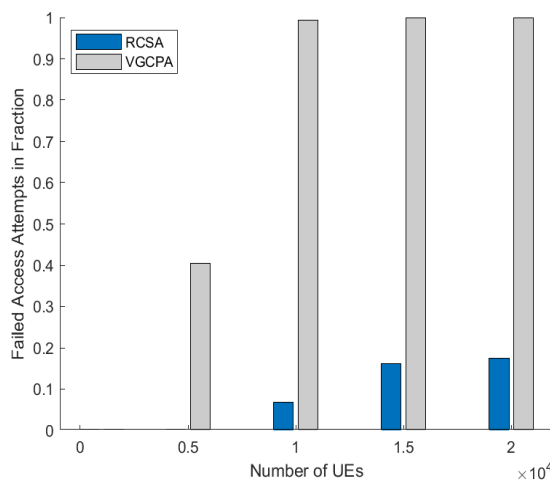


Figure 5. Failed access attempts

Scenario-B

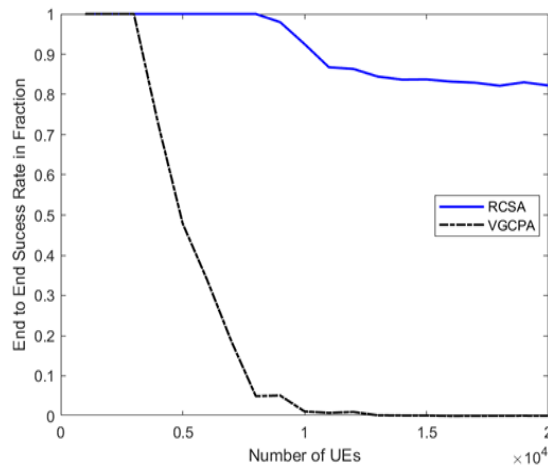


Figure 6. End-to-end success rate

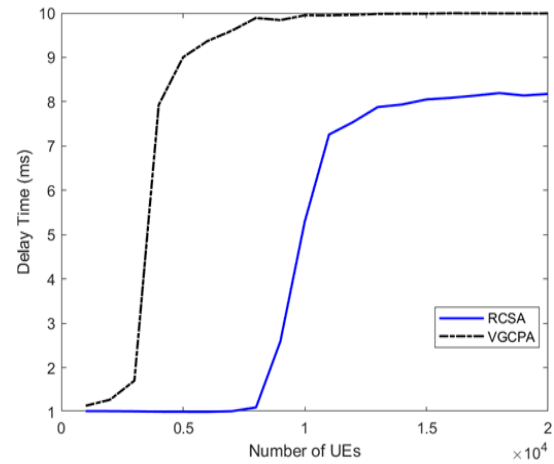


Figure 7. Delay time (ms)

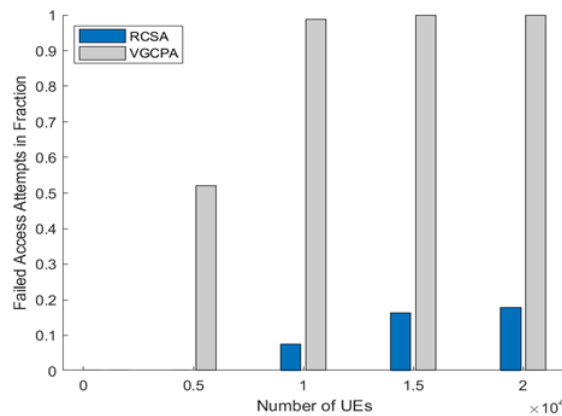


Figure 8. Failed access attempts

5. CONCLUSION

In massive MIMO system, the PC is a big issue that caused by reusing similar pilot sequence at cells. The proposed scheme exhibits the four major steps, which allows decreasing the delay time and failed access attempts, also increases the end-to-end success rate. In reaction of queuing the BS responses through sending the downlink channels that are pre-coded through the channel estimates, which results at spatially aimed signals toward the UEs and offer the suitable RAP resource. The channel state analysis and resource contention mechanism is considered for the non-colliding channel transmission is considerably increased in massive MIMO network. So RCSA approach also allows the massive MIMO system to acknowledge UEs under the crowded scenarios. In the result analysis section our proposed RCSA approach is compared with the VGCPA approach, and we showed that our proposed model has performed considerably well at both considered scenario which validate the performance of our model.

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