METRIC-BASED RANDOM ITERATION ALGORITHM FOR RESOURCE MANAGEMENT IN NON-ORTHOGONAL MULTIPLE ACCESS OF WIRELESS NETWORKS

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ABSTRACT

In this paper, we focus on joint subcarrier and power allocation in the uplink of an NOMA system. The main taxonomy of NOMA is presented by focusing on the following categories: power-domain and code-domain NOMA. Then a novel radio resource management framework is presented metric-based random iteration Algorithm (MRIA) for uplink and downlink transmissions. This method determines target subject that it is number of scheduled users, so that the number of multiple access users in NOMA can be increased compared to previous works. The MRIA transmitter and receiver have been investigated and compared it to other NOMA approaches from the aspect of receiver complexity and system performance.

KEYWORDS*: NOMA; Code-domain; Wireless network; Metric; metric-based random iteration Algorithm (MRIA)*

1.0 INTRODUCTION

NOMA technique has been proposed for 5G wireless systems and beyond is an in-cell multi-user sharing Algorithm that has not been used in the field of power and code in the previous generation. In (Song, L.Y., Li, Y.H., Ding, Z.G., & Poor, V.H., 2017) the domain of code, time and frequency was a characteristic, than NOMA can support simultaneously a large number of users. NOMA allows multiple users to assign a sub-carrier to multiple users, creating multi-user interference. To solve this problem, the Multi-User Detection (MUD) technique, such as SIC interception on the receiving side, is applied to decode

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incoming signals. NOMA utilizes the intelligent reuse of network resources and the integration of multi-user messages in the same transmitter's sub-channel. Resource management is divided into two categories: the power domain and the code domain. Now, by an iteration algorithm based on norm, the total sum-rate and the performance of the system improved.

2.0 SYSTEM MODULE

Consider a downlink NOM network with only one cell and a number of mobile users, given in Figure 1, in which the BS transmits the signals to serve the mobile users denoted by N={1,2,….,N}. The BS divides the available bandwidth into a set of subcarriers, denoted by K={1,2,….,K}, where N is much larger than K. Notice that other types of network resources, such as multiple antennas, time slots and spreading codes, can be also directly applied to avoid inter-group interference. As in (Au, K., Zhang, L.Q., Nikopour, H., Yi, E., Bayesteh, A., Vilaipornsawai, U., Ma, J.L., & Zhu, P.Y., 2014), it is assumed that each SCMA layer represents a user. There are J codebooks assigned by the BS to the users, and each user is assigned with a codebook. It is assumed that each codebook contains M codewords of length K. The number of nonzero elements in each codeword is d_v, and $d_v \ll K$, i.e., the codewords are sparse. At the transmitter, bit streams of each user with the length of $\log_2 M$ bits are directly mapped to different sparse codewords of corresponding codebook, in which the codewords are generated through multi-dimensional constellation (Beko, M., & Dinis, R., 2012). After the data stream of each user N_j is mapped to a sparse codeword x_j, all N SCMA layers are multiplexed over K shared subcarriers. The received signal over subcarrier K can be given by

$$y_k = \sum_{j=1}^{N} h_{kj}\, x_{kj} + n_k, \tag{1}$$

where x_{kj} is the kth component of the codeword x_j, h_{kj} is the channel coefficient of user j over subcarrier K, $n_k \sim CN\ (0, \sigma_n^2)$ is the additive white Gaussian noise (AWGN). To further improve the spectrum efficiency, codebook-based resource allocation needs to be considered, including the subcarrier assignment and power allocation, i.e., determining positions of non-zero elements in each user's codebook and adding power offset to the generated constellation. The BS is supposed to have a complete Channel Information (CSI). Based on the CSI of each channel, the BS assigns a subset of subcarriers to the users and allocates different levels of power to them. According to the SCMA protocol (Nikopour, H., Baligh, H., 2013), one subcarrier can be allocated to at most d_f users, and one user can transmit to the BS through at most d_v subcarriers. The power allocated to user $N_j \in N$ over subcarrier $K_i \in K$ is denoted by p_{ij}, satisfying $\sum_{k\in K} p_{kj} \le P_j$ where P_j is the total transmitted power of user N_j. Let S_i be the set of scheduled users over subcarrier K_i, i.e., the set of users whose codewords have a nonzero element at positioni. For convenience, it is defined a $K \times N$ subcarrier-user matrix $F = [f_1, f_2, \ldots, f_N]$ where the binary entry f_{ij} denotes whether K_i is allocated to user N_j. Thus, the received signal over subcarrier K_i in (1) can be rewritten as

$$y_i = \sum_{j=1}^{N} \sqrt{p_{ij}} h_{ij} \sum_{m=1}^{d_v} v^j{}_{im} g_{jm} + n_i \tag{2}$$

in which V_j is a binary $K \times d_v$ mapping matrix for user N_j satisfying $diag = [V^j(V^j)^T] = f_j$, and $g_j = [g_{j1}, \ldots, g_{j2}]^T$ is a d_v-dimensional vector where g_{ji} is a constellation point with unit average power in the rotated mother constellation without power offset. In (Di, B., Song, L.Y., & Li, Y.H., 2016), the sum-rate of user N_j over K_i, also known as N_j's utility, is then given by

$$R_{ij} = f_{ij} \log_2(1 + \frac{p_{ij}|h_{ij}|^2}{\sigma_n{}^2 + I_{ij}}), \tag{3}$$

Where I_{ij} is the interference that user M_j receives from other users in S_i over subcarrier K_i,

$$I_{ij} = \sum\nolimits_{m\in\{\mathcal{S}_i |\, |h_{im}|^2 > |h_{ij}|^2\}} p_{im}|h_{im}|^2. \tag{4}$$

The optimization problem is then formulated as:

$$\max_{f_{kj}, p_{kj}} \sum_{j\in\mathcal{N}} \sum_{k\in\mathcal{K}} f_{k,j} \log_2\left(1 + \frac{p_{kj}|h_{kj}|^2}{\sigma_n^2 + I_{kj}}\right) \tag{5a}$$

$$s.t.: \sum_{j\in\mathcal{N}} f_{kj} \le d_f, \forall k \in \mathcal{K} \tag{5b}$$

$$\sum_{k\in\mathcal{K}} f_{kj} \le d_v, \forall j \in \mathcal{N} \tag{5c}$$

$$f_{kj} \in \{0,1\}, \forall k \in \mathcal{K}, j \in \mathcal{N} \tag{5d}$$

$$\sum_{j \in \mathcal{K}} p_{kj} \leq P_s, \forall j \in \mathcal{N} \tag{5e}$$

$$p_{kj} \geq 0, \forall k \in \mathcal{K}, j \in \mathcal{N} \tag{5f}$$

Constraints (5*b*)- (5*d*) ensure that each subcarrier can only be assigned to at most d_f users, and at most dv subcarriers can be allocated to one user, which is determined according to the sparse nature of the codewords. Due to the limited transmitted power of each user, the power variables need to satisfy constraint(5*e*) and (5*f*).

This optimization problem is a non-convex one due to the binary constraint as well as the existence of the interference term in the objective function. Therefore, the conventional centralized methods may have the exponential complexity making them intractable. To facilitate the subcarrier allocation as well as to model users' peer effects, we introduce metric-based random iteration Algorithm (MBRI).

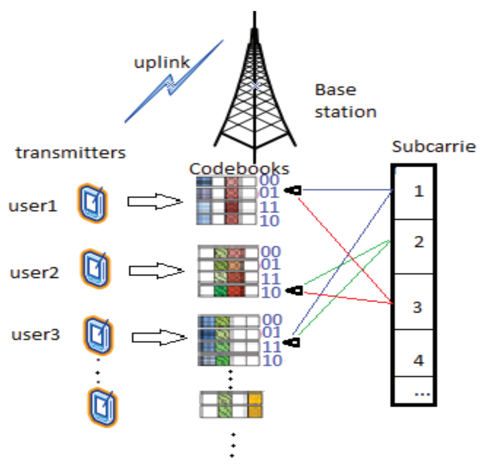

Figure 1 NOMA network system model

3.0 METRIC-BASED RANDOM ITERATION

The problem can be optimized to get Matrix to used MIRA. This matrix is randomly designed, that is the matrix of each series that runs the simulation gives a matrix randomly. Ultimately, Users programmed have been checked against the number of users in a time slot.

This algorithm consists of two steps. In the first step, an initial target and a randomly selected problem solution are chosen. This random response is compared using an error rate with the intended target response. Primary objective is appraised the maximum number of users in resource allocation management with non-orthogonal access methods. The error rate is defined using the Euclidean metric. Using the Euclidean metric, an error rate is defined, and the linear regression between the objective and the solution of the problem is used such that happen randomly in each iteration process, for optimal conditions. Since repeat processing may is time consuming, in the first step, the number of repetitions can be restricted and improve the optimal response in the second stage. In the second step, the responses obtained are initially considered to be objective and apply the first stage processing to the minimum of the error rate obtained in the first step. The algorithm is presented in Table 1.

Table 1 Metric-Based random iteration Algorithm

Algorithm: Optimal solution to the problem (5a)

```
Step 1.
  1.  input  Channel condition, error rate,
      regression, number of iteration, targets
  2.  0utput Optimal problem solution
  3.  i=1 to number of iteration
  4.  f= randomly selected problem solution
  5.  r=norm(f-Targets)
  6.  reg = regression(f,Targets);
  7.  if r< error rate & reg> regression
  8.  break
  9.  r=min(r);
  10. save(OptimaiData.mat,f,r,number of
      iteration)
  11. MyData = matfile(OptimaiData.mat)

  Step 2.
  1.  New error rate < error rate
  2.   Exrra_iteration> number of iteration
  3.  Targets=MyData.f
  4.  i=1 to number of iteration
  5.  f= randomly selected problem solution
  6.  r=norm(f-Targets)
  7.  reg = regression(f,Targets);
  8.  if r< error rate & reg> regression
  9.  break
```

4.0 SIMULATION RESULTS

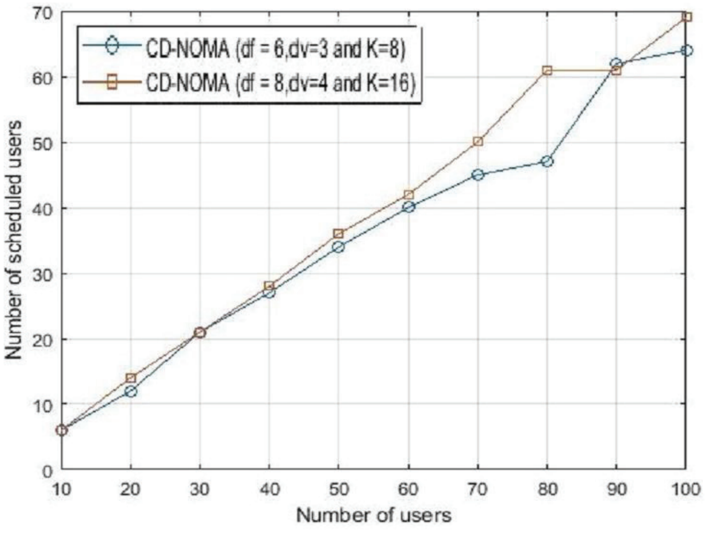

Figure 2 Number of scheduled users v.s. number of the users, in step 1

In this section, we evaluate the performance of the proposed MRIA, and compare its performance with the OFDMA scheme and a random allocation algorithm for the SCMA scheme that is presented in (Di, B., Song, L.Y., & Li, Y.H., 2016). In the OFDMA scheme, it is assumed that each sub channel can only be assigned to one user, and joint subcarrier and power allocation is performed utilizing the algorithm in (Kim, K., & Han, Y.N., 2005). In the random allocation algorithm for the SCMA scheme, the set of subcarriers is randomly allocated to the users by satisfying constraints (5b) and (5c). For the simulations, the peak transmission power of each user is considered , P_s to 23dBm, noise variance, σ2 to -174dBm/Hz, carrier center frequency to 2GHz, resource block bandwidth to 180kHz, and it is assumed that the pass loss is obtained by a modified Hata urban propagation model. Specific values of the non-elements in each SCMA codebook are designed according to (Taherzadeh, M., Nikopour, H., Bayesteh, A., Baligh, H., 2014). All users are uniformly distributed in a square area with the size of length 350m. Figure 2 determine the number of users scheduled in step 1, when error rate = 59, Regression values= 0.95, number of iteration = 10^3. Figure 3 show the number of users scheduled in step 2, when error rate = 58, Regression values= 0.95, number of iteration = 10^4.

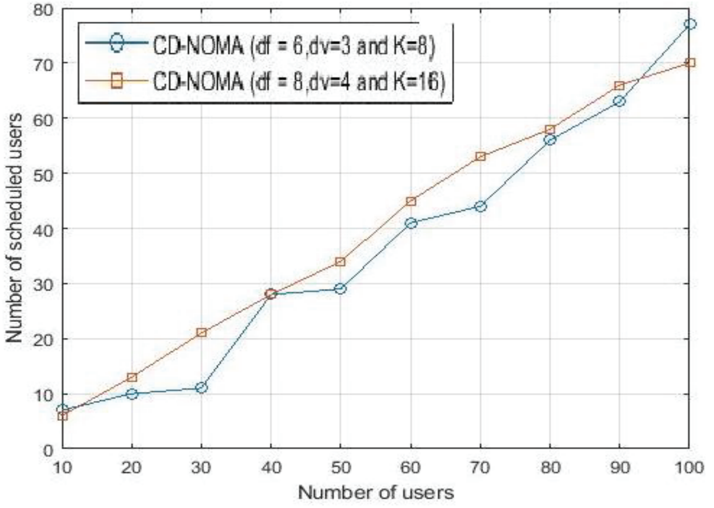

Figure 3 Number of scheduled users v.s. number of the users, in step 2

5.0 CONCLUSION

In this paper, the domain sparse code resource allocation problem in an uplink SCMA wireless network is studied by optimizing the sub-channel assignment and power allocation to maximize the total sum-rate. We propose a new Multiple Access technique for 5G which uses code domain to send multiple users' signals in a subcarrier. The MRIA transmitter and receiver have been investigated and compared it to other NOMA approaches from the aspect of receiver complexity and system performance. To this end, a novel resource allocation problem is presented. To solve the proposed problem, it is used an iteration algorithm based on the Euclidean metric. Moreover, from simulation results, it is concluded that the MRIA technique significantly outperforms other NOMA techniques while imposing a reasonable increase in complexity to the system. Future works include improving the robustness of MIRA decoders by taking into account factors such as CSI uncertainty, and developing more robust SIC ordering techniques. As a future work, the link level performance of MIRA can be studied based on artificial intelligence systems.

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