A Generalized M-Users Pairing Scheme for Non Orthogonal Multiple Access

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Abstract

Non-orthogonal multiple access (NOMA) is a promising candidate to be a part of the 5G wireless communications framework. This paper proposes a generalized *M*-users pairing scheme for a NOMA system. The goal of the proposed scheme is to make sure that maximum possible number of users are paired in a user pair. Minimum allowed channel gain difference between any two paired users is considered as the criteria for pairing the users. It is shown through simulations that the proposed scheme can efficiently make users pairs from a set of *N* users.

Ⅰ. Introduction

Non-orthogonal multiple access (NOMA) is considered as a promising radio access technique for 5G. In NOMA, multiple users can use the same time, frequency and code resources such that their signals from the base station (BS) are superposition coded in the power domain. As multiple users use same resources, mutual interference between paired users is a critical issue. To tackle this, successive interference cancellation (SIC) is used. The performance of SIC depends on the difference in channel gains of paired users and their power allocation factors (PAF). In NOMA, users in a user pair should have large channel gain differences to achieve manifold capacity gains. Some user pairing schemes for maximizing the system capacity are proposed in [1] [2]. Once the users are paired with each other, efficient power allocation must be carried out to achieve the targeted gains [3].

Ⅱ. System Model and Proposed Scheme

We consider a system model consisting of *N* users as shown in Fig. 1. The sorted channel gains of the *N* users are in the order $|h_1|^2 \geq |h_2|^2 \geq \ldots |h_N|^2$. Let the minimum required channel gain difference between any two paired users be denoted by the threshold γ. Then some *M* users can be paired with each other to form a u_{th} pair, if for every two randomly picked users in that user pair, the condition in (1) is satisfied.

$$|h_{u,i}|^2 - |h_{u,j}|^2 > \gamma \qquad \forall\ i,j\ \in\ M \quad \& \quad i \neq j \tag{1}$$

where $|h_{u,i}|^2$ and $|h_{u,j}|^2$ represent the channel gains of any two users i and j in a u_{th} pair. For *N* users with sorted channel gains, let the lowest and highest channel gains $|h_1|^2$ and $|h_N|^2$ be represented as $|h_{min}|^2$ and $|h_{max}|^2$ respectively. From (1), the maximum possible users in a pair is given by (2).

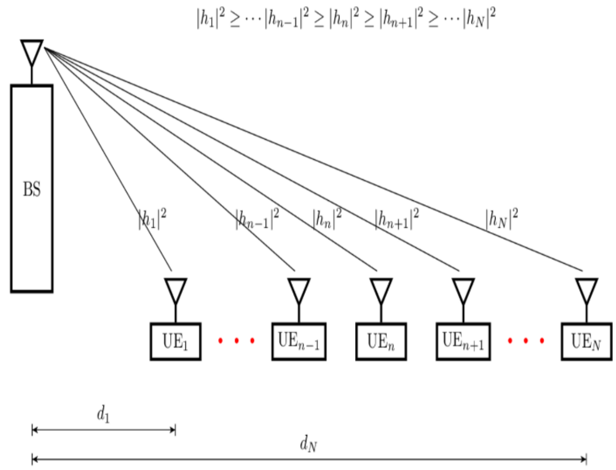

Fig. 1: System Model

$$M_{max} = \left\lfloor \frac{|h_{max}|^2 - |h_{min}|^2}{\gamma} \right\rfloor, \tag{2}$$

where $\lfloor . \rfloor$ is the floor function. We divide cell users into G_{max} groups based on their channel gains, where $G_{max} = M_{max}$. The channel gain range Δh of users in each group is given by (3).

$$\Delta h = \left\lfloor \frac{|h_{max}|^2 - |h_{min}|^2}{G_{max}} \right\rfloor, \tag{3}$$

Thus channel gains of all i_{th} users in the first group will be in the range $|h_{min}|^2 \leq |h_i|^2 \leq |h_{min}|^2 + \Delta h$. The next group users will have channel gains range $|h_{min}|^2 + \Delta h < |h_i|^2 \leq |h_{min}|^2 + 2\Delta h$, and so on. The number of users in each group depends on users' distribution in the cell and the difference $|h_{max}|^2 - |h_{min}|^2$. Once users are divided into groups, user pairs are made by picking appropriate users from these groups. It is evident from (1)-(3) that a user pair cannot have two users from the same group, as they will not satisfy (1).

The proposed user pairing scheme focuses on accommodating maximum possible number of users in pairs. In the start, users from each group find appropriate users from all other groups to make user pairs having M_{max} users. After some users get paired, the probability that a user from any group will find $M-1$ users from other groups to make a M-users pair will decrease. At the end, there can be some unpaired users also. Consider users in a cell being divided into different groups as discussed earlier. For a user i from any group G_x, the set $U_{j|i}$ of eligible users j from an adjacent group G_y out of which any user can be paired with i is given by (4).

$$U_{j|i} = \{ j \mid \text{abs} \left(|h_j|^2 - |h_i|^2 \right) > \gamma \} \quad (4)$$

The set $U_{j|i}$ is used because all users from the adjacent group G_y may not be eligible for pairing with a user $i \in G_x$. For example, users near the boundary of the two adjacent groups cannot be paired with each other as they will have very close channel gains. Consider only two groups G_1 (low gain users) and G_2 (high gain users) for pairing. For any random user $i \in G_1$, it is paired with a user $j \in G_2$ to form a u_{th} user pair using (5).

$$\text{Pair}_u = i, \{ j \mid j = \min(U_{j|i}) \} \ \forall \ i \in G_1, j \in U_{j|i} \quad (5)$$

where $U_{j|i} \subseteq G_2$. Conversely, for any user $i \in G_2$, it is paired with user $j \in G_1$ using (6)

$$\text{Pair}_u = i, \{ j \mid j = \max(U_{j|i}) \} \ \forall \ i \in G_2, j \in U_{j|i} \quad (6)$$

where $U_{j|i} \subseteq G_1$. Using (5) and (6), for a user i from any group, a general equation to find users from adjacent groups to pair with i is shown in (7).

$$\text{Pair}_u = i, \begin{cases} j \mid j = \min\left(U_{j|i}\right), & i \in G_x, U_{j|i} \subseteq G_y, y = x+1 \\ j \mid j = \max\left(U_{j|i}\right), & i \in G_x, U_{j|i} \subseteq G_y, y = x-1 \end{cases} \quad (7)$$

where $y = x+1$ and $y = x-1$ show that G_y is the adjacent higher and lower group to G_x respectively.

Ⅲ. Simulations and Results

We consider a system of $N = 24$ users with random channel gains normalized to 1. $|h_{min}|^2$ and $|h_{max}|^2$ from these gains were picked, $|h_{min}|^2 = 0.15$, $|h_{max}|^2 = 0.91$. $\gamma = 0.18$ is set, which gives $M_{max} = 4$ (maximum four users in a pair), group range $\Delta h = 0.19$. The initial user grouping is shown in Table.1.

Table 1: Grouping of Users

Grp	Channel Gains of Users in Each Group							
G1	.15	.15	.20	.20	.21	.28	.29	.32
G2	.37	.38	.45	.48	.53			
G3	.56	.57	.62	.66	.70			
G4	.76	.76	.80	.84	.91	.91		

User pairing results are shown in Table.2, and Fig. 2.

Table 2: User Pairing Result

Pair	Channel Gains of Users			
P1	.15	.37	.56	.76
P2	.15	.38	.57	.76
P3	.20	.45	.66	.91
P4	.20	.48	.70	.91
P5	.21	.53	.80	
P6	.28	.62	.84	
P7	.29			
P8	.32			

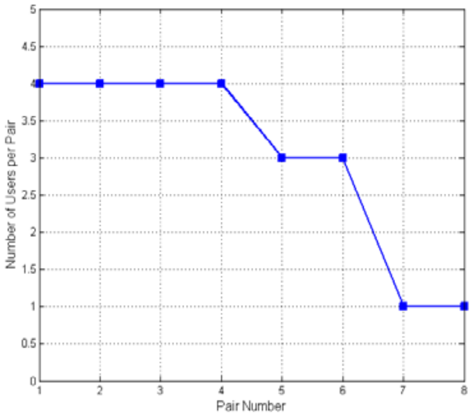

Fig. 2: User Pairing Result.

Ⅳ. Conclusion

This paper proposes a generalized M-users pairing scheme for a NOMA system. The goal of the proposed scheme is to make sure that maximum possible number of users are paired in a user pair. It is shown through simulations that the proposed scheme can efficiently make users pairs from a set of N users.

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