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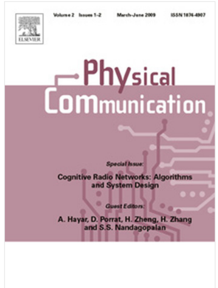

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User Pairing and Power Allocation for Non-orthogonal Multiple Access: Capacity Maximization under Data Reliability Constraints

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Abstract

This paper comprehensively investigates the dynamics of user pairing and power allocation (UPPA) in non-orthogonal multiple access (NOMA). The focal point of this work is to explore the effects of UPPA on capacity and bit error rate (BER) of NOMA users, thereby understanding the tradeoffs involved when UPPA is performed. These tradeoffs facilitate the design of UPPA strategies to maximize system capacity and satisfy individual target data rates of users without exceeding their allowed BER upper bounds to meet the strict data reliability constraints. Data reliability is critical in NOMA and serves as bottleneck to its manifold capacity gains, as NOMA users are prone to significant interference. The existing UPPA strategies focusing on capacity maximization or user fairness completely neglect this extremely critical tradeoff. This paper provides extensive analysis and results of UPPA considering individual/sum capacity and BER of users. Results are summarized in the form of look-up tables, which facilitate swift selection of user pairs and power allocation factors. The process of performing UPPA by using the developed look up tables, such that both capacity and data reliability goals can be simultaneously achieved, is comprehensively explained in the end.

Keywords: Non-orthogonal multiple access (NOMA), user pairing (UP), power allocation (PA), capacity, bit error rate (BER), successive interference cancellation (SIC).

1. Introduction

The fifth generation (5G) of wireless communication technology has been in the limelight because of its expectancy to meet the theatrically increased capacity demands of communication networks [1, 2, 3, 4, 5, 6]. To achieve various goals of 5G, numerous dimensions of technological advancements are being investigated in parallel. The possibility of using non-orthogonal multiple access (NOMA) principle for the design of radio access techniques for 5G is very much on the cards [7, 8, 9]. In particular, power domain NOMA has gained significant research interest by virtue of its astounding spectral efficiency [10, 11, 12, 13].

The essence of this exceptional spectral efficiency of NOMA is in its ability to achieve resource multiplicity by allowing multiple users (in a NOMA pair/group) to be served in each orthogonal resource block, e.g., a time slot, a frequency channel, a spreading code, or an orthogonal spatial degree of freedom. The message signals of paired users are weighted in terms of power, superimposed, and transmitted by the base station (BS). Being prone to considerable mutual interference, some users perform skilled interference cancellation (IC) techniques like successive interference cancellation (SIC), multilevel decoding based on gray labeling, etc., to recover their own signals [14, 15, 16, 17]. Contrary to this, some users in the pair (prone to less interference) directly decode their own signals without employing any IC technique.

User pairing (UP) and power allocation (PA), collectively termed as UPPA, is of paramount importance to achieve manifold capacity gains in NOMA. According to existing literature, to take the best out of NOMA, users paired with each other should be distant in terms of channel gains [18, 19, 20]. Considering two users in a pair, a cell center user (CCU) having high channel gain should be paired with a cell edge user (CEU) having low channel gain. However, this type of UP may cause pairing issues of the middle gain users lying in between the cell center and cell edge. Some UP schemes to resolve the pairing issue of mid users are proposed in [21]. In [22], a matching algorithm based UP strategy is devised. Virtual and time sharing based UP schemes to accommodate similar gain users in NOMA, considering non uniform user distribution in a cell, are proposed in [23, 24, 25]. While most of the existing UP schemes focus on capacity maximization, their corresponding effects on the reliability of data (bit error rate (BER) of users) are completely neglected.

Similar to UP, PA is another critical factor to achieve significant capacity gains in NOMA [26, 27, 28, 29, 30]. Considering the two users (CCU and CEU) pair, the CCU in NOMA must always be allocated less power compared to CEU. Being prone to huge interference, CCU performs SIC or any other IC technique to recover its signal, whereas CEU directly recovers its signal. Most of the PA schemes in NOMA, focusing on capacity maximization, try to allocate the maximum possible power to

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