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ADAPTIVE POWER ALLOCATION FOR COOPERATIVE NOMA SYSTEM WITH IMPERFECT SIC

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ABSTRACT

Nowadays, the wireless networks demand high spectral efficiency, reliability and energy efficiency for future needs. In the recent decade, non-orthogonal multiple access (NOMA) with two-user cooperative schemes has received considerable attention for 5G systems. This work demonstrates between the source and far user that not a single link is directly established and we communicate via the near user. We introduce an adaptive power allocation scheme with the combination of cooperative NOMA networks. The preferred scheme selects the best user relay on the basis of performance while the distribution of power allocation coefficients is calculated in order to avoid the wastage of power. This approach also gives a brief discussion on the issue of imperfect successive interference cancellation (SIC) problems with the combination of adaptive scheme. A comprehensive analysis on the achievable data rate, sum rate and sum capacity performance of the preferred scheme is done on the MATLAB m file user interface and closed form expression is obtained. Through a numerical approach, we compare the performances of fixed and fair adaptive power allocation networks. These simulations result with various process parameters such as transmit power for the same error performance of a fixed and fair power allocation scheme. That shows the improvement in the adaptive scheme in terms of achievable capacity using different power allocation schemes.

KEYWORDS: Adaptive Power Allocation Scheme, Cooperative NOMA Network, Fifth Generation, Non-Orthogonal Multiple Access (NOMA), Successive Interference Cancellation

I. INTRODUCTION

When the number of devices can increase to enhance connectivity, non-orthogonal multiple access (NOMA) techniques make a difference from other fundamental orthogonal multiple access (OMA) schemes [1]. The NOMA technique encourages multiple users to transmit the information with different power domains, but at the same time, code and frequency [2]. NOMA allows the superposition coding at the transmitter end and achieves the actual information using successive interference cancellation (SIC) techniques at the receiver end. The main work of NOMA is distributing the proper power to users according to their channel status. At the receivers, the successive detection strategy is performed and the user having better channel status conveys the message signals remaining to all other users. In the simple manner, the user-relay needs to be used for the enhancement of response between the poor connection's user and the source [3].

Consequently, Cooperative NOMA is an effectual technique that oppose different channel losses such as fading, shadowing and path loss. This must be broadening the coverage area of communication systems [4]. Under this technique, the closest users from base station (BS), i.e., known as near users, should be used as relay for other far users from BS, i.e., known as far users. Depending on the current scenario, cooperative works can be categorised into two types. The dedicated relays are the first category of cooperation relay scheme. These relays set up the link between the base station/source and NOMA users. However, user cooperation scheme acts as a second category, where the weak users can be received data from the strong users. Strongly connected users act as relays for weak connected users from the base station/source [5], [6]. The simplest form of cooperative relaying network contains three primary nodes, named as the source, relay and destination. In particular, Amplify and Forward (AF) relay firstly collect the signal from source node then ahead the measured signal to the destination node [7]. In [8] author detects that Decode and Forward (DF) relay firstly endeavours to access the received signal and retransmits the retained information to the destination node. The combination is natural because the information for the far users is known to the near users owing to SIC. The selection of relay performs a vital role for multi-relay networks that is the only path to desire low-complexity and high diversity gain. However, these works are fully focused on the dedicated relay cooperation scheme to find out best way for the fixed relay selection criteria [9], [10].

In this paper, an Adaptive cooperative transmission scheme is fully exploited on the previously available information in NOMA systems [11]. The system performance of adaptive user cooperative-NOMA is major role for the investigation of the impact of user relay selection (URS). In the SIC receiver, The subtracted signal is imperfect with respect to the NOMA concept and its impact is also presented on overall capacity performance [12], [13]. The basic key features of the thesis are summarized as below:

- We obtain the sum capacity (SC) of preferred NOMA under both perfect and imperfect SIC framework. In order to, previous result of researchers is confirmed by our simulation results.

- For a fixed power allocation of Adaptive NOMA, we create an adaptive network utilize standard cooperative NOMA as a criterion. We additionally performed the Adaptive NOMA-RS scheme under perfect SIC, whereas performance gains under imperfect SIC significantly concentrate on the level of residual interference.

- For a fair power allocation of Adaptive NOMA, we create an adaptive network utilize standard cooperative NOMA as a criterion. We additionally performed the Adaptive NOMA scheme under perfect SIC, whereas performance gains under imperfect SIC significantly concentrate on the level of residual interference.

II. SYSTEM MODEL

Consider a downlink scenario with half-duplex user relay assisted NOMA scheme as illusion in Figure 1. According to that one base station (BS) or source, two users, and amplify-and-forward (AF)-based transmission protocol. It is also involving the user cooperation relay. We assume that each node can accurately detect its channel state information (CSI) using by equipping a half-duplex mode antenna. There is no direct communication between the source and the far users cause of physical obstacles and shadowing effect. The source to relay and relay to user channels are facing an independent and identically Rayleigh flat fading. The user 1 works as a potential relay for the user 2. Our assumptions should only be applicable for urban areas where multiple nodes may be positioned. These lines are interesting topic for the previous researches.
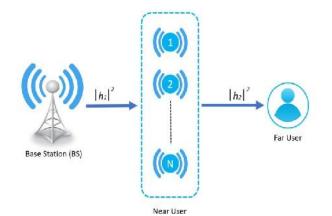
Figure 1: System Model of Adaptive Cooperative NOMA.

In cooperative NOMA, the communication is established using suitable link and it's also influenced the data rate of a user. The design of system model is examined such a manner after that a perfect cancellation should be applied in the users. The model contains the benefits of both the NOMA and cooperative diversity schemes. Origin of every time frame, the BS transmits the superimposed signal of a jth user. That signal may be expressed as follows:

$$x(t) = \sum_{j=1}^{2} \sqrt{\widetilde{p_j}} S_j(t)$$ (1)

Where, $S_j(t)$ is the message signal of jth user of source signal. The fixed power allocation coefficients factor is α_j with $0 < \alpha_j < 1$ and $\alpha_1 + \alpha_2 = 1$. The p_j denotes the transmit power constraint for the message $S_j(t)$. At the jth user relay, user 1 decodes higher power symbol $x(t)$ by owing lower power symbol user 2 act as a noise, and revokes it to perform cancellation technique. Consequently, the received message signal at the jth user relaying is represented as:

$$Y(t) = \sum_{j=1}^{2} \sqrt{P_s} \left| h_j \right|^2 x(t) + W_{s,u}$$ (2)

Where, P_s express power that transmits towards the BS and $W_{s,u}$ is zero mean and unit variance complex additive Gaussian noise, i.e., represented as $W_{s,u} \sim CN(0, \sigma^2)$.

The lower and higher data rate can be distributed according to the pair of S-U1 and U1-U2 continuously. The channel coefficients are $h_{s,r} \sim CN(0, k\lambda_{s,r} = kd_{s,r}^{-v})$, and $h_{r,2} \sim CN(0, \lambda_{r,2} = d_{r,2}^{-v})$, for the links source to the user 1 (S – U1), and user 1 to the user 2 (U1 – U2), respectively. The distance between vehicle i and j represents as $d_{i,j}$ in meters, and v denotes the path loss exponential parameter. Without loss of generality, User's channel has been anticipated as $|h_1|^2 \geq |h_2|^2$ because it is assumed that $d_1 < d_2$.

In fair power allocation section, the scheme is based on distribution of priority to one's user. We can say that the calculation of power allocation coefficients is based on the target rate of far user. Once the target rate of far user is assigned by given formula, all the remaining power is allocated to the near user. This scheme is also known as the dynamic power allocation of the users. Therefore, the power allocation coefficients of the fair PA scheme are given as:

$$\beta_f = \min\left(1, \frac{\varphi P_s |h_2|^2 + N_0}{P_s |h_2|^2 (1+\varphi)}\right)$$ (3)

where denotes the target SINR which derived from target rate of far user and is equal to $2^R - 1$ of the threshold target rate. The power coefficient of other user is assigned as the one minus of the power allocation coefficients of the fair PA.

Conversely, NOMA transmits the data between base station and destination among different transmission phases. We use γ_i^j to denote the signal to noise ratio (SNR) for user j to detect user i's signal in this paper. In cellular networks, SIC should be successfully applied and the data rate of user is increasing in linear manner that also make enhancement on the transmitted SNR γ. Therefore, the signal to noise ratio (SNR) at the user 2 can be represented as below in NOMA system:

$$\gamma_2^1 = \frac{\alpha_1 P_s |h_2|^2}{\alpha_2 P_s |h_2|^2 + N_0} \tag{4}$$

Moreover, we firstly decode data of the user 2 than the user 1. It cancels from the received signal and detects its own data. N_0 is defined as the power spectral density of white Gaussian noise. Therefore, the received SNR at user 1 related to source's data $S_2(t)$ can be expressed as:

$$\gamma_1^s = \frac{\alpha_1 P_s |h_1|^2}{\alpha_2 P_s |h_1|^2 + N_0} \tag{5}$$

We consider the downlink and recall that SIC receiver decodes the user information one by one iteratively unless we find the desired signal of that user. According to SIC scheme, regeneration of the original individual waveform should perform to approach on the desired signal. So, one's subtracted all the highly powered signal from the received signal. Theoretically, it is easy to complete such a difficult task without any error, in practical, it is experiencing some cancellation error. On that basis, we explore that some high-power signal is present after the SIC. In downlink, the SNR for the far user with cancellation error is written as:

$$\gamma_2^1 = \frac{\alpha_1 P_s |h_2|^2}{\epsilon \alpha_2 P_s |h_2|^2 + N_0} \tag{6}$$

Where, ϵ is termed as successive error cancellation that represents the undesired portion of the message signal. The self-interference cancellation represents perfectly as $\epsilon = 0$ in before instances. In the section, the denominator of SNR term is included imperfect cancellation term.

III. PROPOSED POWER ALLOCATION SCHEMES

The system model should be discussed on below lines:

- In first step, the source node is considered as the CSI between user relaying node and far user /or the destination node before transmission. Assume that the source node has previous knowledge of channel state between itself and the other nodes (relay node and destination node). Our aim is to optimize the system performance and the power allocation should be considered according to known information.

- The source node itself conveys and informs power allotted information to the user 1, which are act as relays. They select these users cooperate relay according to the power and higher rate.

- These selected relays are amplifying and forwarding of far user's information.

- The far user recovers the information from the source via user relays node that passes and forwards it, then combine them.

Consequently, the achievable rates for U1 and U2 are represented below, respectively:

$$R_{n,1} = \log_2(1 + \gamma_1^s) \tag{7}$$

and

$$R_{n,2} = \log_2(1 + \gamma_2^1) \tag{8}$$

All the nth stage consists on selecting the appropriate user relaying and destination link on the basis of one's available distance, which maximizes the data rate of $S_j(t)$ at far user, i.e.,

$$R_{n,i} = arg \max_{S \in n} (R_{n,1}, R_{n,2}) \tag{9}$$

In this subsection, we focus the effect of user pairing on the sum rate and all the user's data rate using Fixed NOMA is explored. This Adaptive NOMA achieves sum rate can be represented as:

$$R_n = mean(R_{n,1} + R_{n,2}) \tag{10}$$

IV. NUMERICAL STUDIES

In Figure 2, we set the sum rate achieved of both the weak and strong user by the two Power allocation schemes, is shown as a function of transmit power in dBm, with fixed power allocation factor of 0.75 and 0.25. As performance standard, we contrast between the fair and fixed PA policies assuming user pairing and perfect SIC. Obviously, the performance of the proposed adaptive PA scheme is better for 4 user relay system with 3 user relay system. For each user relay, they are selected according to the placement of user from the BS. The distance is varying with respect to user. In the fair PA strategy, power allocation factor values are calculated on the basis of formula 3, which can be the user with better channel condition. But the fixed PA strategy cannot be so good result as shown in fair PA strategy. Additionally, the adaptive PA scheme is favourable at most to the strong user. After that, No is mainly adopted in terms of thermal errors and etc. The value of path loss is assigned to the 4.
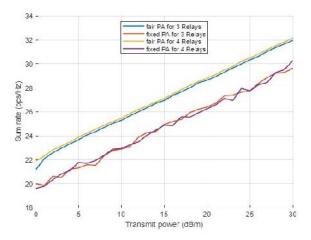

Figure 2: Impact of User Pairing Achieved by Adaptive Cooperative NOMA on Sum Rate.

Consider Figure 3, the impact of imperfect SIC of ϵ in the achievable capacity gain are residually investigated in terms of SIC factor and IS factor. As can be seen, the capacity increases as increment of transmit power. The capacity gain obviously depends in terms of interference coefficient at the medium to high transmit power. By using fair PA, the capacity of graph is improved as the power allocation coefficient ϵ increases with other non-adaptive technologies.
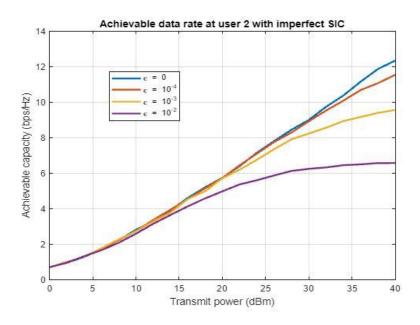
**Figure 3: Impact of Imperfect SIC Achieved by Fair Power Allocation
Scheme.**

Furthermore, we are verifying impressive impact of imperfect SIC on the capacity. The value of path loss is assigned to the 4. But the result of imperfect SIC with respect to the fixed PA, as shown in the figure 4, gives the tremendous effect of this research areas.
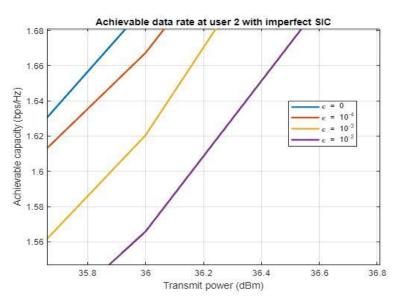

**Figure 4: Impact of Imperfect SIC Achieved by Fixed Power
Allocation Scheme.**

Figure 5 presents the data rate and sum rate versus distance for strong users. In addition, we notice the variation the distance with respect to the data rate of the far user. Figure demonstrates how variation of distance gain for different power allocation schemes that can be obtained by pairing it with different users.
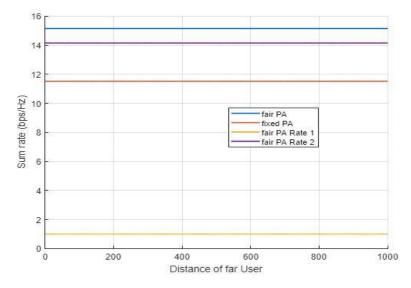
Figure 5: Adaptive Cooperative NOMA on Sum Rate with the Distance of Far User Pairing.

In the other hand, the performance of the fair PA is showing better result according to the fixed PA scheme for all distance values. That is also justifiable that every relay allocates the adaptive power selection towards and also provide controllability to fading effects.

V. CONCLUSIONS

By comparing OMA based approaches, NOMA scheme definitely improves the usage of transmission in the presence of limited sources. In this paper, we can add an adaptive approach with original cooperative NOMA scheme. The user cooperation should be adopted in the particular research work. Where all the users are characterized on the basis of channel conditions regarding the others' messages in NOMA systems. These results have been drawn in terms of transmit power and distance. Fixed and fair options of adaptive PA coefficient have been applied in this paper, thus the main important is studying the relay selection strategy for cooperative NOMA [13]. After that future technology will try on the simultaneous wireless information and power transfer to NOMA as practically available. Optimal relay selection strategy is beneficial to the availability of CSI and limited feedback. Analytical results have been developed those the adaptive PA strategies is selected the relays on the basis of its maximum value. In addition, the simulation results have authenticated the advantage of this power allocation scheme.

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