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Research Paper

Adaptive Power Allocation for Cooperative FD-NOMA Systems in 5G Systems

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Abstract— *To establish communication via vehicle, recent researchersare working on the topic of vehicle-to-vehicle (V2V) communication. It provides information in safe manner and infotainers service. In vehicular communication scenarios, the increment of transmit rate and Quality of Service (QoS) are highly demanding. So, the implementation of V2V communication system such as, non-orthogonal multiple access (NOMA) and full duplex (FD) for the 5G wireless communication system. These technologies enhance spectral efficiency, achieve low-latency and provide massive connectivity.Weinvestigate a unified model for cooperative NOMA networks with multiple FD relays in this work for communication scenarios. The power allocation strategy is executed adaptivelyusing multiple user-relays thatshould maximize achievable rate of the minimum user based on the channel state information. In this scheme, the source granted the power towards the users which chooses these user relays on the basis of performance enhancement. The Simulation results show the satisfactory results regarding achievable rate, and sum rate in the adaptive power allocation with fixed and fair power allocation strategy. The numerical approach should improve the gap between two different power allocation schemes.*

Index Terms—*Non-orthogonal multiple access (NOMA), cooperative networks, vehicle-to-vehicle (V2V), Quality of Service, 5G communications, adaptive power allocation, full duplex.*

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I. INTRODUCTION

Now a days, the 5th generation (5G) is very fast and rapid growing wireless technology [1], non-orthogonal multiple access (NOMA) has beenaccepted as the favourableprotocol because of its potential in achievinglow latency, higher spectral efficiency andmassive connectivity [2]. By using NOMA technique, multiple usersshare the same time, code and frequency resources via power domain or code domain multiplexing. Byestablishingmulti-userinterference, NOMAallowscontrollable useof higher user connectivity, promoting the restriction of the maximum user number with respect to other conventional orthogonal multiple access (OMA) schemes. Hence, the combination of cooperative relaying and NOMA technique may mitigate the effect of fading and increase the performance of 5G V2V communication. This has beenbecoming more attracting research topic andrecently adapted [3], [4]. After that, cooperative NOMA has sparked wide interest in research topics. Specifically, the work in [5], [6]improves the QoS achievements of cooperative NOMA guaranty using fixed power allocation (FPA). This scheme is used for twostage maximum to minimum RS users. In this schemes, duplicate transmission can also adopt the data transmission of both near and far users by adding extra relay network. In recent years,cooperativerelay selection (C-RS) techniques have been improved system complexity in the multiple relays cooperative NOMA system. In [7], the researchers integrated amplifyandforward (AF) relay system with NOMA scheme by using partial relay selection (PRS) technique.The researcher in [8] proposed relay scheme for cooperative-NOMA with two-stage AF and decode-and-forward (DF)adaptive PA. These relays scheme further essentialfor QoS needs at the users.

To further enhancement of spectral efficiency for relaying scheme, FD relay was appliedby assumingideal self-interference cancellation, which requires one slot fortransmission.Ding et al. areinspected the outage achievement of uplink and downlink FDNOMAin [9].Atthe same time, transmissions are carried out. The half-duplex (HD)NOMA and orthogonal multiple access are demonstrating that FD-NOMA outperforms by using co-channel interference successfully. The main advantage of FD and NOMA are utilizing the prior two techniques for boosting user connectivity and attaining better data rates in vehicular communication scenarios. In 5G cellular V2X communications [10], Z. Wang et al. considered HD relay-assisted NOMA and FD relay-assisted NOMA for the power allocation problems of broadcasting/multicasting transmission schemes.We investigate poor channel conditions and assure increasing the QoS of the vehicle. In [11], the researcher considered cooperative NOMA V2V system with an eavesdropper and an FD relaying.They solved a confidentiality foroptimize the sum rate problem by using the instantaneous channel state information (ICSI). According to the researchers, mostly current scenario discussed secure automotive technology, supported the Internet oriented things [12]. That alsoevaluate security issues and providing valuable perspectives of vehicular communication in different dimensions. It is including authentication, integrity and availability of Internet users [13].

Furthermore, we investigatean Adaptive cooperative-NOMA V2V transmission scheme with the multiple FD relay.It is noteworthy that user-assisted, single relay-assistedare concerned worked on the PA strategies previously with ideal successive interference cancellation (SIC), for better investigation in multiple relays still remainsat different powerlevels. Weconsider that adaptive PA scheme with cooperative multiple relay FD NOMA system at the strong user. Our goal is toperformthe adaptivepower allocation using multiple user relays by which we are maximizing the achievable rates. Simulation results are expressed in terms of adaptive PA allocation schemes at the last and sensitive conversations are extracted.

II. SYSTEM MODEL

Based on V2V communication scenario,we consider an FD-NOMA consisting of multiple vehicles as shown in Figure 1, first block (source vehicle S) transmits information in the half-duplexmethodology to a pair of users (U1 and U2) with the assistance of strong vehicle operating as a relay vehicle R fromthe user relay. When the FD scheme is combined with previous techniques, the user-based relay vehicles suffer from a self-interference (SI) loop that totally affects the power distribution of the system.Moreover, ourassumption is not any direct communication link between source and destinationdue to strong fading and physical obstacles[12].

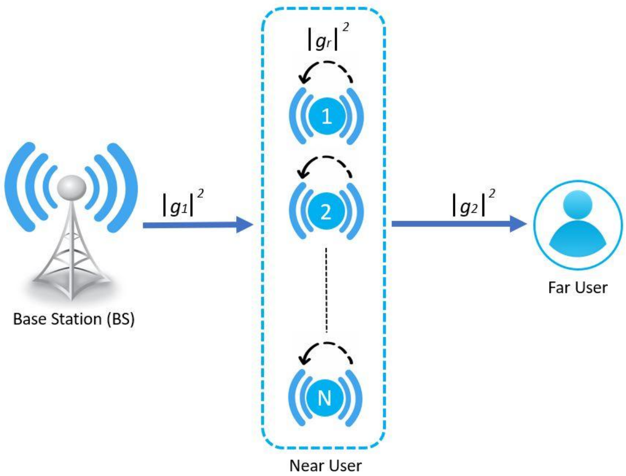

Fig. 1. System Model of Adaptive cooperative FD-NOMA.

In first phase, the base station communicates the information of2user to the destination according to the NOMA principle, i.e., the base station sends$x(t) = \sum_{m=1}^{2} \sqrt{p_m}\, S_m$ where S_m is the message for the m^{th}user, and $p_m$is the power allocation coefficient. The study of the user relay received message signal is given by,

$$Y = \sum_{m=1}^{2} \sqrt{p_m}\, |g_m|^2 S_m + W_m (1)$$

where g_m expressed asa Rayleigh fading channel coefficient from the base station to the m^{th} user and W_m denotes independent and identically distributed (i.i.d) additive Gaussian noise with unit variance of σ^2, that is represented as $W_m \sim CN(0, \sigma^2)$.Without loss of generality, the channel gains are assumed to be instructed as$|g_1|^2 \geq |g_2|^2 \geq \cdots \geq |g_m|^2$.The use of NOMA implies $|p_1|^2 \leq |p_2|^2 \leq \cdots \leq |p_m|^2$with the total power allocated for the user is $P_T = \alpha_m p_m$.The fixed power allocation coefficients factor is $\alpha_m$with $0 < \alpha_m < 1$ and $\alpha_1 + \alpha_2 = 1$.

In the downlink NOMA system, assume that the multi-relays cooperative FD byAF technique, as shown in Fig. 1. Thissystem consists of a base station (BS) with the set of nuser relays (U1) and one destination user (U2) using different channel conditions. Tosupport in the communication process, one FD relay is choosing from the set of user relays that passes information from source to distant user. The user relays are equipped with two antennas, one for reception and one for transmission, while all other nodes are equipped with a single antenna.In addition, the users subscribe to the same traffic service that requires a minimum data rate to be satisfactorily issued [13].The channel coefficients between the links BS → U1, U1 → U2, and R → Rare, $g_{n,1} \sim CN(0, \lambda_{s,n})$, $g_{n,2} \sim CN(0, \lambda_{n,2})$, and$g_r \sim CN(0, \lambda_r)$, respectively and n ∈ {1, 2,. . ., N}, where $\lambda_{s,n} = d_{s,n}^{-v}$,$\lambda_{n,2} = d_{n,2}^{-v}$, and $\lambda_r = d_r^{-v}$.The distance of vehiclei and vehiclej are connecting in terms of$d_{i,j}$ in meters, and $v$considered as theexponential path loss.

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

$$\beta_f = \min\left(1, \frac{\varphi P_s |g_2|^2 + N_0}{P_s |g_2|^2 (1 + \varphi)}\right) (2)$$

where φdenotes 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 users is assigned as the one minus of the power allocation coefficients of the fair PA.

Conversely, the communication data can be transferred between the source and destination by the transmission stages of NOMA-RS. The signalto interference noise ratio (SINR) denoted asγ_i^j for the user j to detect the signal of user iin this paper. In cellular networks, data rate of users is showing linear increment of the transmit SINR$\gamma$of the user pair after successfully executing the SIC strategy in NOMA. The channel gain of full-duplex NOMA should perform the main problem that is produced as a self-interference loop in the system model. Furthermore, the values of SINR are considered for two users at the FD relay:

$$\gamma_2^1 = \frac{\alpha_1 P_s |g_2|^2}{\alpha_2 P_s |g_2|^2 + \alpha_2 P_r |g_r|^2 + N_0} (3)$$

Consequently, the instantaneous SINR at user 1 regarding the data of user 2 are represented as:

$$\gamma_1^s = \frac{\alpha_1 P_s |g_1|^2}{\alpha_2 P_s |g_1|^2 + \alpha_2 P_r |g_r|^2 + N_0} (4)$$

Therefore, the user 1 first decodes user 1's dataand subtracts it from the received signal, then detects its own data according to SIC and $N_0$is the power spectral density of white Gaussian noise. These are the theoretical observations of the system model.

III. PROPOSED POWER ALLOCATION SCHEMES

The proposed scheme of communication model is discussing as below:

1. Before transmission, the source should contain the knowledge aboutchannel state information (CSI) between user relaying nodes and far user /or the destination node. Then, the information of source obtains between itself and the other's node which are all relays and destination node.

2.Optimizing the system performanceis our main goal, source node allocates power to user according to need of channel. Then, source node transmits power domain information to desire user, and notifies that theuser 1 must be act as relays. They selected power allocated cooperation towards them.

3. The selected user relays firstlyamplify the power cooperated signaland then forward information towards thefar user node.

4. In the last step, the far user node receives the information from the predefined way that source node transmits and passes through the user relays node forward, then combine them.

Therefore, we discussed the theoretical possibilities for completion of this process in practical and this is supposed to test some cancellation error.

According to the adaptive PA, the achievable rates for U1 and U2 are represented as, sequentially:

$R_{n,1} = \log_2(1 + \gamma_1^s)$ (6)

and

$$R_{n,2} = \log_2(1 + \gamma_2^1) \quad (7)$$

On the basis of one's availability, all the n^{th} stage selectsbased on thebest distancebetween source link and destination link, which maximizes the data rate of $S_j(t)$ at far user, i.e.,

$$R_{n,i} = arg \max_{S \in n} (R_{n,1}, R_{n,2}) \quad (8)$$

In this section, we are basically focusing on the separate user rates attained by Fixed-NOMA and Fair-NOMA and the effect of user relaying on the sum rate is investigated. This Adaptive NOMA achieves sum rate can be represented as:

$$R_n = R_{n,1} + R_{n,2} \quad (9)$$

IV. NUMERICAL STUDIES

In Fig. 2 and 3, we set an achievable data rate achieved of both the weak and strong user. We take the comparison between the two Power allocation schemes, such as, fair PA and fixed PA. As shown that the graph between the achievable data rates as a purpose of transmit power in dBm, the value for the fixed PA factor is 0.75 and 0.25. As performance benchmark, we are assuming a user pairing and perfect SIC for the fair and fixed PA policies.

Therefore, the execution of the proposed adaptive PA scheme is the best for 5 user relay systems with 3 user relay systems. For each user relay, they are selected according to the placement of the user from the base station. The distance is varying with respect to the user. In the fair PA strategy, power allocation factor values are calculated on the basis of formula 2, which can be the user having better channel condition. But the fixed PA strategy can show good results with respect to a fair PA strategy. After that, No is mainly adopted for thermal errors etc.

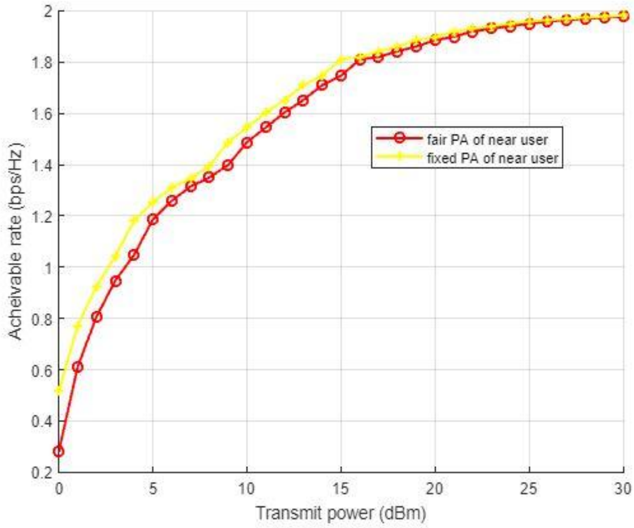

Fig. 2. Impact of user pairing achieved by Adaptive cooperative FD- NOMA on the basis of Rate.

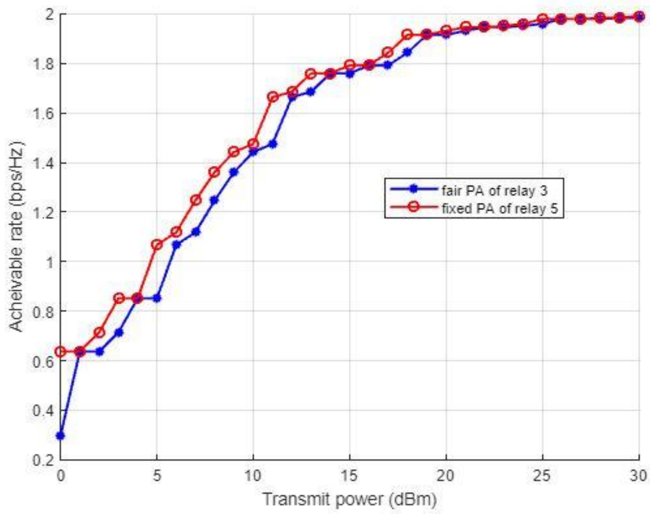

Fig. 3. Impact of user pairing achieved by Adaptive cooperative FD-NOMA onthe basis of Rate.

In this figure, both the graphs can show the achievable rates for the strong and weak users respectively. At the summary, we say that the data are equally received by both the users by the proposed scheme.But the result of perfect SIC with respect to the fixed and fair PA, as shown in the figure 4, gives the tremendous effect of this research areas.

Consider Fig. 4, the impact of the achievable capacity gains is investigated in terms of self-interference cancellation factor. The value of path loss is assigned to the 4. The channel gains seriously depend genuinely on the residual interference for higher transmit power. Additionally, the achievement of this adaptive PA scheme is the bestnotably for 5 user relay systems with 3 user relay systems increasing the distance of weak users. We investigated that the rate between for strong and weak users reaches its previous stage which was studied earlier.

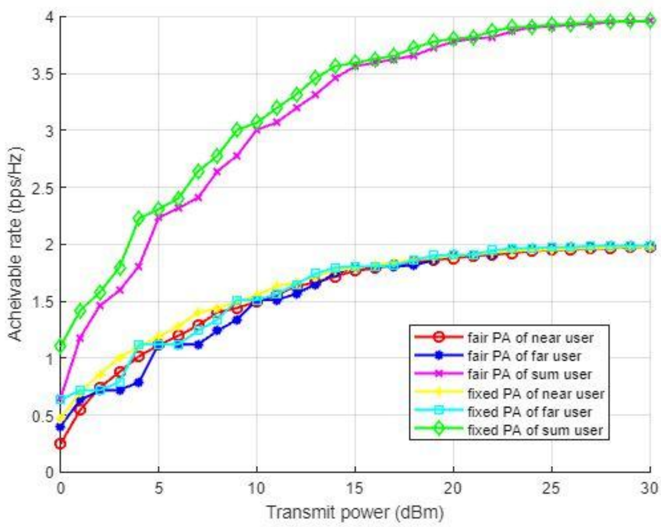

Fig. 4. Impact of Adaptive cooperative FD-NOMA on sum and achievable Rate.

V. CONCLUSIONS

In this scheme, we have proposed a cooperative FD NOMA based adaptive power allocation transmission scheme. This fact knows previously that some users previously have information concerning the others' user messages in the cooperative NOMA system.Furthermore, fixed and fair possibilities of adaptive power allocation coefficients have been employed. The analytical results have been examined that there is no need to use power selection approach for the performance gain. The result of fair power allocation scheme is not shown as impressive as possible.This is grantingfordifferent power allocation selection researchin cooperative relaying NOMA.Afterall, the future direction is toimprove the power allocation scheme and also refer simultaneous wireless information and power transfer, and multipleinput and multipleoutput (MIMO) in order to achieve practical constraints.

REFERENCES

[1]. Y. Saito, Y. Kishiyama, A. Benjebbour, T. Nakamura, A. Li, and K. Higuchi, "Non-orthogonal multiple access (NOMA) for cellular future radio access," IEEE 77th Vehicular Technology Conf., pp. 1–5, 2013.

[2]. Z. Ding, M. Peng, and H. V. Poor, "Cooperative non-orthogonal multiple access in 5G systems", *IEEE Communications Letter*, vol. 19, no. 8, pp. 1462– 1465, Aug. 2015.

[3]. M. Zeng, W. Hao, Octavia A. Dobre, and Z. Ding, "Cooperative NOMA: State of the Art, Key Techniques and Open Challenges", IEEE Networks, vol. 30, no. 4, pp. 1–7, Apr. 2020.

[4]. L. Wei, Y. Chen, D. Zheng, and B. Jiao, "Secure Performance Analysis and Optimization for FD-NOMA Vehicular Communications", China Communication, vol. 17, no. 11, pp. 29–41, Nov. 2020.

[5]. S. Lee, D. B. da Costa, Q. Vien, T. Q. Duong, and R. T. de Sousa, "Non-orthogonal multiple access schemes with partial relay selection", IET Communications, vol. 11, no. 6, pp. 846–854, 2017.

[6]. Z. Yang, Z. Ding, Y. Wu, and P. Fan, "Novel relay selection strategies for cooperative NOMA", IEEE Transactions onVehicularTechnology, vol. 66, no. 11, pp. 10 114–10 123, Nov. 2017.

[7]. Z. Ding, P. Fan, and H. V. Poor, "On the coexistence between full-duplex and NOMA", IEEE Wireless Communications Letters, vol. 7, no. 5, pp. 692–695, Oct. 2018.

[8]. Z. Ding, G. Liu, Z. Wang, J. Hu, and P. Fan, "Cooperative NOMA Broadcasting/Multicasting for Low-Latency and High-Reliability 5G Cellular V2X Communications", IEEE Internet of Things Journal, vol. 6, no. 5, pp. 7828–7838, Oct. 2019.

[9]. Y. Li; Y. Z. Li, X. Chu, Y. Ye and H. Zhang, "Performance Analysis of Relay Selection in Cooperative NOMA Networks", *IEEE Wireless Communications Letter*, vol. 23, no. 4, pp. 760-763, Apr. 2019.

[10]. Brena K. S. Lima, Daniel B. da Costa, Liang Yang, F. Rafael M. Lima, Rodolfo Oliveira, and Ugo S. Dias, "Adaptive Power Factor Allocation for Cooperative Full-Duplex NOMA Systems with Imperfect SIC and Rate Fairness", IEEE Transactions on Vehicular Technology, vol. 69, no. 11, pp. 14061–14066, Nov. 2020.

[11]. G. Li and D. Mishra, "Cooperative NOMA Networks: User Cooperation or Relay Cooperation?", *IEEE International Conference on Communications (ICC), Dublin, Ireland*, pp. 1-6, June 2020.

[12]. G. Li, D. Mishra, Y. Hu, Y. Huang and H. Jiang, "Adaptive Relay Selection Strategies for Cooperative NOMA Networks with User and Relay Cooperation",*IEEE Transactions on Vehicular Technology*, vol. 69, no. 10, pp. 1728 - 1742, Oct. 2020.

[13]. G. Liu, X. Chen, Z. Ding, Zheng Ma, and F. Richard Yu, "Hybrid Half-Duplex/Full-Duplex Cooperative Non-Orthogonal Multiple Access with Transmit Power Adaptation", *IEEE Transactions on Wireless Communications*, vol. 17, no. 1, pp. 1–14, Nov. 2017.

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