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On Inflated Achievable Sum Rate of 3-User Low-Correlated SC NOMA

Kyuhyuk Chung

Professor, Department of Software Science, Dankook University, Korea
khchung@dankook.ac.kr

Abstract

In the Internet of Thing (IoT) framework, massive machine-type communications (MMTC) have required large spectral efficiency. For this, non-orthogonal multiple access (NOMA) has emerged as an efficient solution. Recently, a non-successive interference cancellation (SIC) NOMA scheme has been implemented without loss. This lossless NOMA without SIC is achieved via correlated superposition coding (SC), in contrast to conventional independent SC. However, conventional minimum high-correlated SC for only 2-user NOMA schemes was investigated in the lossless 2-user non-SIC NOMA implementation. Thus, this paper investigates a 3-user low-correlated SC scheme, especially for an inflated achievable sum rate, with a design of 3-user low-correlated SC.

First, we design the 3-user low-correlated SC scheme by taking the minimum sum rate between 3–user SIC NOMA and 3-user non-SIC NOMA, both with correlated SC. Then, simulations demonstrate that the low correlation in the direction of the first user's power allocation inflates the sum rate in the same direction, compared to that of conventional minimum high-correlated SC NOMA, and such inflation due to low correlation is also observed similarly, in the direction of the second user's power allocation. Moreover, we also show that the two low correlations of the first and second users inflates doubly in the both directions of the first and second users' power allocations.

As a result, the proposed 3-user low-correlated SC could be considered as a promising scheme, with the inflated sum rate in the future fifth-generation (5G) NOMA networks.

Keywords: *NOMA, 5G, Correlation Coefficient, Superposition coding, Successive interference cancellation, Power allocation.*

1. Introduction

The Internet of Thing (IoT) framework has required a massive connectivity, such as massive machine-type communications (MMTC) [1], [2]. For this spectral efficiency, non-orthogonal multiple access (NOMA) has been considered as an appropriate multiple access scheme [3], [4]. Higher spectral efficiency can be a superiority of NOMA, compared with existing orthogonal multiple access (OMA) in 4G cellular communications [5-7]. The superiority of NOMA was optimized [8]. Cooperative NOMA was studied for full-duplex relaying [9]. Underwater visible light communication for NOMA was investigated [10]. A power-outage tradeoff for NOMA was studied [11]. The bit-error rate for NOMA were investigated [12], whereas

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Corresponding Author: khchung@dankook.ac.kr
Tel: +82-32-8005-3237, Fax: +82-504-203-2043
Professor, Department of Software Science, Dankook University, Korea

local oscillator imperfection in NOMA was considered [13]. The power splitting for correlated superposition coding (SC) NOMA was investigated [14]. For *M*-user NOMA systems, power allocation was studied for first and second strongest channel gain users [15]. In addition, the achievable data rate for NOMA with the asymmetric binary pulse amplitude modulation (2PAM) was studied [16]. Recently, the NOMA schemes were investigated for correlated information sources [17]. Negatively-correlated information sources were investigated in [18]. A rate-lossless non-successive interference cancellation (SIC) NOMA scheme was studied for asymmetric 2PAM [19].

Recently, a non-SIC NOMA scheme has been implemented without loss [20]. Such lossless non-SIC NOMA is achieved via correlated SC, in contrast to conventional independent SC. Note that correlated SC uses superimposed signals which are correlated, whereas in independent SC, the signals are superimposed independently. However, the conventional minimum high-correlated SC scheme for only 2-user NOMA was investigated in the lossless 2-user non-SIC NOMA implementation. Thus, this paper investigates a 3-user low-correlated SC scheme, especially for an inflated achievable sum rate, with a design of 3-user low-correlated SC.

First, we design the 3-user low-correlated SC scheme by taking the minimum sum rate between 3–user SIC NOMA and 3-user non-SIC NOMA, both with correlated SC. Then, simulations demonstrate that the low correlation in the direction of the first user's power allocation inflates the sum rate in the same direction, compared to that of conventional minimum high-correlated SC NOMA, and such inflation due to low correlation is also observed similarly, in the direction of the second user's power allocation. Furthermore, we also show that the two low correlations of the first and second users inflates doubly in the both directions of the first and second users' power allocations.

The remainder of this paper is organized as follows. In Section 2, the system and channel model are described. The achievable sum rate of 3-user low-correlated SC NOMA is derived in Section 3. The numerical results are presented and discussed in Section 4. Finally, the conclusions are presented in Section 5.

The main contributions of this paper are summarized as follows:

- We propose a 3-user low-correlated SC NOMA scheme, in contrast to a conventional 3-user minimum high-correlated SC NOMA scheme.
- Then, we design the 3-user low-correlated SC scheme by taking the minimum sum rate between 3–user SIC NOMA and 3-user non-SIC NOMA, both with correlated SC.
- It is shown that the low correlation in the direction of the first user's power allocation inflates the sum rate in the same direction, compared to that of conventional minimum high-correlated SC NOMA.
- And such inflation due to low correlation is also observed similarly, in the direction of the second user's power allocation.
- Moreover, we also show that the two low correlations of the first and second users inflates doubly in the both directions of the first and second users' power allocations.

2. System and Channel Model

In a cellular downlink NOMA network with one base station and three users, the complex channel coefficient between the *m*th user and base station is denoted by h_m, $m = 1,2,3$, and the channels are sorted as

$|h_1| \geq |h_2| \geq |h_3|$. The base station can send the superimposed signal $x = \sqrt{P\alpha_1}s_1 + \sqrt{P\alpha_2}s_2 + \sqrt{P\alpha_3}s_3$, where P is the average power of x, s_m is the signal for the *m*th user with the average unit power, and α_m is the power allocation coefficient, with $\alpha_1 + \alpha_2 + \alpha_3 = 1$. The received signal r_m at the *m*th user is expressed as follows:

$$r_m = h_m x + n_m, \tag{1}$$

where $n_m \sim CN(0, \sigma^2)$ is a complex additive white Gaussian noise (AWGN). On the other hand, the base station can also send the *correlated* superimposed signal $z = \sqrt{P_A\beta_1}c_1 + \sqrt{P_A\beta_2}c_2 + \sqrt{P_A\beta_3}c_3$, where the average *allocated* total power P_A of c_1 and c_2 is given by

$$P_A = \frac{P}{\sum_{i=1}^{3}\sum_{j=1}^{3}\rho_{i,j}\sqrt{\beta_i\beta_j}}, \tag{2}$$

with the correlation coefficient of the messages' signals $\rho_{1,2} = E\left[c_1 c_2^*\right]$, and c_m is the signal for the *m*th user with the average unit power. β_m is the power allocation coefficient, with $\beta_1 + \beta_2 + \beta_3 = 1$. The received signal y_m at the *m*th user is expressed as follows:

$$y_m = h_m z + n_m. \tag{3}$$

3. Derivation of Achievable Sum Rate of Proposed 3-User Low-Correlated SC NOMA

In this section, in order to derive the achievable sum rate of the 3-user low-correlated SC NOMA scheme, we first present the achievable sum rate of the existing NOMA schemes [21]: The *conditional* achievable sum rate given $|h_1|$, $|h_2|$, and $|h_3|$ in conventional 3-user correlated SC/SIC NOMA schemes is expressed as:

$$R^{(\text{CSC/SIC})}_{sum\,|\,|h_1|,|h_2|,|h_3|} = R^{(\text{CSC/SIC})}_{1\,|\,|h_1|,\,(\text{SIC})} + R^{(\text{CSC/SIC})}_{2\,|\,|h_2|,\,(\text{SIC})} + R^{(\text{CSC/SIC})}_{3\,|\,|h_3|,\,(\text{non-SIC})}, \tag{4}$$

where

$$R^{(\text{CSC/SIC})}_{1||h_1|,\,(\text{SIC})} = \log_2\left(1 + \frac{|h_1|^2 P_A\beta_1(1-\rho_{1|2,3}^2)}{\sigma_2}\right), \tag{5}$$

$$R_{2\,|\,|h_2|,\,(\mathrm{SIC})}^{(\mathrm{CSC/SIC})}=\log_2\left(\frac{|h_2|^2 P_A\begin{pmatrix}\beta_1\left(1-\rho_{1,3}^2\right)+\beta_2\left(1-\rho_{2,3}^2\right)\\ +2\sqrt{\beta_1}\sqrt{\beta_2}\left(\rho_{1,2}-\rho_{1,3}\rho_{2,3}\right)\end{pmatrix}+\sigma^2}{|h_2|^2 P_A\beta_1\left(1-\rho_{1|2,3}^2\right)+\sigma^2}\right), \tag{6}$$

and

$$R_{3\,|\,|h_3|,\,(\mathrm{non\text{-}SIC})}^{(\mathrm{CSC/SIC})}=\log_2\left(\frac{|h_3|^2 P+\sigma^2}{|h_3|^2 P_A\begin{pmatrix}\beta_1\left(1-\rho_{1,3}^2\right)+\beta_2\left(1-\rho_{2,3}^2\right)\\ +2\sqrt{\beta_1}\sqrt{\beta_2}\left(\rho_{1,2}-\rho_{1,3}\rho_{2,3}\right)\end{pmatrix}+\sigma^2}\right), \tag{7}$$

with

$$\rho_{1|2,3}^2=\frac{\left(\rho_{1,2}-\rho_{1,3}\right)^2+2\rho_{1,2}\rho_{3,1}\left(1-\rho_{2,3}\right)}{1-\rho_{2,3}^2}. \tag{8}$$

And for 3-user correlated SC/non-SIC NOMA schemes, The *conditional* achievable sum rate given $|h_1|$, $|h_2|$, and $|h_3|$ is expressed as:

$$R_{sum\,|\,|h_1|,|h_2|,|h_3|}^{(\mathrm{CSC/non\text{-}SIC})}=R_{1\,|\,|h_1|,\,(\mathrm{non\text{-}SIC})}^{(\mathrm{CSC/non\text{-}SIC})}+R_{2\,|\,|h_2|,\,(\mathrm{non\text{-}SIC})}^{(\mathrm{CSC/non\text{-}SIC})}+R_{3\,|\,|h_3|,\,(\mathrm{non\text{-}SIC})}^{(\mathrm{CSC/non\text{-}SIC})}, \tag{9}$$

where

$$R_{1\,|\,|h_1|,\,(\mathrm{non\text{-}SIC})}^{(\mathrm{CSC/non\text{-}SIC})}=\log_2\left(\frac{|h_1|^2 P+\sigma^2}{|h_1|^2 P_A\begin{pmatrix}\beta_2\left(1-\rho_{2,1}^2\right)+\beta_3\left(1-\rho_{3,1}^2\right)\\ +2\sqrt{\beta_2}\sqrt{\beta_3}\left(\rho_{2,3}-\rho_{2,1}\rho_{1,3}\right)\end{pmatrix}+\sigma^2}\right), \tag{10}$$

$$R_{2\,|\,|h_2|,\,(\mathrm{non\text{-}SIC})}^{(\mathrm{CSC/non\text{-}SIC})}=\log_2\left(\frac{|h_2|^2 P+\sigma^2}{|h_2|^2 P_A\begin{pmatrix}\beta_1\left(1-\rho_{1,2}^2\right)+\beta_3\left(1-\rho_{3,2}^2\right)\\ +2\sqrt{\beta_1}\sqrt{\beta_3}\left(\rho_{1,3}-\rho_{1,2}\rho_{2,3}\right)\end{pmatrix}+\sigma^2}\right), \tag{11}$$

and

$$R_{3||h_3|,\,\text{(non-SIC)}}^{\text{(CSC/non-SIC)}} = \log_2\left(\frac{|h_3|^2 P + \sigma^2}{|h_3|^2 P_A \begin{pmatrix} \beta_1\left(1-\rho_{1,3}^2\right)+\beta_2\left(1-\rho_{2,3}^2\right) \\ +2\sqrt{\beta_1}\sqrt{\beta_2}\left(\rho_{1,2}-\rho_{1,3}\rho_{3,2}\right)\end{pmatrix} + \sigma^2}\right). \tag{12}$$

Then, for the conventional minimum high-correlated SC/non-SIC NOMA scheme, the *conditional* achievable sum rate given $|h_1|$, $|h_2|$, and $|h_3|$ is calculated, based on the following conditions [21]:

$$R_{1||h_1|,\,\text{(non-SIC)}}^{\text{(CSC/non-SIC)}} \geq R_{1||h_1|,\,\text{(SIC)}}^{\text{(CSC/SIC)}}, \tag{13}$$

$$R_{2||h_2|,\,\text{(non-SIC)}}^{\text{(CSC/non-SIC)}} \geq R_{2||h_2|,\,\text{(non-SIC)}}^{\text{(CSC/SIC)}}, \tag{14}$$

and

$$R_{3||h_3|,\,\text{(non-SIC)}}^{\text{(CSC/non-SIC)}} \geq R_{3||h_3|,\,\text{(non-SIC)}}^{\text{(CSC/SIC)}}. \tag{15}$$

Note that in the conventional correlated SC/non-SIC NOMA scheme, the minimum and high values of the correlation coefficients are used, because the lower value has the discontinuity in the power allocation range to be achieved, and the higher value reduces such power allocation range.

Now, on the contrary, we define the *conditional* achievable sum rate given $|h_1|$, $|h_2|$, and $|h_3|$ for the 3-user low-correlated SC/non-SIC NOMA scheme, based on the following condition:

$$\min\left\{R_{sum||h_1|,|h_2|,|h_3|}^{\text{(CSC/SIC)}}, R_{sum||h_1|,|h_2|,|h_3|}^{\text{(CSC/non-SIC)}}\right\}. \tag{16}$$

Since $R_{3||h_3|,\,\text{(non-SIC)}}^{\text{(CSC/non-SIC)}} = R_{3||h_3|,\,\text{(non-SIC)}}^{\text{(CSC/SIC)}}$, we simplify the above-mentioned condition more as follows:

$$\min\left\{R_{1||h_1|,\,\text{(non-SIC)}}^{\text{(CSC/non-SIC)}} + R_{2||h_2|,\,\text{(non-SIC)}}^{\text{(CSC/non-SIC)}}, R_{1||h_1|,\,\text{(SIC)}}^{\text{(CSC/SIC)}} + R_{2||h_2|,\,\text{(non-SIC)}}^{\text{(CSC/SIC)}}\right\}. \tag{17}$$

It should be noted that our design guarantees $\min\left\{R_{sum||h_1|,|h_2|,|h_3|}^{\text{(CSC/SIC)}}, R_{sum||h_1|,|h_2|,|h_3|}^{\text{(CSC/non-SIC)}}\right\} \leq R_{sum||h_1|,|h_2|,|h_3|}^{\text{(CSC/SIC)}}$, which is a necessary condition for the conventional minimum high-correlated SC/non-SIC NOMA scheme.

4. Numerical Results and Discussions

In this section, we investigate the effects of the proposed 3-user low-correlated SC schemes, by comparing

$R^{(\text{CSC/non-SIC})}_{sum||h_1|,|h_2|,|h_3|}$ of the proposed low-correlated 3-user SC scheme to $R^{(\text{CSC/non-SIC})}_{sum||h_1|,|h_2|,|h_3|}$ of the conventional minimum high-correlated 3-user SC scheme. For this, the conditionals are assumed to be $|h_1|=\sqrt{2}$, $|h_2|=1$, and $|h_3|=0.1$, and the average total transmitted signal-to-noise power ratio (SNR) is $P/\sigma^2=50$. Then, for the conventional minimum high-correlated 3-user SC scheme, $\rho_{1,2}=\rho_{1,3}=\rho_{2,3}=\sqrt{0.50}$, whereas for the proposed low-correlated 3-user SC scheme, $\rho_{1,2}=\sqrt{0.50}$, $\rho_{1,3}=\sqrt{0.35}$, and $\rho_{2,3}=\sqrt{0.50}$. Note that we investigate the lower value $\rho_{1,3}=\sqrt{0.35}<\sqrt{0.5}$ for the correlation coefficient $\rho_{1,3}$, based on the observation that as the correlation coefficient $\rho_{1,3}$ decreases, the discontinuity of the power allocation range to be achieved becomes broader, whereas as the correlation coefficient $\rho_{1,3}$ increases, the power allocation range to be achieved becomes narrower.

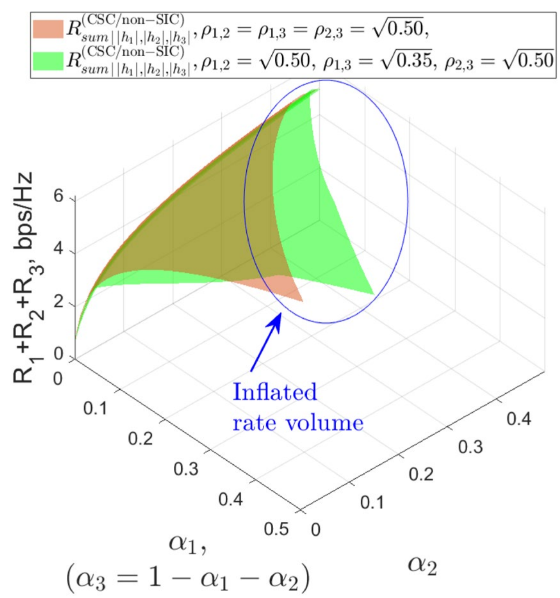

Figure 1. Comparison of achievable sum rates of conventional minimum high-correlated 3-user SC scheme and proposed low-correlated 3-user SC scheme, ($\rho_{1,3}=\sqrt{0.35}$).

As shown in Fig. 1, for the low correlation, i.e., $\rho_{1,3}=\sqrt{0.35}<\sqrt{0.50}$, the sum rate $R^{(\text{CSC/non-SIC})}_{sum||h_1|,|h_2|,|h_3|}$ of the proposed low-correlated 3-user SC scheme is inflated in the direction of the axis α_1, with respect to that of the conventional minimum high-correlated 3-user SC scheme. Notably, the axis α_1 is related with the low correlation $\rho_{1,3}$. In addition, we observe that the sum rate $R^{(\text{CSC/non-SIC})}_{sum||h_1|,|h_2|,|h_3|}$ of the proposed low-correlated 3-user SC scheme is deflated to a small amount, compared to that of the conventional minimum high-correlated 3-user SC scheme, over the power allocation ranges of the smaller sum rates.

Second, in order to investigate the impact of another correlation coefficient $\rho_{2,3}$ on the sum rate, we depict $R^{(\text{CSC/non-SIC})}_{sum||h_1|,|h_2|,|h_3|}$ of the proposed low-correlated 3-user SC scheme with $\rho_{1,2}=\sqrt{0.50}$, $\rho_{1,3}=\sqrt{0.50}$, and $\rho_{2,3}=\sqrt{0.35}$ in Fig. 2.

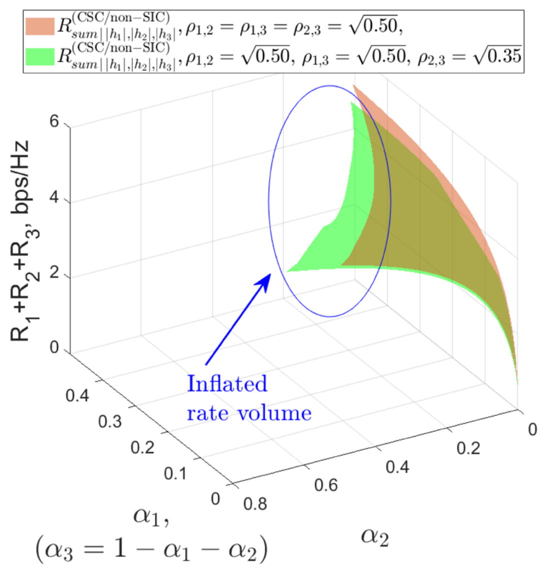

Figure 2. Comparison of achievable sum rates of conventional minimum high-correlated 3-user SC scheme and proposed low-correlated 3-user SC scheme, ($\rho_{2,3} = \sqrt{0.35}$).

As shown in Fig. 2, in this time, the sum rate $R^{(\mathrm{CSC/non\text{-}SIC})}_{sum||h_1|,|h_2|,|h_3|}$ of the proposed low-correlated 3-user SC scheme is inflated in the direction of the axis α_2, with respect to that of the conventional minimum high-correlated 3-user SC scheme. Thus, we conjecture that the low correlation inflates the sum rate, although the sum rate deflates, over the power allocation ranges of the smaller sum rates.

Third, in Fig. 3, to investigate the compound impact of the two correlation coefficients $\rho_{1,3}$ and $\rho_{2,3}$, we depict $R^{(\mathrm{CSC/non\text{-}SIC})}_{sum||h_1|,|h_2|,|h_3|}$ of the proposed low-correlated 3-user SC scheme with $\rho_{1,2} = \sqrt{0.50}$, $\rho_{1,3} = \sqrt{0.35}$, and $\rho_{2,3} = \sqrt{0.35}$.

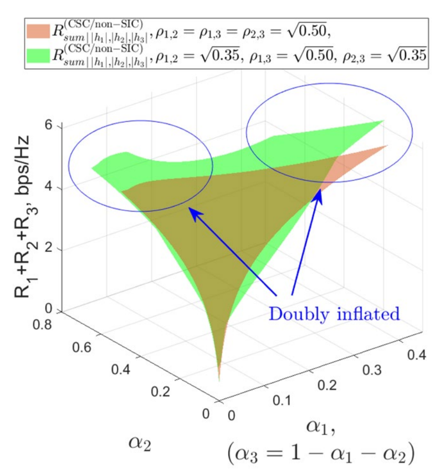

Figure 3. Comparison of achievable sum rates of conventional minimum high-correlated 3-user SC scheme and proposed low-correlated 3-user SC scheme, ($\rho_{1,3} = \sqrt{0.35}$, $\rho_{2,3} = \sqrt{0.35}$).

As shown in Fig. 3, with the two low correlations $\rho_{1,3} = \sqrt{0.35}$, and $\rho_{2,3} = \sqrt{0.35}$, the sum rate $R_{sum||h_1|,|h_2|,|h_3|}^{(\text{CSC/non-SIC})}$ of the proposed low-correlated 3-user SC scheme is inflated *doubly* in the directions of the axis α_1 and the axis α_2, with respect to that of the conventional minimum high-correlated 3-user SC scheme. Therefore, we conclude that whether $\rho_{1,3}$ or $\rho_{2,3}$, the low correlations inflate effectively the sum rate, even though the sum rate deflates, over the power allocation ranges of the smaller sum rates.

5. Conclusion

In this paper, we investigated a 3-user low-correlated SC scheme, especially for an inflated achievable sum rate, with a design of 3-user low-correlated SC.

First, we designed the 3-user low-correlated SC scheme by taking the minimum sum rate between 3–user SIC NOMA and 3-user non-SIC NOMA, both with correlated SC. Then, simulations demonstrated that the low correlation in the direction of the first user's power allocation inflates the sum rate in the same direction, compared to that of conventional minimum high-correlated SC NOMA, and such inflation due to low correlation is also observed similarly, in the direction of the second user's power allocation. Moreover, we also showed that the two low correlations of the first and second users inflates doubly in the both directions of the first and second users' power allocations.

As a result, the proposed 3-user low-correlated SC scheme could be a promising SC scheme, with the inflated sum rate in the future fifth-generation (5G) NOMA networks.

References

[1] A. Emir *et al*., "DeepMuD: Multi-user Detection for Uplink Grant-Free NOMA IoT Networks via Deep Learning," *IEEE Wirel. Commun*. Lett., vol. 10, no. 5, pp. 1133–1137, 2021. DOI: https://doi.org/10.1109/LWC.2021.3060772

[2] L. Chettri and R. Bera, "A comprehensive survey on internet of things (IoT) toward 5G wireless systems," *IEEE Internet of Things Journal*, vol. 7, no. 1, pp. 16–32, Jan. 2020. DOI: https://doi.org/10.1109/JIOT.2019.2948888

[3] Z. Ding, P. Fan, and H. V. Poor, "Impact of user pairing on 5G nonorthogonal multiple-access downlink transmissions," *IEEE Trans. Veh. Technol.*, vol. 65, no. 8, pp. 6010–6023, Aug. 2016. DOI: https://doi.org/10.1109/TVT.2015.2480766

[4] Z. Ding, X. Lei, G. K. Karagiannidis, R. Schober, J. Yuan, and V. Bhargava, "A survey on non-orthogonal multiple access for 5G networks: Research challenges and future trends," *IEEE J. Sel. Areas Commun.*, vol. 35, no. 10, pp. 2181–2195, Oct. 2017. DOI: https://doi.org/10.1109/JSAC.2017.2725519

[5] S. Kim, "Link adaptation for full duplex systems," *International Journal of Advanced Smart Convergence (IJASC)*, vol. 7, no. 4, pp. 92-100, Dec. 2018. DOI: http://dx.doi.org/10.7236/IJASC.2018.7.4.92

[6] S. Kim, "Switching between spatial modulation and quadrature spatial modulation," *International Journal of Advanced Smart Convergence (IJASC)*, vol. 8, no. 3, pp. 61–68, Sep. 2019. DOI: http://dx.doi.org/10.7236/IJASC.2019.8.3.61

[7] S. Kim, "Transmit antenna selection for quadrature spatial modulation systems with power allocation," *International Journal of Advanced Smart Convergence (IJASC)*, vol. 9, no. 1, pp. 98–108, Mar. 2020. DOI: http://dx.doi.org/10.7236/IJASC.2020.9.1.98

[8] Z. Chen, Z. Ding, X. Dai, and R. Zhang, "An optimization perspective of the superiority of NOMA compared to conventional OMA," *IEEE Trans. Signal Process.*, vol. 65, no. 19, pp. 5191–5202, Oct. 2017. DOI: https://doi.org/10.1109/TSP.2017.2725223

[9] Z. Yong, V. W. S. Wong, and R. Schober, "Stable throughput regions of opportunistic NOMA and cooperative NOMA with full-duplex relaying," *IEEE Trans. Wireless Commun.*, vol. 17, no. 8, pp. 5059–5075, Aug. 2018. DOI: https://doi.org/10.1109/TWC.2018.2837014

[10] M. Jain, N. Sharma, A. Gupta, D. Rawal, and P. Garg, "Performance analysis of NOMA assisted underwater visible light communication system," *IEEE Wireless Commun. Lett*., vol. 9, no. 8, pp. 1291-1294, Aug. 2020. DOI: https://doi.org/10.1109/LWC.2020.2988887

[11] Z. Sun, Y. Jing, and X. Yu, "NOMA design with power-outage tradeoff for two-user systems," *IEEE Wireless Commun. Lett.*, vol. 9, no. 8, pp. 1278-1282, Aug. 2020. DOI: https://doi.org/10.1109/LWC.2020.2987992

[12] M. Aldababsa, C. Göztepe, G. K. Kurt, and O. Kucur, "Bit Error Rate for NOMA Network," *IEEE Commun. Lett*., vol. 24, no. 6, pp. 1188-1191, Jun. 2020. DOI: https://doi.org/10.1109/LCOMM.2020.2981024

[13] A.-A.-A. Boulogeorg, N. D. Chatzidiamantis, and G. K. Karagiannid, "Non-orthogonal multiple access in the presence of phase noise," *IEEE Commun. Lett*., vol. 24, no. 5, pp. 1133-1137, May. 2020. DOI: https://doi.org/10.1109/LCOMM.2020.2978845

[14] K. Chung, "On power splitting under user-fairness for correlated superposition coding NOMA in 5G system," *International Journal of Advanced Smart Convergence (IJASC)*, vol. 9, no. 2, pp. 68-75, Jun. 2020. DOI: http://dx.doi.org/10.7236/IJASC.2020.9.2.68

[15] K. Chung, "On power calculation for first and second strong channel users in *M*-user NOMA system," *International Journal of Advanced Smart Convergence (IJASC)*, vol. 9, no. 3, pp. 49-58, Sept. 2020. DOI: http://dx.doi.org/10.7236/IJASC.2020.9.3.49

[16] K. Chung, "Analysis on achievable data rate of asymmetric 2PAM for NOMA," *International Journal of Advanced Smart Convergence (IJASC)*, vol. 9, no. 4, pp. 34-41, Dec. 2020. DOI: http://dx.doi.org/10.7236/IJASC.2020.9.4.34

[17] K. Chung, "NOMA for correlated information sources in 5G Systems," *IEEE Commun. Lett*., vol. 25, no. 2, pp. 422-426, Feb. 2021. DOI: https://doi.org/10.1109/LCOMM.2020.3027726

[18] K. Chung, "Achievable sum rate of NOMA with negatively-correlated Information Sources," *International Journal of Advanced Smart Convergence (IJASC)*, vol. 10, no. 1, pp. 75-81, Mar. 2021. DOI: http://dx.doi.org/10.7236/IJASC.2021.10.1.75

[19] K. Chung, "Achievable power allocation interval of rate-lossless non-SIC NOMA for asymmetric 2PAM," *International Journal of Advanced Smart Convergence (IJASC)*, vol. 10, no. 2, pp. 1-9, June. 2021. DOI: http://dx.doi.org/10.7236/IJASC.2021.10.2.1

[20] K. Chung, "Correlated superposition coding: Lossless two-user NOMA implementation without SIC under user-fairness," *IEEE Wireless Commun. Lett*., June. 2021. (Early Access) DOI: https://doi.org/10.1109/LWC.2021.3089996

[21] K. Chung, "On larger rate volume of non-SIC NOMA over SIC NOMA for 3-user correlated information sources," *J. of the Korea Institute of Electronic Communication Sciences*, vol. 16, no. 3, June. 2021, pp. 457-464. DOI: https://doi.org/10.13067/JKIECS.2021.16.3.457