

BER and Capacity Performance for Wavelet Based Three User MIMO-NOMA System

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Abstract

The new era of fifth-generation (5G) has revolutionized the industry and the technologies therein with high capacity that encompasses the high data rate. Multiple-input-multiple-output (MIMO) non-orthogonal multiple access (NOMA) system is anticipated for three user case, where the desired user's signal is subjected to the imperfect successive interference cancellation (SIC) because of the residue signal chunk of the undesired user. This imperfect SIC is catered utilizing the wavelet transform at the receiver end that improves the symbol-error-rate (SER) and the capacity of the overall system.

I. Introduction

In the recent times, 5G has immensely boosted the ubiquitous connectivity, wireless applications and the multimedia services over the cellular networks. This trend is expected to multiply the data traffic volume to the multiple folds of the recent data traffic [1]. In order to meet the demand of such a gigantic number of users to the network, the third-generation partnership project (3GPP) has already started to discuss the new technologies and network models for the future wireless communication systems [2]. Since the discussion of 5G is started, NOMA has been proposed the best suitable candidate that can improve the system performance with the enhanced capacity in the 5G and beyond 5G (B5G).

In this article, the NOMA scheme is implemented for three users. Multiple number of antennas are considered at the base-station (BS) and the users are accumulated in a cluster. The prime focus of this work is to analyze the impact of imperfect SIC and the wavelet filters are utilized to improve the system performance in terms of SER. In real world scenarios, several impairments and hardware issues occur that can affect the process of signal reception at the receiver. The poor signal recovery is due to the added noise from the channel and the incomplete subtraction of the undesired user data. The presence of undesired user data degrades the SIC process and causes the residue signal to deteriorate the signal recovery [2]. This implies that the propagation of residue signal during the SIC process of NOMA users is an essential parameter to cater for a realistic MIMO-NOMA network.

To mitigate the added noise in the NOMA system, studies [2] show that wavelet filter banks can improve the performance of the system due to its ability to provide additional flexibility for signal reconstruction. The multiresolution analysis of the signal via wavelet filters is vital to mitigate the interference power in the signal [3]. Typically, in the conventional system, FFT-OFDM is utilized for pulse shaping. It offers reduced latency and simplified channel equalization though, but bandwidth inefficiency comes along due to

cyclic prefixing. Also, it has reduced noise immunity because of rectangular pulse shaped carriers [2]-[4].

Simulation results in the following section will show the improvements provided by the utilization of wavelet filters at the receiver end.

II. System Model

A typical downlink NOMA system is considered for this work in which users are multiplexed at the BS. As per multiuser MIMO setup, only one cell scenario is assumed with three users, as shown in Figure 1. There are 2 transmit antenna are considered at the BS. The users are grouped in a one cluster and superposition algorithm is applied at the transmitter side. Each user is located at the distance (d) from the base station. The whole bandwidth is allocated to the 3 users individually and are segregated by power level assigned to each user. The beamforming matrix (V_b) is considered to focus the signal towards the desired cluster. The precoding vector is also derived to assign the symbols to the 3-user group in single cluster.

At the receiver side, the channel equalization is carried out first and then the signal are passed through the wavelet filter banks for interference cancellation. As the signal passed through the channel, where inter-symbol-interference (ISI) occurs due to the delayed waves of subchannels and affects the transmitted symbols. The interference along with the channel noise deteriorates the signal and cause the SIC failure. The imperfect SIC does not allow the SIC performing user to completely eliminate the signal of high-power user.

That is why, the User 1 which is the nearest user will suffer from the residue signal of the User 2 and User 3. These residue from other users will act as an additional interference and the BER of the desired user will decrease. Similarly, the User 2 will suffer from the residue of the User 3 signal while User 1 being the low power user will put no effect on the User 2. Hence, the signal of low power user will be treated as a noise and effectively be cancelled out after channel equalization.

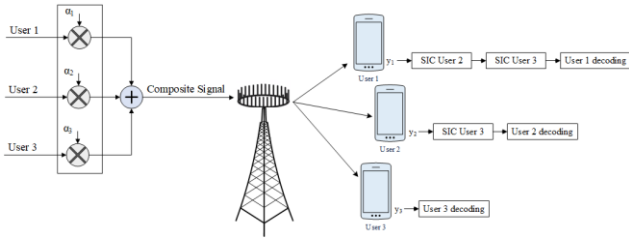


Figure 1. System Model for 3-User MIMO NOMA

The User 3 is the highest power user and will treat other users signal as noise, but User 3 will suffer from the additive interference due to the presence of residue signal power from both the User 1 and User 2. So, wavelet filter banks are employed in the system to efficiently recover the desired signal and effectively remove the unwanted noise. Wavelet transformation shows the less peak-to-average-power-ratio (PAPR) and lesser side lobe energy compared to the conventional FFT based systems.

III. Results

In the Figure 2, the SER performance of the 3-User NOMA system is shown. It can be seen that the imperfect SIC causes the deterioration of the user's signal and affects the SER of each user in the system. The trend of three user SER without implying the wavelet filters vs utilizing wavelets can be seen. SER of the users improve as the SNR increases on the x-axis. As the imperfect SIC creates residue in the signal and it can be seen from the Figure 2 that User 1 will suffer the more by the interferences of the other two high power users. But wavelet transform helps to reduce the effect of additional interferences and improves the User's SER. Similarly, Figure 3 highlights the importance of wavelet filter banks for the case of imperfect SIC. The total sum-rate of the system improves due to wavelet filter banks compared to the sum-rate curve for the imperfect SIC case that causes the residue in the signal.

IV. Conclusion

In this work, the SER and sum-rate performance of the MIMO-NOMA system is analyzed and it is demonstrated that for downlink MIMO-NOMA system the wavelet filter banks can improve the system performance for the case of imperfect SIC. This work can be extended for further realization of the multi-level filter analysis and other mathematical models can be examined to validate the theoretical and analytical findings of the network.

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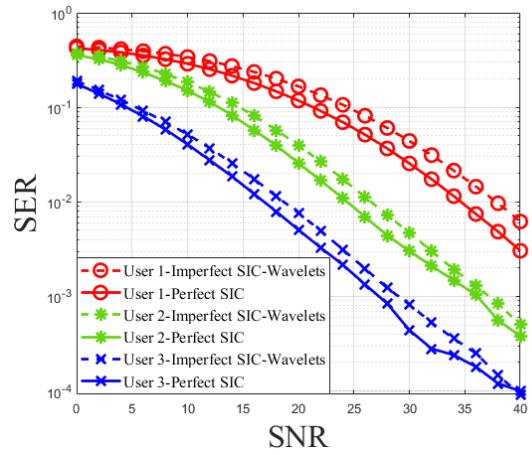


Figure 2. SER performance of the 3-User NOMA system

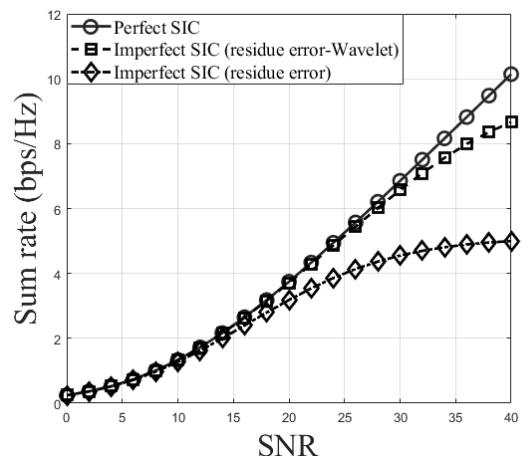


Figure 3. Achievable sum-rate of 3 NOMA users with and without imperfect SIC

References

- [1] Y. Liu, X. Yuan, Z. Xiong, J. Kang, X. Wang and D. Niyato, "Federated learning for 6G communications: Challenges, methods, and future directions," in *China Communications*, vol. 17, no. 9, pp. 105–118, Sept. 2020.
- [2] Ahmad, M., Baig, S., Asif, H. M., & Raahemifar, K. (2021). Mitigation of Imperfect Successive Interference Cancellation and Wavelet-Based Nonorthogonal Multiple Access in the 5G Multiuser Downlink Network. *Wireless Communications and Mobile Computing*, 2021, 1– 11.
- [3] A. S. de Sena et al., "Massive MIMO-NOMA Networks With Imperfect SIC: Design and Fairness Enhancement," in *IEEE Transactions on Wireless Communications*, vol. 19, no. 9, pp. 6100–6115, Sept. 2020.
- [4] Ahmad, M., Ramatryana, I. N., & Shin, S. Y. (2020). NOMA and OMA Comparison for Multiple Antenna Technologies under high Capacity Constraints for 5G and Beyond. *The Journal of Korean Institute of Communications and Information Sciences*, 45(11), 2004– 2013.