

A Review on Rate-Splitting Multiple Access Schemes with Successive Interference Cancellation Constraints

Anh-Tien Tran, Thanh Phung Truong, 권구락*, 조성래

중앙대학교, *조선대학교

attran@uclab.re.kr, tptruong@uclab.re.kr, grkwon@chosun.ac.kr, srcho@cau.ac.kr

Abstract

Two advanced techniques that have garnered significant attention for their potential to enhance network performance are Successive Interference Cancellation (SIC) and Rate-Splitting Multiple Access (RSMA).

SIC is a powerful method used to mitigate interference in wireless networks, allowing the receiver to sequentially decode and cancel out interference from stronger signals before decoding weaker ones. This short survey explores various RSMA works focusing on SIC constraints, highlighting the technical details, and analyzing performance evaluation. We also draw insights from recent studies to highlight the current advancements in this new research trend.

I. Introduction

The RSMA is an advanced multiple access system that divides user messages into shared and individual components, which are then encoded and delivered concurrently. RSMA effectively manages interference and optimizes transmission for users with varying channel conditions by using rate splitting. This approach is very successful in situations when there are diverse user needs and fluctuating channel conditions, offering a versatile and resilient solution for contemporary wireless networks.

The combination of SIC and RSMA presents a compelling opportunity to augment the functionalities of wireless communication systems. By integrating SIC's sequential interference removal capability with RSMA's dynamic message splitting and encoding techniques, networks may attain enhanced spectrum efficiency, increased data speeds, and more dependable connections. This introduction examines the possible advantages and uses of combining SIC with RSMA, emphasizing their collective influence on the performance and efficiency of future wireless networks.

II. Literature Review

In emerging multiple access techniques such as RSMA and Non-Orthogonal Multiple Access (NOMA), SIC is considered a key for performance enhancement. Therefore, the power constraint for implementing SIC is also studied in some research.

The paper [1] formulates the problem of rate allocation and power management as an optimization problem. The objective is to maximize the total network sum-rate, considering rate and SIC constraints in both SISO and MISO systems. The problem of maximizing the sum rate is presented for MISO-RSMA

systems, considering both rate and SIC constraints. The nonconvex issue is addressed using a recommended strategy that relies on sequential convex approximation (SCA) to provide a local optimal solution.

The SIC power constraint was also considered in [2]. This work aims at maximizing effective throughput by optimizing transmission rate and beamforming vector in multi-user MISO system. To solve the problem, the authors proposed a block coordinate descent and successive convex approximation-based iterative algorithm for alternating design transmission rate and beamforming factor.

The paper [3] explores the design of precoding for RSMA using interference nulling to manage multi-user interference in a MIMO system. The authors propose strategies to optimize the sum rate while reducing the complexity associated with precoding. It addresses the complexity of achieving optimal SIC in RSMA by introducing hierarchical user grouping and decoupling the optimization problem. The proposed algorithms aim to reduce the computational burden of SIC while maintaining high performance in terms of sum rate and interference management. The proposed SIN-MaxSNR and UBA algorithms demonstrate superior performance, particularly in scenarios with high inter-user correlation and channel disparity.

In the paper of [4], the objective is to maximize the sum-rate by adjusting the users transmit power and the base station's decoding order. The study compares RSMA with other access methods like NOMA, FDMA, and TDMA, demonstrating that RSMA can achieve significant gains in sum-rate performance. The paper also introduces a user-pairing algorithm to reduce the complexity of the optimization algorithm used in RSMA. The decoding order at the BS is

critical for effective interference cancellation. It is determined by a predefined permutation that optimizes the decoding process based on the transmission power and channel conditions of the sub-messages. The paper finds the decoding order by exhaustive search method.

III. Discussion

Despite the fact the integration of SIC into RSMA brings various benefits including enhanced spectral efficiency, robustness to interference, user fairness, and compatibility with advanced technologies such as MIMO, there is some challenges to satisfying SIC at every user in RSMA:

- **Computational Complexity:** Implementing SIC requires significant computational resources for decoding and cancelling interference, which can be challenging, especially in real-time applications. The need for high-speed, low-latency processing units can impose constraints on the hardware, increasing the cost and complexity of network devices.
- **Error Propagation:** The errors in the initial stages of SIC can propagate to subsequent stages, leading to degraded performance and increased bit error rates (BER). Also, it is a significant challenge to ensure robust performance in the presence of channel estimation errors and hardware imperfections.
- **Channel State Information (CSI) Requirements:** The implementation of SIC requires accurate and timely CSI, which can be difficult to obtain in fast-changing environments. The feedback overhead can also be problematic because providing and maintaining accurate CSI necessitates substantial feedback overhead.
- **User Pairing and Scheduling:** The problem of finding the optimal pairs or groups of users for applying SIC is complex because it requires channel conditions, user requirements, and interference levels.

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REFERENCES

- [1] Z. Yang, M. Chen, W. Saad, M. Shikh-Bahaei, "Optimization of rate allocation and power control for rate splitting multiple access (RSMA)", in IEEE Transactions on Communications, vol. 69, num. 9, 2021.
- [2] X Ou, X Xie, H Lu, H Yang. "Resource allocation in MU-MISO rate-splitting multiple access with SIC errors for URLLC services," In IEEE Transactions on Communications, vol. 71, num. 1, 2022.
- [3] E. Sadeghabadi, SD. Blostein. "RSMA Precoding Design Based on Interference Nulling and Sum Rate Upper Bound," In IEEE Transactions on Communications, 2023.
- [4] Z. Yang, M. Chen, W. Saad, W. Xu, M. Shikh-Bahaei. "Sum-rate maximization of uplink rate splitting multiple access (RSMA) communication," IEEE Transactions on Mobile Computing, vol. 21, num. 7, 2020.