**IOSR Journal of Engineering (IOSRJEN)** **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 15, Issue 2, February 2025, ||Series -1|| PP 01-10

# Facilitate heavy heterogeneous data traffic with Rate-Splitting Multiple Access through Deep Learning

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*Received 08February 2025; Accepted 18February 2025*

**Abstract:**Future communication networks may encounter various issues in order to facilitate heavy heterogeneous data traffic and large number of users, therefore more advanced multiple access (MA) schemes is required to meet the changing requirements. Recently, a promising physical-layer MA technique has been suggested for multi-antenna broadcast channels, namely Rate Splitting Multiple Access (RSMA). This new scheme has the ability to partially decode the interference and partially treat the remaining interference as noise which makes it to cope with wide range of user deployments and network loads. On the other hand, interleave division multiple access (IDMA) has already been recognized as a potential code domain NOMA (non-orthogonal multiple access) scheme, suitable for 5G and beyond communication network. Hence, in this paper, a new approach of multiple access scheme is proposed to get the grip on new challenges in future communication (6G). The proposed framework consists the joint processing of RSMA and IDMA (code domain NOMA), in which the transmitter involves an IDMA as encoder and allows rate splitting to split the message in two parts i.e. common part and private part, before the actual transmission. The mathematical modeling of proposed system is elaborated in the paper and for simulation purpose the downlink communication scenario has been considered where users faced diverse channel conditions. The weighted sum rate (WSR) performance is evaluated for the proposed scheme which validate the quality of service (QoS) of the joint RS-IDMA system.
**Keywords-** RSMA,Interference, Multiaccess communication, NOMA, Spectral efficiency, 6G mobile communication, MIMO communication

## I. INTRODUCTION

The advantage of a solitary radio wire ulceration utilizing SC-SIC is consequently to be capable, in spite of the presence of a solitary send receiving wire in a very SISO BC, to adapt to associate degree over-burden system in a very awfully adept means wherever numerous shoppers expertise presumably whole completely different channel qualities/way misfortunes on an analogous time/recurrence quality. The constraint of a solitary radio wire ulceration lies in its involution because the amount of shoppers develops. To be sure, for K-client SISO BC, foremost grounded shopper needs to interpret utilizing set on the K − one messages of all co-planned shoppers and consequently strip off K − one layers before progressing to its expected stream. The involution and likelihood of blunder proliferation seems to be speedily essential for uncounted shoppers. This necessitate ways in which of decreasing the number of set on layers at each shopper. One may isolate shoppers into very little gatherings of shoppers with dissimilar channels & applying SC-SIC in every gathering & timetable gatherings on symmetrical assets (utilizing OMA), but which may prompt many execution misfortune and idleness increment. In recently remote organizations, passages square measure often supplied with over one radio wire.

This spatial aspect makes the way for another notable sort of numerous entrance, in particular SDMA. SDMA superposes clients in a similar time-recurrence asset and isolates client by means of an appropriate utilization of the spatial aspects. Multireceiving wire BC is non-degraded compared to the SISO BC since clients cannot be requested based on their direct assets in realworld scenarios. Because of this, SC-SIC is not limit achieving, and merely method which attains limit area of varied info single output BC by great CSIT is the complicated messy paper coding (DPC). As opposed to SC-SIC, which performs obstacle scratchoff at the receivers, DPC may be thought of as a sort of enhanced impedance abrogation so at transmitters and hence relies on optimal CSIT.

Because of the great computational weight of DPC, straight pre-coding is regularly viewed as the most alluring choice to work on the transmitter plan. Strangely, in a MISO BC, multi-client direct pre-coding (MU-LP), into shut structure or upgraded utilizing advancement strategies, however less than ideal, is frequently extremely valuable when clients experience somewhat comparative channel qualities or longer haul signal-to-commotion proportion (SNR) & has semi-symmetrical to symmetrical channels.

SDMA is in this manner regularly executed utilizing MU-LP. The straight pre-coders make various bars with each pillar being dispensed a negligible part of the complete communicate power. This means that, like NOMA, SDMA may be thought of as a superposition of users in power field; but, unlike NOMA, in SDMA the users are separated from one another using spatial beam formers on the transmitter side, rather than by SIC on the receiver side. Multiple 4G and 5G techniques rely on SDMA based on MU-LP as its backbone technology. These techniques include multiuser multiple information multiple result (MU-MIMO), facilitated multipoint (CoMP) composed beam-forming, network MIMO, millimeter wave MIMO, & monster MIMO.

By using a coffee-based pre-coder and a simple receiver, SDMA with MU-LP is able to reap all the benefits of spatial multiplexing afforded by a MISO BC by seamless CSIT. Triplet SDMA restrictions, for starters, it's suitable the underneath loaded system and execution of MU-LP within the over-burden system quickly drops because it needs additional send radio wires than purchasers to possess the choice to proficiently upset the multi-client obstruction.

At the purpose once the MISO BC becomes over-burden, this and celebrated methodology for the transmitter is to set up gathering of purchasers over symmetrical aspects and perform direct pre-coding in every gathering, which could expand immobility and alteration QoS relying upon the applying. Next, its exhibition is delicate to shopper channel symmetry & qualities needs computer hardware to match semi-symmetrical purchasers with comparative channel qualities along. The complexity of the computer hardware will quickly increment once

An intensive inquiry is performed, but low-intricacy (sub-par) booking and shopper matching calculations exist. Third, it is excellent from the perspective of levels of freedom3 (DoF), also called as spatial multiplexing gain, in a seamless CSIT environment but not in view of imperfect CSIT. Challenge of SDMA deployment within context of imperfect CSIT consists of adapting a system roused by ideal CSIT to items with blemished CSIT rather than deploying a framework roused by faulty CSIT from the first. When this occurs within the view of tainted CSIT, the infamous austere act loss of MU-LP ensues.

While SDMA & ulcer literature both completely interpret intrusion & consider intrusion as noise, we at RSMA choose to take a different approach. We provide a new generic and potent multiple access architecture that uses linearly pre-coded rate cacophonous (RS) so at broadcaster with attack at the receivers. Decrypting the interference in this way permits the remainder of the interference to be ignored as noise. In this way, RSMA may gently bridge the gap between two risky approaches of completely treating interference as noise & completely encoding interference. This is in stark contrast to SDMA and ulcer, which focus only on one end of the spectrum or some combination of the two. RS depend on on a superimposed transmission of mutual messages decrypted by numerous operators & personal messages decrypted by its expressive & receptive, so that it can do two things at once: partially decrypt interference & partly treat interference as noise. Attackers may think that it's easier to get into the private messages if they can first decode the public ones. RS may smoothly transition among two dissipations of treating interfering as noise & decrypting it entirely by altering message split, by extension, power allocation between common & private messages.

Carleial's work is the foundation for the RS idea, and the Han dynasty & Kobayashi (HK) theme provides the foundation for our understanding of the two-user, single-antenna interference channel (IC). Recent studies have proved advantage of RS in multi antenna BC, therefore new development on describing elemental limitations of multi-antenna BC by poor CSIT, motivates the usage of RS as building block of RSMA. Consequently, we prefer to employ RS during a completely different found out, especially in a BC even with multiple antennas, in disparity to conventional RS used in two-user SISO IC.

## II. RELATED WORK

**Y Saito, Y Kishiyama, T Nakamura, K Higuchi, in VTC Spring. NOMA IEEE, 2013, pp. 1–5**

This article introduces a NOMA model for future radio access (FRA) in preparation for the information society of the 2020s. Even while NOMA's fundamental signal waveform may be based on the same OFDMA or DFT-spread OFDM as LTE baseline, it differs from LTE's current radio access strategy (up to Release 11) in that it superposes numerous users in the power domain. We propose that, in light of the anticipated development in device processing capabilities, NOMA should use a sequential SIC receiver as its primary receiver architecture for reliable multiple access. With system-level tests, we demonstrate that downlink NOMA and SIC enhances capacities & cell-edge user output performance, even without a frequency-selective channel measure of quality (CQI) available at the base station.We also discuss potential NOMA extensions, such as the use of multi-antenna/site technologies in conjunction with suggested NOMA/MIMO scheme employing SIC & IRC receiver, to achieve even greater capacity gains, such as a three-fold increase in spectrum efficacy, which is a difficult but attainable goal for frequency reuse allocation (FRA).

**Indoor, & Mobile Radio Communications (PIMRC). IEEE, 2013, pp. 3326. H Nikopour, H Baligh, in 2013, –336**

By utilizing a complicated spreading sequence, the QAM symbols that make up a multicarrier CDMA signal are dispersed among a number of OFDMA tones. A QAM sign is effectively echoed over a wide range of tones. By using a CDMA variant called low density signature (LDS), we may take use of a nearly optimum ML receiver at a complexity that is realistically achievable. Here, we present a novel multiple access approach termed SCMA, which shares LDS's low complexity receiving technique while offering improved performance. In SCMA, incoming bits are immediately translated to a multidimensional codeword of an SCMA codebook set, eliminating the need for a separate mapping method from bits to QAM symbols. There is a separate codebook for each tier or user. The fundamental reason LDS performs better than just repeating the same QAM symbols over and over again is due to shaping gain of multidimensional constellation. In most cases, designing an SCMA codebook entails solving an optimization issue. This article proposes a non-optimal method for creating SCMA codebooks.

**Z Ding, Y Liu, Q Sun, M Elkashlan, C-l I, HV Poor, Application of non-orthogonal multiple access in LTE and 5G networks. IEEE Mag. 55(2), 185–191 (2017)**

Recent proposals for 3GPP Long Term Evolution (LTE) include non-orthogonal multiple access (NOMA), latest member of multiple access family that is expected to play a crucial role in 5G mobile networks. NOMA's primary characteristic is its capability to increase spectral effectiveness over traditional orthogonal MA by serving many users on same time, frequency, and code at various power levels. From its use in tandem using multiple-input multiple-output (MIMO) technology to cooperative NOMA to interaction among NOMA & cognitive radio, this article gives a thorough examination of this cutting-edge innovation. Also discussed are the current developments in NOMA standardization initiatives for LTE & 5G networks.

**A. SHUKLA: "joint RSMA & IDMA-based ulceration system for downlink communication in 5G and upon far side network". In 2020 journal of communications package and systems, pp, 1-5.IEEE, 2020.**

Various challenges may arise in the future of communication networks as they attempt to accommodate substantial diverse data traffic and a large number of users, hence it is imperative that more sophisticated multiple access (MA) systems be developed to satisfy these new demands. Rate-splitting multiple-access has recently been projected as a practical physical-layer MA approach for RSMA. This novel approach can handle a broad variety of user installations and network loads since it can partly decipher interference & partly treating remaining disturbance as noise. Interleaved division multiple access (IDMA), on the other hand, has been identified as a feasible code domain NOMA method, appropriate for 5G well beyond communication networks.

**Mao, Yijie, and Victor ok Li. "Rate-splitting multiple access' energy efficacy & advantages in performance over SDMA & NOMA". In 2018 fifteenth international conference on wireless communication systems (ISWCS), pp, 1-5. IEEE, 2018.**

SDMA & NOMA are specific examples of the more generic and potent multiple access framework known as RSMA, which is used for downlink multi-antenna systems. To decrypt some of intrusion while disregarding rest as noise, RSMA uses linearly precoded rate-splitting with SIC. In recent years, it has become clear that RSMA provides superior throughput over SDMA & NOMA in a variety of network configurations and load conditions (both under- and over-loaded states). It was also shown that RSMA outperformed NOMA in terms of spectrum efficiency and QoS improvements while using less processing power from the transmitters and receivers. This research expands on those findings by exploring RSMA's energy efficiency in light of its rivals, SDMA and NOMA. As a result, we can say that RSMA is superior than SDMA & NOMA in relations of spectral effectiveness & energy consumption.

## III. METHODOLOGY

### 3.1 INTRODUCTION:

Multiple antennas are common on modern wireless network access points. With the addition of space, SDMA becomes a viable multiple access method. With SDMA, several users share a same moment resource while being kept apart thanks to the clever utilization of spatial dimensions. Users cannot be prioritized based on channel strengths in a multi-antenna BC deployment. Consequently, capability area of multiple-input single-output BC by perfect CSIT cannot be achieved using SC-SIC, and the only technique that can is the sophisticated filthy paper coding. In this way, MU-LP is a popular method for implementing SDMA. As a result of the linear pre-coders, many beams are generated, each of which receives a certain percentage of the available transmission power.

In contrast, RSMA takes a new tack by moving away from both the completely decrypt intrusion & treat interference as noise camps present in the SDMA & NOMA literature. Through the use of linearly pre-coded RS at transmitter and SIC at receivers, we provide a more flexible & potent numerous access architecture.

RS divides communications into public and private and depends along an overlaid transmission of public messages decrypted by various users & private messages deciphered by their respective users in order to partly decode & partially treat disturbance as noise. In order to read the secret messages, users must first decode the public ones using SIC. In this case, by redistributing resources between public and private communications and redistributing the message load.

Because of its increased spectrum efficiency, NOMA is seen as a potential multiple access approach for 5G networks. In this letter, we first investigate the emerging capacity maximization dilemma for MIMO ulceration systems using channel state information derived from applied mathematics at transmitter (CSIT). To optimize piecewise capacity of MIMO ulceration system within constraints of total transmit power & minimum rate of weak user, we present both optimal and poor quality suboptimal transmit power techniques. According to the simulation findings, the suggested ulceration themes are able to decisively defeat the conventional orthogonal multiple access strategy.

Typically, we showed how to invigorate a preexisting 2-user downlink NOMA system. At that point, we typically design the ulceration's capacity, outage probability, & BER using MATLAB simulation. Since this is the case, we often believe that interference can be cancelled perfectly (SIC). In reality, though, it's not always possible to hold out dead while under assault. To put it another way, our current state of attack is subpar.

**3.2 PROPOSED SYSTEM:**

Allowing subscribers to transfer data from mobile stations to base stations at same time they receive data from base stations is an attractive feature of many wireless communication systems. Any given region is partitioned into smaller sections called "cells," and inside each cell is a mobile device that may interact with a central base station. The primary goal of cellular system architecture is to maximize channel capacity, or the number of calls that can be processed in a given amount of available bandwidth while maintaining acceptable quality of service.

Channel access may be permitted in a number of ways. The following are the most prominent examples of this: There are several types of MIMO systems, including FDMA , TDMA, SDMA, and NOMA. Space division multiple access, also called as spatial division multiple access, is a kind of MIMO architecture widely used in wireless & satellite communication. Using SDMA, several users may simultaneously transmit and receive data over a single channel. In SDMA, the base station uses directional spot-beam antennas to keep tabs on a roaming user and regulate how much power is sent to each of them individually. To increase spectral efficacy while tolerating some multiple-access interference at receivers, NOMA concept has emerged as a viable option. With a single model, uplink & downlink transmissions, as well as expansions to MIMO and cooperative communication situations, are all covered.

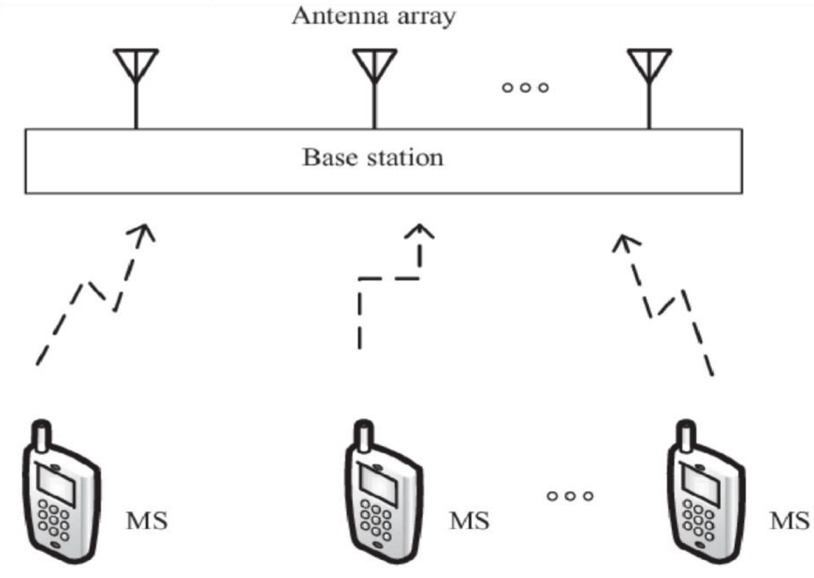


Figure 1: SDMA system Block Diagram

Figure 1 illustrates the notion of SDMA systems, in which a mobile station uses a single transmission antenna and a base station uses a collection of receiving antennas. This channel transfer function is the basis of SDMA's spatial signature, allowing numerous users to communicate in real time over the same frequency band.

We have assumed 2 users in our downlink ulceration network for the proposed system. Two different messages must be sent to each user from bottom station (BS). The first user is the far or weak one, while second is the nearby or powerful one.

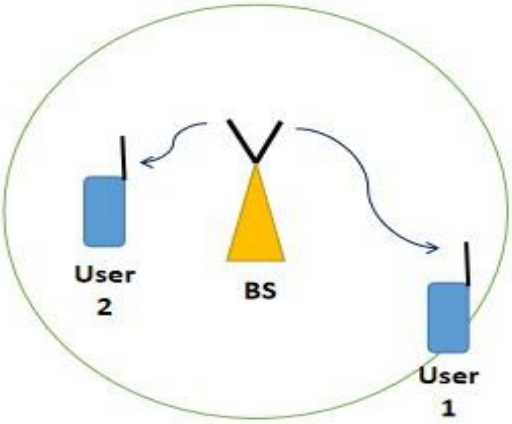


Figure 2: Network model of RSMA

As a fast refresher, bear in mind as received signals at near & far user will be depicted like:

$$y_1 = h_1x + w_1 = h_1[P(\sqrt{\alpha 1}x1 + \sqrt{\alpha 2}x2)] + w_1 \; y_2 = h_2x + w_2 = h_2[P(\sqrt{\alpha 1}x1 + \sqrt{\alpha 2}x2)] + w_2$$

Where,

$$x = \overline{P}(\sqrt{\alpha 1}x1 + \sqrt{\alpha 2}x2)$$

Is superposition encoded transmits signal by BS.
Again the notations are same as before,

- $x_i$ – Data projected for i[th] user.
- $\alpha_i$ – Portion of power assigned for i[th] user.
- $h_i$ – Rayleigh fading coefficient by BS to i[th] user.

As per rules of RSMA, $\alpha_1 > \alpha_2$. User-1 is at a greater distance and will employ direct decoding, whereas User-2 will need to use SIC to obtain his data..
Then, we often present the idea of RS by providing two-user and three-user examples (K=2 and K=3, respectively). Then, we present the RS framework in general and detail two RS techniques with modest complexity. There are two more ways in which we may differentiate between RSMA and SDMA: by examining their fundamental structure and quality. At last, we talk about the overarching optimization approach for fixing the WSR issue.

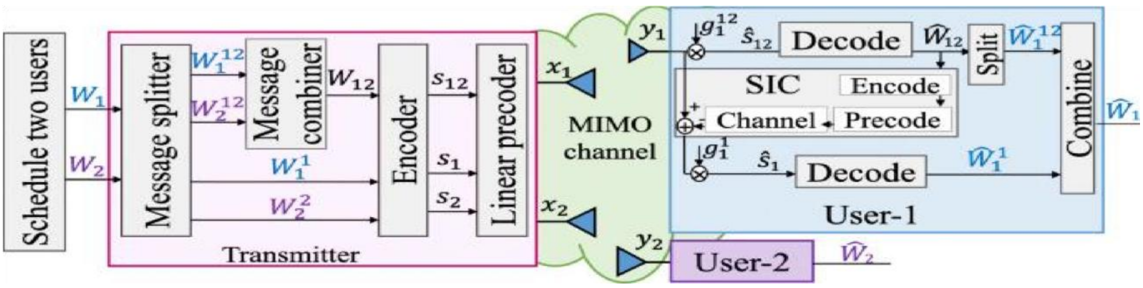


Figure 3: 2-user transmission model victimization RSMA

The higher than figure represents the two-user example. There are 2 messages $W_1$ and $W_2$ meant for user-1 and user-2, severally. The messages of every user is split into 2 components, for user-1 and for user-2.The messages $\{W_1^{12}, W_2^{12}\}$ are encoded along into a typical stream $S_{12}$ employing a codebook shared by each users. Hence, $S_{12}$ may be a common stream needed to be decoded by each users. The messages $W_1^1$ and $W_2^2$ are encoded into the personal stream $S_1$ for user-1 and $S_2$ for user-2, severally. The knowledge stream to be supported RS is

$$S = [S_{12}, S_1, S_2]^T$$

Each user on their end initially decrypts the information stream $S_{12}$ by ignoring the noise introduced by $S_1$ and $S_2$. Since message of opposing intrusive user is encoded in $S_{12}$, some of the interference is decoded at each user. Upon successful decoding of $S_{12}$, contribution of $S_{12}$ to initial received signal may be determined.

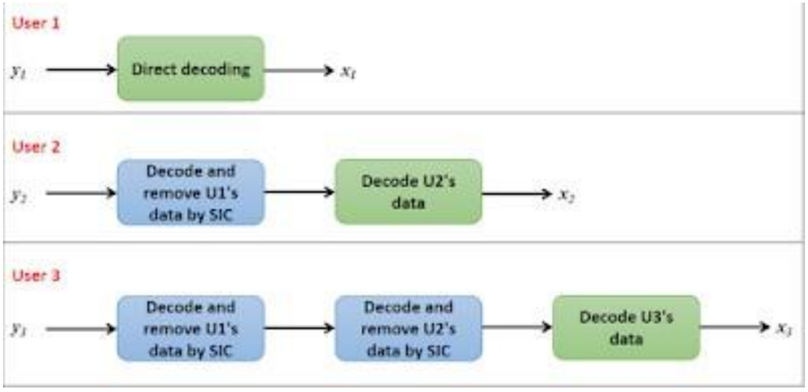


Figure 4: Attack decryption procedure

At User 1

Since U1 is given the most resources, he can bypass U2 and U3 and directly decode from y1. U1 is thus a pace that is feasible to achieve.,

$$R_1 = \log_2\left(1 + \frac{\alpha_1 P|h_1|^2}{\alpha_2 P|h_1|^2 + \alpha_3 P|h_1|^2 + \sigma^2}\right)$$

Which can additional be simplified as,

$$R_1 = \log_2\left(1 + \frac{\alpha_1 P|h_1|^2}{(\alpha_2 + \alpha_3)P|h_1|^2 + \sigma^2}\right)$$

Since α2+ α3 is a gift at the dividend in the above equation, we now need to fulfill α1> α2+ α3. This is necessary for U1's strength to be the dominant feature of both the sent (x) and received (y 1) signals.

At User 2

In the next step, we'll formulate the equation for U2's velocity. Since α2 <α1 and α2>α3, U2 must engage in ordered fading channels to eliminate U1's information through attack, and so U2's achievable rate is,

$$R_2 = \log_2\left(1 + \frac{\alpha_2 P|h_2|^2}{\alpha_3 P|h_2|^2 + \sigma^2}\right)$$

At User 3

Lastly, U3 (α_3<α_1,α_3<α_2) should double-attack y 3 to erase all traces of U1 and U2 knowledge. The 1term should be eliminated first from y 3 due to its preponderance. Next, the 2 component may be eliminated. Rates of this magnitude are
realistically,

$$R_3 = \log_2\left(1 + \frac{\alpha_3 P|h_3|^2}{\sigma^2}\right)$$

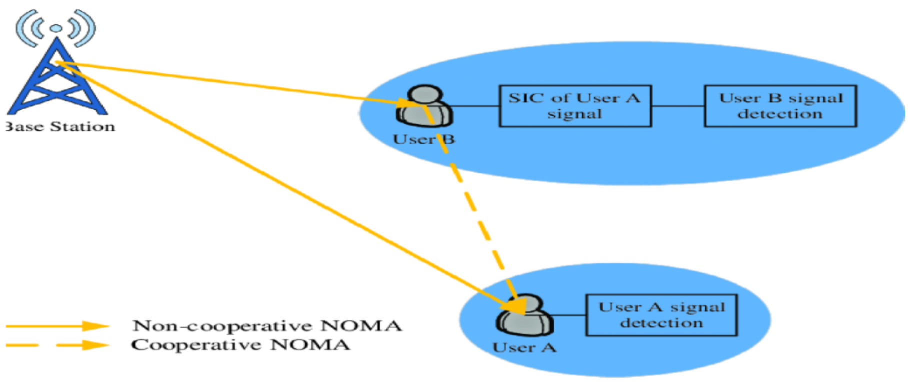


Figure 5: NOMA system Block Diagram

For the scenario of single base station & 2 users, the block diagram of a NOMA system is shown above. The strength of the nonorthogonal signal sent by the base station to user 2 is proportional to distance between base station and that user. Since the signal reaching user 1 seems like noise owing to channel attenuation, user 1 executes SIC operation to eliminate signal of user 2, and then obtains the signal delivered to them.

## IV. RESULT AND DISCUSSION:

**SDMA BEAM-PATTERN**

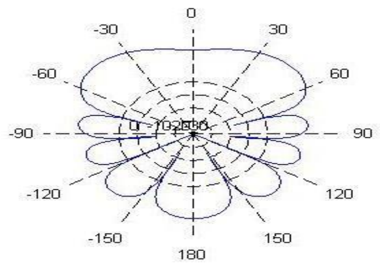


**Figure 6:** Beam-pattern of SDMA

Beam strength varies with direction and distance from the source. Beam-forming is a method for focusing transmissions and receptions on a narrow beam.

**NOMA SIMULATION**

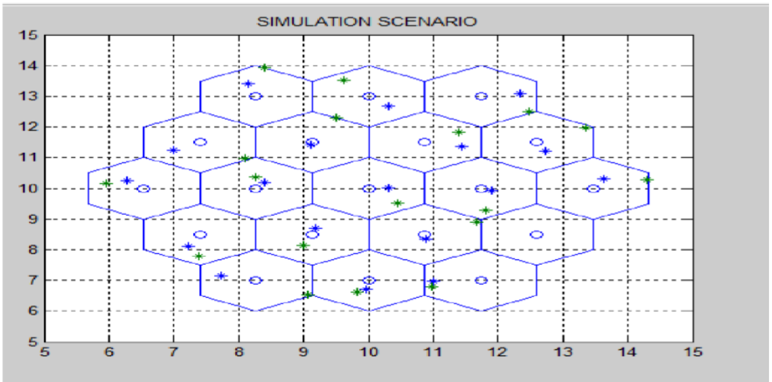


**Figure 7**: NOMA simulation

Envision 19-cell ulceration with wrap-around. There are a total of 19 neighboring cells in this region. In each unit of the network, there were two users in tandem, each linked to a single baccalaureate. As a result, link measure model calculates BER in a manner that takes into account the fact that every user in a particularly large cell is subject to interference from each of its eighteen nearby cells. First cell's blue circle base station, first tier's blue star base station, and second tier's green star base station are all shown.

Even though there are 19 cells total, the border cells do not share all of their hexagonal borders with their neighbors. This suggests that boundary cells experience less interference than inside cells. Two layers of cells are regarded surrounding the cells to imitate the same interference state as the users in the core cell. The BER calculated by link performance model for users on the edge of the coverage area is the same as that calculated for users in the central coverage area.

**NOMA 2-USER**

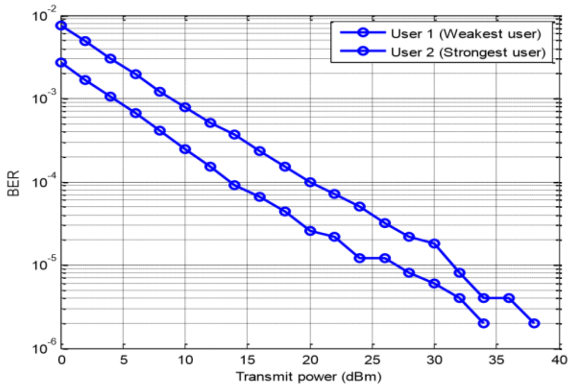


**Figure 8:** BER v/s Transmit Power NOMA 2 user

despite having a lower BER than user 2, user 1 has more interference.

**RSMA 2 USER**

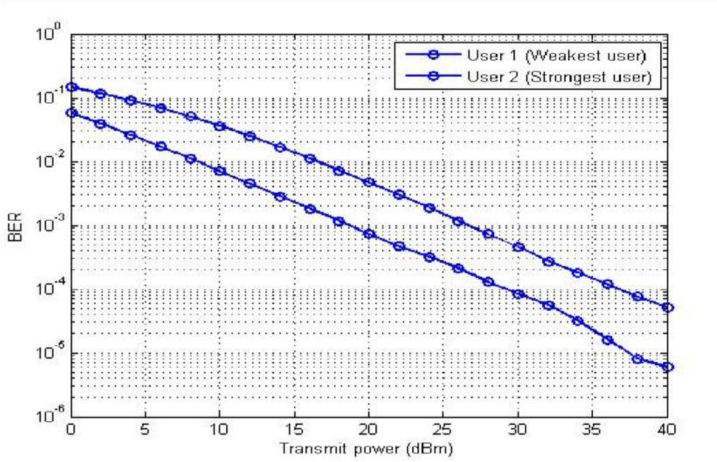


Figure 9: BER v/s Transmit power RSMA 2 user

Users' relative strengths , where the weakest user (User-1) is given more resources while the stronger users (Users-2 and 3) are given less resources in an effort to enhance user fairness. When compared to NOMA, RSMA's high transmit power ensures that the channel state information sent in the message is accurate (CSI).

**RSMA FOR 3-USER**

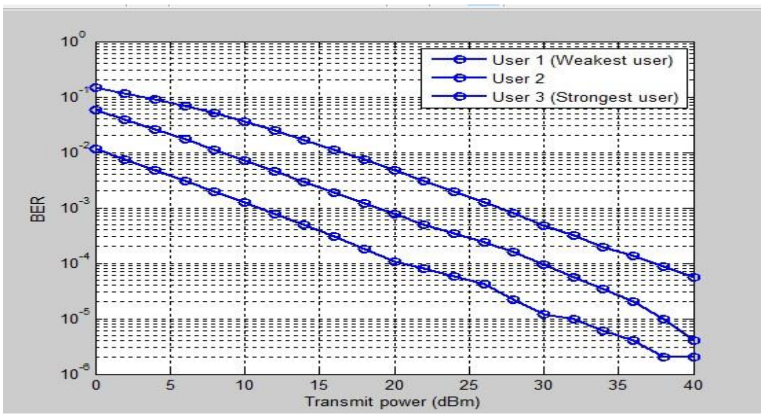


Figure 10: BER v/s Transmit Power RSMA 3-user

BER for User 1 is clearly the highest of the three users. Because he gets the most disruptions, that's why. That is to say, Users 2 and 3 both contribute to disturbance for User 1. Interference from User 3 is somewhat distracting to User 2. User 3 does have lowest BER of the bunch since finally free of interruption.

**COMPARISON OF SDMA RSMA NOMA**

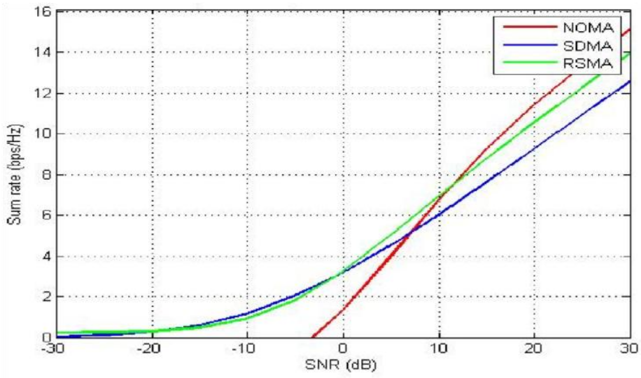


Figure 11: Comparison study of SDMA, NOMA, RSMA

When compared to both NOMA and SDMA, RSMA consistently produces the highest performance. Since there is only one SIC in RSMA and two in NOMA, the latter allocates more power to users with lower channel gains in accordance with the former's successful SSICs' power needs, resulting in a lower aggregate throughput. In particular, when the maximum transmit power of the BS is kept low, this value beats NOMA. Since all users may be supplied with the full bandwidth of the BS, RSMA is superior than SDMA and NOMA.

## V. CONCLUSION

IDMA has already been considered as code domain NOMA system for future communication networks. However, in multiuser scenario the rate of IDMA system saturates with imperfect CSIT. Rate splitting approach can tackle the degradation of performance of system due to multiple access interference (MAI). Hence, in this paper the joint rate splitting approach based IDMA (RS-IDMA) system has been proposed. Remarkably, RS improved the proposed system performance. Moreover, the simulation results which are based on weighted sum rate (WSR) approach, validated the proposed system performance. Moreover, the use of different interleavers in IDMA can be used as future work for further improvement of the proposed system. The sensitivity analysis can also be done as a future work plan, to ensure the effect of channel and other parameter ambiguities.

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