Power Allocation for Common and Private Messages in LEO-Terrestrial RSMA Networks

M. B. de Paiva and F. R. M. Lima

***Abstract*— The increasing demand for high-capacity wireless communication has led to the investigation of advanced multiple access techniques. Rate-Splitting Multiple Access (RSMA) stands out for its interference management capabilities, while Low Earth Orbit (LEO) satellite networks offer global, high-speed coverage. This work explores the integration of RSMA into LEO satellite systems, aiming to maximize the total data rate. This paper adapts and applies a low-complexity approach by designing private and common precoders and optimizing transmit power allocation. Simulations demonstrate that the method achieves superior data rates and robustness under imperfect channel conditions, outperforming conventional benchmark solutions.**

***Keywords*— RSMA, LEO Satellite, Precoder, Power Allocation.**

I. Introduction

The increasing demand for high-capacity and low-latency wireless communication has driven research into advanced multiple access (MA) techniques [1]. RSMA has emerged as a promising solution due to its ability to efficiently manage interference and improve spectral efficiency [2]. By leveraging the principle of rate splitting, RSMA enables more flexible and robust communication strategies compared to traditional MA schemes such as orthogonal multiple access (OMA), non-orthogonal multiple access (NOMA) and spatial-division multiple access (SDMA) [2].

Simultaneously, the deployment of low Earth orbit (LEO) satellite networks has gained prominence as a means of providing global coverage and high-speed connectivity [3]. The integration of RSMA with LEO satellite communication systems presents a significant opportunity to optimize resource allocation, improve system reliability, and maximize the system throughput [4]. However, achieving optimal performance in such integrated systems requires advanced optimization techniques.

In [5], the authors make a comparative analysis of the data rate achieved by RSMA, SDMA and OMA in a multi-beam downlink system via LEO satellite. Using conventional precoders for common and private streams and a simplified scenario with two users, the authors optimize the RSMA data rate based on an exhaustive search for the power division between private and common messages. The provided simulation results showed that RSMA is able to achieve data rates better than or equal to those provided by SDMA and OMA. In [6], the authors implemented a system model similar to that in [5], but to evaluate a precoding solution based on machine learning (ML) for SDMA. The results showed that the proposed solution was able to achieve better performance especially in scenarios with imperfect channel state information at the transmitter (CSIT).

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In this paper we consider the optimization of the total data rate in LEO-based communication systems with RSMA, where we employ precoding for common and private messages and power distribution between these messages. The employed power allocation has a lower computational complexity compared to [5], which was based on exhaustive search. The simulation results show that our solution offers similar flexibility and robustness to [5], and even outperforms it in some scenarios.

The remainder of the paper is structured as follows: Section II presents details of the system model and the formulation of the total data rate maximization problem. In Section III, we describe the implementation of RSMA and the power allocation strategy. Finally, the performance evaluation is presented in Section IV, and the conclusion in Section V.

II. System Model and Problem Formulation

We consider a downlink LEO communication system employing RSMA over a line-of-sight (LOS) channel. The LEO is equipped with a uniform linear array (ULA) of N antennas, each with gain G_{sat}, serving K single-antenna users with gain G_{user}, as illustrated in Fig. 1. The angle of departure (AoD) from the array to user k is β_k. The satellite's minimum distance to Earth's surface is d_{sat}, and users are uniformly distributed around a cell center at distance $\overline{D}$ from the satellite's nadir, with $\mathbf{h}_k \in \mathbb{C}^{N\times 1}$ denoting the LOS channel to user k. The received signal at the k-th user can be expressed as

$$y_k = \mathbf{h}_k^{\text{H}}\mathbf{x} + n_k = \sum_{n=1}^{N} h_{k,n}x_n + n_k, \tag{1}$$

where $\mathbf{x} \in \mathbb{C}^{N\times 1}$ is the precoded signal, x_n its n-th element, $h_{k,n}$ the channel response between antenna n and user k, and $n_k \sim \mathcal{CN}(0, \sigma_n^2)$ is the complex additive white Gaussian noise (AWGN).

A. Channel State Information

We adopt the LOS channel model from [5], where the response between the n-th satellite antenna and user k is

$$h_{k,n}(\cos(\beta_k)) = \sqrt{G_{\text{user}}G_{\text{sat}}}\frac{\lambda_{\text{carr}}}{4\pi d_k}e^{-j\omega_k}a_{k,n}(\cos(\beta_k)), \tag{2}$$

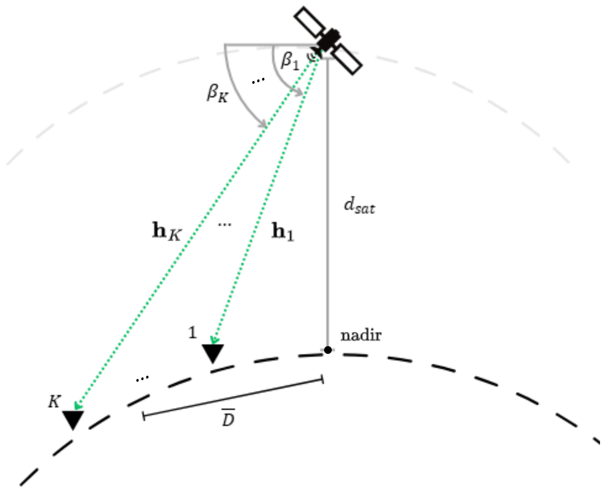


Fig. 1: LEO Satellite System.

with d_k the distance to user k, λ_{carr} the carrier wavelength, $\omega_k \in [0, 2\pi]$ the total phase shift, and $a_{k,n}(\cos(\beta_k))$ the relative phase shift defined as

$$a_{k,n}(\cos(\beta_k)) = \exp^{-j\pi \frac{d_a}{\lambda_{\text{carr}}}(N+1-2n)\cos(\beta_k)}, \tag{3}$$

where d_a is the distance between ULA elements. Defining the steering vector $\mathbf{a}_k(\cos(\beta_k)) = [a_{k,1}(\cos(\beta_k)), \ldots, a_{k,N}(\cos(\beta_k))]^{\text{T}}$, we write

$$\mathbf{h}_k(\cos(\beta_k)) = \sqrt{G_{\text{user}} G_{\text{sat}}} \frac{\lambda_{\text{carr}}}{4\pi d_k} e^{-j\omega_k} \mathbf{a}_k(\cos(\beta_k)). \tag{4}$$

Given the high Doppler shifts in LEO systems, we consider imperfect CSIT, modeled as an AoD cosine perturbation $\tau_k \sim \mathcal{U}(-\tau, +\tau)$ [5], so that

$$\mathbf{h}_k^{'}(\cos(\beta_k)) = \mathbf{h}_k(\cos(\beta_k)) \circ \mathbf{a}_k(\tau_k), \tag{5}$$

where $\circ$ denotes the Hadamard product. Since CSIT impacts the precoder, it affects the overall RSMA design, addressed next.

B. Transmit Model

To apply RSMA, the messages of each user are divided into a common part and a private part. Thus, for user k, the message W_k is divided into a common part $W_{\text{c},k}$ and a private part $W_{\text{p},k}$. The common messages $W_{\text{c},1}, \ldots, W_{\text{c},K}$ of the users are superimposed to form a single common message W_{c}, which is encoded into a common stream s_{c} and transmitted to all users. The private parts $W_{\text{p},1}, \ldots, W_{\text{p},K}$ are encoded separately in individual streams $s_1, \ldots, s_K$. Thus, the transmission signal is given by

$$\mathbf{x} = \mathbf{p}_{\text{c}} s_{\text{c}} + \mathbf{p}_1 s_1 + \ldots + \mathbf{p}_K s_K. \tag{6}$$

At the receiver, i.e., at user k, the common stream s_{c} is decoded first, to obtain $\widehat{W}_{\text{c}}$ treating the interference from private messages as noise. By applying successive interference cancellation (SIC), the estimated contribution of s_{c} is reconstructed and subtracted from the received signal, allowing user k to decode its private stream s_k to obtain $\widehat{W}_{\text{p},k}$, treating the remaining signals as noise. Thus, user k reconstructs its original message of interest by extracting $\widehat{W}_{\text{c},k}$ from $\widehat{W}_{\text{c}}$ and combining $\widehat{W}_{\text{c},k}$ with $\widehat{W}_{\text{p},k}$ to form $\widehat{W}_k$. The rate of the k-th common stream is given by

$$R_{\text{c},k} = \log_2 \left(1 + \frac{\left|\mathbf{h}_k^H \mathbf{p}_{\text{c}}\right|^2}{\sigma^2 + \sum_{i=1}^{K} \left|\mathbf{h}_k^H \mathbf{p}_i\right|^2}\right). \tag{7}$$

To guarantee fairness, such that each user successfully decodes the common stream, the common rate for all users is given by

$$R_{\text{c}} = \min_{k' \in K} \{R_{\text{c},k'}\}. \tag{8}$$

The rate of the k-th private stream is given by

$$R_{\text{p},k} = \log_2 \left(1 + \frac{\left|\mathbf{h}_k^H \mathbf{p}_k\right|^2}{\sigma^2 + \sum_{i\neq k}^{K} \left|\mathbf{h}_k^H \mathbf{p}_i\right|^2}\right). \tag{9}$$

Finally, the achievable rate for user k is the sum of its private rate with its common rate, C_k, such that, $\sum_{k=1}^{K} C_k \leq R_c$. Thus, the rate for user k is given by

$$R_k = C_k + R_{\text{p},k}. \tag{10}$$

Next, we present the problem formulation for the total achievable data rate in rate-splitting multiple access (RSMA).

C. Problem Formulation

We aim to maximize the sum-rate of the RSMA-based LEO system. The optimization variables are the power allocation between streams and the precoders, under a total power constraint:

$$\max_{\mathbf{p},s} \sum_{k=1}^{K} R_k, \tag{11}$$

s. t.:

$$\|\mathbf{p}\|_2^2 \leq P_{\text{max}}, \tag{12}$$

where $\mathbf{p} \in \mathbb{C}^{(K+1)N\times 1} = [(\mathbf{p}_1)^T, ..., (\mathbf{p}_K)^T, (\mathbf{p}_{\text{c}})^T]^T$ is the aggregate precoder, and $s \in [0, 1]$ controls power split between common and private parts. The proposed solution is detailed next.

III. Proposed Solution

The formulated problem is very complex as the involved objective and constraint are non-convex functions on the oprimization variables. In this paper, we resort to a low-complex solution by adapting the solutions presented in [7] and [8] where zero-forcing (ZF) is employed for private messages and a max-min data rate precoder is applied for the common message. We also limit the analysis to a simplified scenario with two users.

A. Precoder Analysis

The application of the ZF consists of fixing the direction of the precoders and adjusting the power of the streams, such that the users receive the desired signal with maximum strength and the other signals arrive with negligible strength. We can express the ZF precoding vector $\mathbf{p}_k$ for user k as

$$\mathbf{p}_k = \sqrt{P_k}\frac{\mathbf{c}_k}{\|\mathbf{c}_k\|}, \tag{13}$$

where $\mathbf{c}_k$ is obtained from the pseudo-inverse of the channel matrix $\mathbf{H}$:

$$\mathbf{P}_{\text{ZF}} = \mathbf{H}(\mathbf{H}^{\text{H}}\mathbf{H})^{-1}, \tag{14}$$

where $\mathbf{H} = [\mathbf{h}_1 \dots \mathbf{h}_k]$ and $\mathbf{c}_k$ corresponds to the k-th column of $\mathbf{P}_{\text{ZF}}$. Also, P_k is the power allocated to the k-th private stream.

This way, we have $\left|\mathbf{h}_k^H\mathbf{p}_i\right| = 0,\ i \neq k$, and $\left|\mathbf{h}_k^H\mathbf{p}_k\right|^2 = \|\mathbf{h}_k\|^2\rho P_k$, where $\rho \in [0,1]$ expresses the correlation between the channels, such that 0 and 1 correspond to completely aligned and orthogonal channels, respectively. The correlation factor is given as the determinant of the Gram matrix, which contains all the inner products of the normalized channel vectors. For $K=2$, $\rho = 1 - \left|\overline{\mathbf{h}}_1^H\overline{\mathbf{h}}_2\right|^2$, where $\overline{\mathbf{h}}_k = \frac{\mathbf{h}_k}{\|\mathbf{h}_k\|}$.

On the other hand, the common stream precoder is design as the beamforming vector which maximizes the common rate. This way, we have

$$\begin{aligned}\max_{\mathbf{p}_c}\min&\left(\frac{\left|\mathbf{h}_1^H\mathbf{p}_c\right|^2}{\sigma^2+\left|\mathbf{h}_1^H\mathbf{p}_1\right|^2},\frac{\left|\mathbf{h}_2^H\mathbf{p}_c\right|^2}{\sigma^2+\left|\mathbf{h}_2^H\mathbf{p}_1\right|^2}\right)\\ \text{s.t.}\quad &\|\mathbf{p}_c\|^2 = P_c.\end{aligned} \tag{15}$$

Let $\psi_k^2 = \sigma^2 + \left|\mathbf{h}_k^H\mathbf{p}_k\right|^2 = \sigma^2 + \|\mathbf{h}_k\|^2\rho P_k$, and $\tilde{\mathbf{h}}_k = \mathbf{h}_k/\psi_k$, thus, we reformulate the problem as follows:

$$\max_{\mathbf{p}_c}\min\left(\left|\tilde{\mathbf{h}}_1^H\mathbf{p}_c\right|^2,\left|\tilde{\mathbf{h}}_2^H\mathbf{p}_c\right|^2\right)\quad \text{s.t.}\quad \|\mathbf{p}_c\|^2 = P_c, \tag{16}$$

such that the solution to (16) is $\mathbf{p}_c = \sqrt{P_c}\mathbf{f}_c$, where $\mathbf{f}_c(\|\mathbf{f}_c\|^2 = 1)$ is the direction of the precoder, obtained by [8]

$$\mathbf{f}_c = \frac{1}{\sqrt{\lambda}}\left(\mu_1\tilde{\mathbf{h}}_1 + \mu_2\tilde{\mathbf{h}}_2 e^{-j\angle\alpha_{12}}\right) \tag{17}$$

with

$$\lambda = \frac{\alpha_{11}\alpha_{22} - |\alpha_{12}|^2}{\alpha_{11}+\alpha_{22}-2|\alpha_{12}|}, \tag{18}$$

$$\begin{bmatrix}\mu_1\\ \mu_2\end{bmatrix} = \frac{1}{\alpha_{11}+\alpha_{22}-2|\alpha_{12}|}\begin{bmatrix}\alpha_{22}-|\alpha_{12}|\\ \alpha_{11}-|\alpha_{12}|\end{bmatrix}, \tag{19}$$

$$\begin{bmatrix}\alpha_{11} & \alpha_{12}\\ \alpha_{12}^* & \alpha_{22}\end{bmatrix} = \begin{bmatrix}\tilde{\mathbf{h}}_1^H\\ \tilde{\mathbf{h}}_2^H\end{bmatrix}\begin{bmatrix}\tilde{\mathbf{h}}_1 & \tilde{\mathbf{h}}_2\end{bmatrix}. \tag{20}$$

We also define $r_k^2 = 1 + \frac{\left|\mathbf{h}_k^H\mathbf{p}_k\right|^2}{\sigma^2} = 1 + \frac{\|\mathbf{h}_k\|^2\rho P_k}{\sigma^2}$. Thus, the total rate achieved by the users, employing RSMA with the aforementioned precoders, can be written as $R_{\text{sum}} = R_c + \log_2(r_1^2) + \log_2(r_2^2)$, where R_c satisfies (15). We observe that, given $\mathbf{p}_c$ by (17), and as $\left|\tilde{\mathbf{h}}_1^H\mathbf{p}_c\right| = \left|\tilde{\mathbf{h}}_2^H\mathbf{p}_c\right|$, thus $R_c = \log_2\left(1 + \left|\tilde{\mathbf{h}}_2^H\mathbf{p}_c\right|^2\right)$. Furthermore, we observe that $\psi_k^2 = \sigma^2 r_k^2$. Hence, the total sum rate is obtained by

$$R_{\text{sum}} = \log_2(r_1^2) + \log_2\left(r_2^2 + \frac{\left|\mathbf{h}_2^H\mathbf{p}_c\right|^2}{\sigma^2}\right). \tag{21}$$

Next, we present the power allocation formulation among common and private streams, and its optimization.

B. Power division

Let $P_{\max}$, P_p and P_c be the total available transmit power, the total power allocated to private streams and total power allocated to common stream, respectively, such that, $P_p = sP_{\max}$ and $P_c = (1-s)P_{\max}$, we optimize the power allocation among private streams by applying the water-filling (WF) solution. In this way, the power allocated to the k-th private stream is given by

$$p_k = \frac{1}{K}\left(\sum_{\forall i}\frac{\sigma^2}{\rho||\mathbf{h}_i||^2} + P_p\right) - \frac{\sigma^2}{\rho||\mathbf{h}_k||^2}. \tag{22}$$

Following [7], we define $\Gamma = \frac{1}{\rho}\left[\frac{1}{||\mathbf{h}_2||^2} - \frac{1}{||\mathbf{h}_1||^2}\right]$, which reflects the channel correlation and the disparity of the channels strengths. In this way, we consider two main regimes of operation of the RSMA.

1) OMA/NOMA/Multicasting: If $sP_{\max} \leq \Gamma$, we allocate $P_2 = 0$ and $P_1 = sP_{\max}$. According to [7], we observe that RSMA performs multicasting for $s=0$, NOMA for $0 \leq s \leq 1$, and OMA for $s=1$. Thus, we adjust s so that RSMA performs the best MA scheme for this operating regime.

2) SDMA/RSMA: On the other hand, if $sP_{\max} > \Gamma$, we have that P_1 and P_2 are given by the WF and are greater than zero. Furthermore, RSMA performs SDMA if $s=1$, while it does not perform any other scheme if $0 < s < 1$. Note that, we can replace r_k^2, ψ_k^2, and P_k into (21), such that

$$R_{\text{sum}} = \log_2\left[\frac{ac + (ad+bc)s + bds^2}{(\sigma^2)^2}\right], \tag{23}$$

where $b = \frac{\|\mathbf{h}_1\|^2\rho P_{\max}}{2}$, $a = \sigma^2 + \frac{\Gamma}{P_{\max}}b$, $d = \frac{\|\mathbf{h}_2\|^2\rho P_{\max}}{2} - \left|\mathbf{h}_2^H\mathbf{f}_c\right|^2 P_{\max}$, and $c = \sigma^2 - \frac{\Gamma}{P_{\max}}d + \left|\mathbf{h}_2^H\mathbf{f}_c\right|^2(P_{\max} - \Gamma)$. Additionally, if $P_1 > 0$ and $P_2 > 0$, then (23) is not a function of s nor the difference in channel intensities, but only of the channel directions [7]. Thus, the solution of $\frac{\partial R_{\text{sum}}}{\partial t} = 0$ provides the optimal s for $0 < s < 1$, whose solution is $s = -\frac{a}{2b} - \frac{c}{2d}$. Therefore, the optimal s for the regime is

$$s = \min\left(-\frac{a}{2b} - \frac{c}{2d}, 1\right). \tag{24}$$

In the next section, we evaluate the performance of our proposed approach using numerical simulations and comparative analysis.

IV. Performance Evaluation

Here, we present the implementation details, benchmark solutions, and results, discussing the advantages and disadvantages of the proposed approach. Table I summarizes the key parameters for system implementation, taken from [5].

TABLE I: Simulation Parameters.

Parameter	Variable	Value
Satellite altitude	d_{sat}	600 km
Carrier frequency	f	2 GHz
Satellite array size	N	6
Inter-antenna-spacing	d_{a}	7.5 cm
Satellite antenna gain	G_{sat}	16 dBi
User antenna gain	G_{user}	0 dBi
Noise power	σ_n^2	-122 dBW
Satellite transmit power	$P_{\max}$	25 dBW

A. Implementation Details

We considered a simplified scenario with two users, uniformly distributed around a cell center located at a distance $\overline{D}$ from the satellite's nadir. Thus, the distance of user k to the satellite's nadir is given by a random variable $\overline{D}_k \sim \mathcal{U}(\overline{D} - \Delta\overline{D}, \overline{D} + \Delta\overline{D})$. Furthermore, a minimum separation between users, also equal to $\Delta\overline{D}$, is ensured.

Two cases are analyzed to evaluate the performance of the MAs: (i) varying $\overline{D}$ with $\Delta\overline{D} = 10$ km, and $\tau = 0$ (perfect CSIT) and $\tau = 0.05$ (imperfect CSIT); (ii) fixing $\overline{D} = 100$ km and $\Delta\overline{D} = 10$ km, while increasing τ. Each case uses 1,000 Monte Carlo repetitions to ensure statistical reliability. Other parameters follow [5] and [7].

B. Benchmark Solutions

For comparison purposes, we also analyze some benchmark solutions. In [5], the authors compare RSMA, OMA, and SDMA in a LEO satellite communication system. The authors propose a power division in RSMA based on the parameter α, which is optimized by employing exhaustive search. Specifically, $P_{\text{c}} = P_{\max} - P_{\max}^{\alpha}$ and $P_{\text{p}} = P_{\max}^{\alpha}$, where P_{c} and P_{p} are the powers of the common and private streams, respectively, and $P_{\max}$ is the total available power for the system. Additionally, a fixed precoder for the common stream is used, given by $\mathbf{p}_{\text{c}} = \sqrt{\frac{P_{\text{c}}}{N}} \begin{bmatrix} 1 & 1 \end{bmatrix}^T$. For the private stream, the minimum mean squared error (MMSE) precoder is used, whose precoding matrix is modeled as $\mathbf{P}_{\text{p}} = \sqrt{\frac{P_{\text{p}}}{\text{tr}(\mathbf{W}^H\mathbf{W})}}\mathbf{W}$ where $\mathbf{W} = \left[\mathbf{H}^H\mathbf{H} + \sigma_n^2 \frac{K}{P_{\max}} \mathbf{I}_N\right]^{-1} \mathbf{H}^H$, where $\mathbf{H}$ is the channel matrix, and K is the number of users. The MMSE was also employed in the implementation of SDMA, but the precoding matrix is scaled using the total power since there is no message division. Lastly, the authors used the maximum ratio transmission (MRT) precoder in the OMA implementation, whose precoding matrix for the k-th user is $\mathbf{p}_k^{\text{MRT}} = \sqrt{\frac{P_{\max}}{K}} \frac{\mathbf{h}_k^H}{\|\mathbf{h}_k\|}$. In the next section, we show the results of the simulations campaigns and our findings.

C. Results

In this section, we present and analyze the results from the simulation campaigns, comparing the performance of the proposed RSMA approach against conventional OMA, SDMA and the benchmark RSMA scheme from [5], for both (i) and (ii) cases.

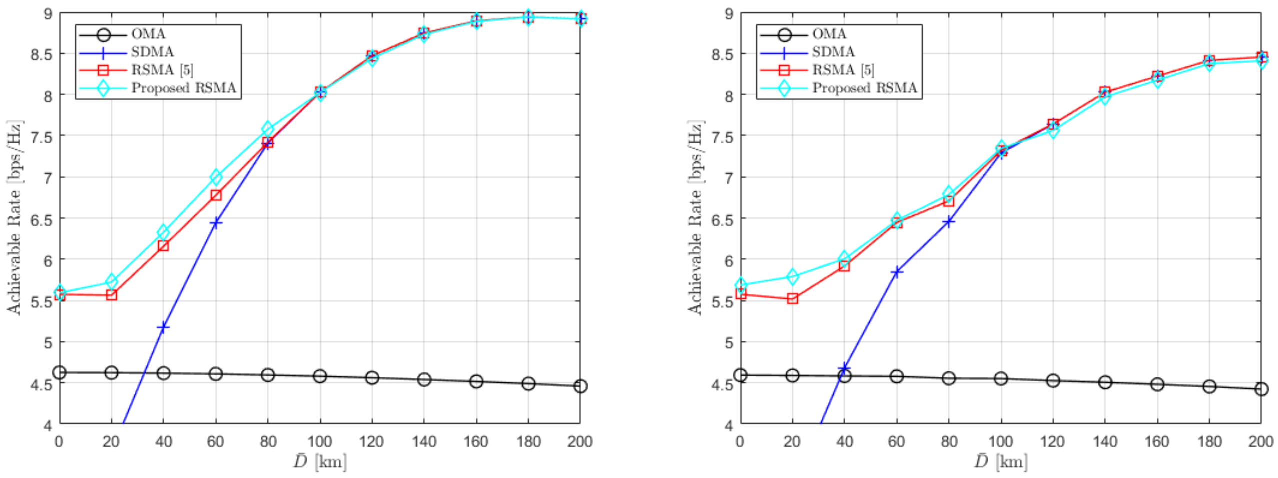
1) Impact of User Distance ($\overline{D}$): For scenario (i), Fig. 2 shows the behavior of achievable rates, normalized by band, as $\overline{D}$ increases.

Under perfect CSIT, depicted in (Fig. 2a), OMA maintains relatively stable performance due to its orthogonal resource allocation, which effectively eliminates inter-user interference but at the cost of spectral efficiency. In contrast, SDMA and RSMA exhibit significant gains as $\overline{D}$ increases, particularly under perfect CSIT conditions. This behavior is attributed to their ability to leverage spatial diversity and optimize precoding strategies. Notably, the proposed RSMA can achieve rates at least equal to the benchmark RSMA solution across all distances, demonstrating better power allocation and interference management under conditions of higher channel reliability. This advantage becomes more pronounced in regions closer to the satellite, where higher achievable rate values are observed for the proposed RSMA.

Under imperfect CSIT, depicted in (Fig. 2b), all techniques experience performance degradation due to reduced channel state accuracy. SDMA performance gains are more modest compared to the perfect CSIT scenario, reflecting its reliance on accurate channel knowledge for effective beamforming. The benchmark RSMA still maintains a superior performance over OMA and SDMA, capitalizing on its robustness against CSIT imperfections. The proposed RSMA presents superior performance to the reference RSMA for a $\overline{D}$ of up to 120 km, after which the performance starts to present a drop in the total achievable rate compared to the benchmark solutions. Although the rate drop is not very significant, this indicates that the combination of the distance to the satellite and imperfect channel conditions causes greater degradation in the proposed solution. However, the appropriate operating range for the proposed solution is considerable, which makes the solution useful for the studied scenario.

2) Impact of CSIT Imperfection Level: To evaluate scenario (ii), we set the value of $\overline{D}$ at 100 km, which is an average distance capable of providing a good separation between users, as applied in [6]. Fig. 3 shows the behavior of achievable rate, normalized by band, as τ increases.

The OMA result was omitted due to its low performance, which explains its limitations in terms of adaptability to interference variations due to its orthogonal nature. SDMA also suffers from increasing τ, reinforcing its sensitivity to CSIT inaccuracies. Conversely, RSMA mitigates these effects by effectively balancing common and private stream allocations, leading to a more gradual performance degradation. The proposed RSMA further refines this strategy, consistently outperforming the benchmark RSMA implementation across all values of τ, demonstrating a superior power allocation framework that enhances robustness against CSIT imperfections for the scenario considered.



(a) Perfect CSIT.

(b) Imperfect CSIT.

Fig. 2: Total data rate achieved by users as a function of $\overline{D}$ to evaluate MA performance. The simulation was conducted with $\Delta\overline{D} = 10$ km, considering $\tau = 0$ for perfect CSIT and $\tau = 0.05$ for imperfect CSIT.

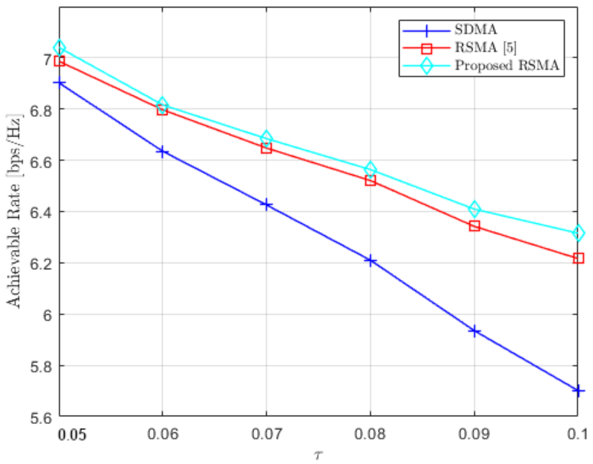


Fig. 3: Total data rate achieved by users as a function of τ to evaluate MA performance. The simulation was conducted with $\Delta\overline{D} = 10$ km and $\overline{D} = 100$ km.

3) Note On Computational Complexity: It is important to note that the RSMA solution evaluated in [5], the transmit power division between common and private messages is optimized by employing exhaustive-search solution. In contrast, the solution employed in this paper applies a closed-form expression for power allocation between these messages, resulting in lower computational complexity.

V. Conclusion

This paper analyzed the impact of power allocation and precoder design on RSMA performance in satellite networks. We formulated the RSMA rate maximization problem and proposed a low-complexity solution using a max-min data rate common precoder and ZF for private messages. This approach allowed analytical modeling and optimization of power allocation, offering flexibility and robustness—often surpassing benchmark solutions—under challenging channel conditions, as confirmed by simulations.

Future work may extend the model to support more users and account for imperfect SIC. Additionally, incorporating quality of service constraints and exploring classical or machine learning-based optimization methods could further enhance the system's practical relevance.

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