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EVALUATING THE CAPABILITIES OF ENERGY HARVESTING OF PROPOSED HYBRID TIME-DIVISION MULTIPLE ACCESS (TDMA) -NOMA TECHNIQUE

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ABSTRACT

Introduction - The energy harvesting (EH) capabilities of time division multiple access (TDMA) and NOMA systems have been considered in the combination of NOMA and OMA schemes. The simultaneous wireless information and power transfer (SWIPT) technique is used in this hybrid TDMA-NOMA system so that the user can harvest energy and decode information at the same time.

Aim of the study–The main aim of this study is to assess the Capabilities of Energy Harvesting Of Proposed Hybrid Time-Division Multiple Access (TDMA) -Noma Technique

Proposed Methodology-A hybrid TDMA-NOMA system's EH capabilities are examined. SWIPT method is specifically used for wireless information and power transfer to users. In this way, power allocation and power splitting ratios are determined entirely for all users to minimise the required transmit power at minimum rate and minimum EH criteria.

Data analysis - The performance of the proposed hybrid TDMA-NOMA design is evaluated using data analysis and results, and it is demonstrated that the proposed hybrid scheme outperforms the conventional TDMA system in terms of transmit power consumption.

Conclusion - The EH capabilities of the TDMA-NOMA system beat those of the conventional TDMA system, according to simulation studies.

Keywords - Time-Division Multiple Access, Noma, hybrid, conventional, energy, harvesting etc.

1. INTRODUCTION

1.1 Overview

Basic phone services were enabled on the first-generation (1G) of commercial cellular networks, which were established in the 1980s. More capacity and digital voice communications services were given a decade later by replacing 1G cellular networks with second-generation (2G) cellular networks. The increased rates given by 2G networks are obtained by using either code division multiple access (CDMA) or time division multiple access (TDMA) technologies (TDMA)Because of its potential benefits, such as greater spectrum efficiency and user fairness, non-orthogonal multiple access (NOMA) has recently been proposed as a possible multiple access approach for 5G and beyond wireless networks. Unlike conventional orthogonal multiple access (OMA) schemes like time division multiple access (TDMA) and orthogonal frequency division multiple access (OFDMA), multiple users in NOMA-based downlink transmission share the same orthogonal radio resources, such as time and frequency, by utilising power-domain multiplexing at the transmitter. Superposition coding (SC) is a type of multiplexing in which signals for various users are encoded with varying power levels that are inversely proportional to their channel strengths. Serving numerous users concurrently within the same resource block using NOMA, in particular, encourages the spread of Internet-of-Things (IoTs) by providing huge connection. Stronger users use the sequential interference cancellation (SIC) technique to decode messages intended for weaker users before decoding their own signals at the receiver end. However, as the number of consumers served in the system grows, so does the computing complexity of SIC.

One of the most promising radio access strategies in next-generation wireless communications is non-orthogonal multiple access (NOMA). In this context, lattice-partition multiple access, multi-user shared access, and pattern-division multiple access are all closely related multiple access systems. By dividing each cellular channel into various time slots, TDMA allows several users to share the same frequency. In effect, a single frequency can handle many data channels at the same time.

1.2 TDMA

The digital modulation technology Time Division Multiple Access (TDMA) is utilised in digital cellular telephone and mobile radio communication. TDMA is one of two methods for sharing a radio frequency (RF) cellular channel's limited spectrum. Frequency division multiple access is the other (FDMA).

In its most basic form, TDMA divides each cellular channel into various time slots to allow numerous users to share the same frequency. In effect, a single frequency can handle many data channels at the same time. Two users can share the same frequency with a two-time slot TDMA. Three users can share the same frequency with a three-time slot TDMA, and so on.

Users broadcast in quick succession utilising their own time slots in TDMA. This shuttling procedure is so quick that each user believes they are sharing the same RF channel. TDMA enhances the amount of data that may be transported across the channel while allowing simultaneous talks by giving a defined amount of bandwidth to each user.

TDMA separates RF into time slots, each of which is assigned to a different user. As a result, each user shares the available channel bandwidth in a time-shared manner. Users alternate using the channel in a timely and effective manner. As a result, TDMA enhances spectrum efficiency over analogue systems.

1.3 TDMA-NOMA system

NOMA has been combined with a variety of other technologies, including multiple-antenna approaches and conventional OMA schemes, to overcome the practical obstacles of deploying SIC in dense networks and to satisfy the enormous requirements of future wireless networks. The available resources (i.e., time or frequency) are divided into various sub-resource blocks in a hybrid OMA-NOMA system, and each sub-resource block is assigned to service multiple people based on NOMA. For example, the energy harvesting possibilities of a hybrid TDMA-NOMA system have been examined, in which the available transmission time is distributed evenly among numerous groups of users (i.e., clusters). The system is considered to be a hybrid OFDMA-NOMA system, in which the available bandwidth is divided into numerous sub-bandwidths and the available resources are distributed to maximise the system's energy efficiency. For hybrid OFDMA-NOMA systems, different resource allocation algorithms are explored. In fact, by leveraging separate domains to serve many users, these combinations not only ease the implementation of SIC, but also provide extra degrees of flexibility. The work in the literature assumes equal time assignments to service the available groups of users to reduce computational strain at the receiver ends while considering the hybrid TDMA-NOMA system. However, because opportunistic time allocations provide additional benefits to groups of users, equal time assignments limit the performance increase of such a hybrid TDMA-NOMA system. Furthermore, one of the main goals of such hybrid TDMANOMA systems is to serve each user while maintaining a fair throughput. However, improving the system's total throughput decreases individual user performance while reducing user fairness in terms of achievable rates.

Motivated by these facts, we set out to maximise the lowest per-user rate for a single-input single-output (SISO) hybrid TDMA-NOMA system while remaining within the system's restrictions. This can be accomplished by creating an optimization framework for optimally allocating available transmit power among users and opportunistically assigning available transmission time between clusters (i.e., groups of users). The defined optimization problem is non-convex and cannot be solved with currently available software. As a result, we devise an iterative approach that makes use of sequential convex approximation (SCA). Furthermore, some non-convex constraints are cast as SOCs using a novel form of a second-order cone (SOC). Finally, we draw a number of performance comparisons to demonstrate the advantages of the proposed hybrid NOMA-TDMA technique over the conventional schemes with equal time allocations

2. LITERATURE REVIEW

Sivasankar Sundaram (2020) -A unique technique was utilised in this project to improve the throughput of a 5G network employing NOMA. One of the proposed radio access strategies for improving system performance in 5G networks is the Non-Orthogonal Multiple Access (NOMA) scheme. It has been proved that NOMA technology can outperform OMA technology. We examine numerous parameters and compare them using the NOMA technique. In this strategy, 5G networks are designed to allow for easy virtual network construction in order to better match network costs to application requirements. The NOMA Algorithm increases the throughput of a 5G network. The power-domain NOMA technique performs superposition coding (SC) at the transmitter and successive interference cancellation (SIC) at the receiver and is one of the most basic NOMA schemes. The importance of Power Allocation (PA) in achieving successful SIC and high system throughput cannot be overstated. The goal of this research is to reduce interference and increase throughput in a NOMA-based 5G network.

Xinchen Wei, et al (2020) - We present a resource allocation strategy for a hybrid TDMA-NOMA system with opportunistic time assignment in this paper. The available transmission time is divided into various time-slots, each of which serves several users by utilising power-domain NOMA. To fully exploit the underlying benefits of our hybrid TDMA-NOMA system, we efficiently allocate available resources to multiple groups of users in the system by jointly assigning transmit power and time-slots. Furthermore, these resources are allocated to maximise the system's minimum user rate. Due to connected design factors of time and power allocations, this max-min resource allocation problem is non-convex. To tackle this non-convexity issue, we use a novel second-order cone formulation and create an iterative algorithm to solve the original max-min problem. When compared to the conventional resource allocation technique, which assigns equal time slots to groups of users, simulation findings demonstrate that this joint resource allocation technique has a significant performance improvement in terms of both minimum achieved rate and overall system throughput.

Zeming Li and **JinsongGui (2019) -** Machine-to-machine (M2M) communications, which are a key component of the Internet of Things (IoT), are becoming increasingly common. Meanwhile, cellular-enabled M2M communication is a viable alternative for M2M-based applications because to the advantages of cellular networks (e.g., great coverage, mobility/roaming support). Due to the unique characteristics of M2M-based applications (e.g., huge concurrent uplink transmissions, tiny bursty traffic, and high energy efficiency (EE) requirements), cellular-enabled M2M communications face considerable problems. Non-orthogonal multiple access (NOMA), on the other hand, can serve numerous users at the same time and frequency by dividing separate users in the power domain, resulting in a higher number of concurrent connections. In this paper, we present an energy-efficient resource allocation strategy for cellular-enabled M2M networks using a hybrid TDMA-NOMA scheme. First, the user equipments (UEs) are configured as machine-type communication gateways (MTCGs). Then we present our time-sharing plan. The resource allocation problems are then formulated as a noncooperative game.

Haitham Al-Obeidollah, et al (2019) - In this study, we look at the energy harvesting capabilities of a hybrid TDMA-NOMA system, which combines a non-orthogonal multiple access (NOMA) scheme with a standard time division multiple access (TDMA) scheme. Users are separated into a number of groups in such a hybrid scheme, and the entire time allocated for transmission is shared among these groups through numerous time slots. In particular, each group is given a time slot to be served, and the users in that group are served using the power-domain NOMA technique. Furthermore, at each user, a simultaneous wireless power and information transfer technology is used to harvest energy and decode information.

Abhay Mohan (2017) - NOMA stands for Non-Orthogonal Multiple Access and is a proposed multiple access technique for Future Radio Access (FRA). It's one of many technologies that promises higher capacity and spectral efficiency than the current state of the art, making it a possibility for 5G cellular networks. A distinct multiple access system is usually associated with each iteration of cellular technology. From the first to the fourth generation, the wireless sector has witnessed technologies such as Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Wideband Code Division Multiple Access (WCDMA), and Orthogonal Frequency Division Multiple Access (OFDMA). This method necessitates the use of a SIC (Successive Interference Cancellation) receiver. The non-orthogonally optimises resource utilisation and increases user throughput by roughly 38%. The presentation will cover the NOMA principle as well as some practical aspects such as signalling overhead, power allocation strategies, and so on.

3. OBJECTIVES OF THE STUDY

1. To study the meaning and concept of TDMA-NOMA system
2. To compare the hybrid TDMA-NOMA with conventional TDMA system using results
3. To compare the minimum rate requirement and harvested power for TDMA-NOMA

4. PROPOSED METHODOLOGY

To jointly address the original non-convex optimization problem OP_{10}, an iterative technique is given. The initial parameter selection and convergence of the suggested iterative technique are discussed later in this section. However, in the next subsection, a brief overview of the proposed grouping technique is offered first.

4.1 Techniques of Grouping

Because the optimal solution of OP_{10} can only be established by creating the best groups, selecting an effective grouping approach is critical to the performance of the hybrid TDMA-NOMA system. Only by solving OP_{10} with an exhaustive search through all possible sets of groups can the requisite optimal transmit power be established. However, in terms of computational complexity, it is too expensive in actual systems, such as IoTs on future wireless networks. Furthermore, the difference in channel strengths across users in the same group is another important aspect that influences the system's overall effectiveness. Because users within each group are serviced using NOMA, the practical implementation of the SIC approach necessitates a substantial variance in channel strengths between users. Furthermore, clustering users with comparable channel strengths might generate SIC implementation problems, lowering the system's overall performance. The users are categorised based on this essential feature so that the disparity between their channel strengths is as large as possible. The user groups based on the proposed grouping technique can be defined as follows with two users in each group (i.e., $K_i = 2$):

$$\left(\{u_1, u_{2,1}\}, \{u_{1,2}, u_{2,2}\}, \ldots \{ui_{1,C}, u_{2,C}\}\right) \equiv \left(\{u_1, u_k\}, \{u_2, u_{k-1}\}, \ldots . \left\{u\frac{K}{2}, u\frac{K}{2} + 1\right\}\right) \quad (1)$$

This channel gain difference grouping method has been frequently used in the context of several NOMA approaches, it is worth noting. Several sub-optimal clustering strategies, in instance, can be suggested; nevertheless, the effectiveness of such techniques could be studied in future research.

4.2 Proposed Methods and Algorithm

The non-convex optimization problem OP_{10} is now solved using the SCA method, assuming that the users have previously been divided into groups. The non-convex terms in SCA are estimated by a collection of lower bounded convex terms, and the original non-convex issue is resolved using this approximated convex problem. The constraint's non-convexity is initially addressed by adding new slack variables$\vartheta_{j,i}$ and $\theta_{j,i}$such that,

$$\mathbf{R_{j,i}} \geq \vartheta_{j,i}, \forall i \in C, \forall j \in K_i \qquad (2a)$$

$$\left(1 + \mathrm{SINR}_{j,i}^{d}\right) \geq \theta_{j,i},, \forall i \in C, \forall j \in K_i, \forall d \in \{j+1, \ldots., K_i\}, \qquad (2b)$$

$$\theta_{j,i} \geq 2^{\vartheta_{j,i}} \forall i \in C, \forall j \in K_i \qquad (2c)$$

To account for the non-convexity of (2b), a slack variable$\chi_{j,i}$is added which is as follows:

$$\frac{\beta_{j,i}\left|h_{j,i}\right|^2 p_{d,i}^2}{\beta_{j,i}\left|h_{j,i}\right|^2 \sum_{s=1}^{d-1} p_{s,i}^2 + \beta_{j,i}\sigma_{j,i}^2 + \tilde{\sigma}_{j,i}^2} \geq \frac{(\theta_{j,i} - 1)X_{j,i}^2}{X_{j,i}^2}, \forall i \in C, \forall j \in K_i, \forall d \in \{j+1, j+2, \cdots, K_i\} \quad (3)$$

The constraint in (3) is then reduced into the two constraints below:

$$\beta_{j,i}\left|h_{j,i}\right|^2 p_{d,i}^2 \geq (\theta_{j,i} - 1)X_{j,i}^2, \forall i \in C, \forall j \in K_i, \forall d \in \{j+1, j+2, \ldots, K_i\} \quad (4)$$

$$\beta_{j,i}\left|h_{j,i}\right|^2 \sum_{s=1}^{d-1} p_{s,i}^2 + \beta_{j,i}\sigma_{j,i}^2 + \tilde{\sigma}_{j,i}^2 X_{j,i}^2, \forall i \in C, \forall j \in K_i, \forall d \in \{j+1, j+2, \ldots, K_i\} \quad (5)$$

Another slack variable$\alpha_{j,i}^{d}$ is used to manage the non-convexity of these constraints is included in such a way that

$$\boldsymbol{\beta_{j,i} p_{d,i}^2} \geq \alpha_{j,i}^{\prime d} \forall i \in C, \forall j \in K_i, \forall d \in \{j+1, j+2, \ldots, K_i\} \quad (6)$$

The constraint in (6) is obviously still non-convex. As a result, a linear term is used to approximate the left-hand side of (6) using the first-order Taylor series. As a result, the approximated convex form of (6) becomes:

$$\beta_{j,i}^{(t)} P_{d,i}^{2\ (t)} + 2 p_{d,i}^{\ (t)} \beta_{j,i}^{(t)} \left(p_{d,i} - p_{d,i}^{(t)}\right) + P_{d,i}^{2\ (t)} \left(\beta_{j,i} - \beta_{j,i}^{(t)}\right) \geq \alpha'^{d}_{j,i}, \forall i \in C, \forall j \in K_i, \forall d \in \{j+1, j+2, \ldots . K_i\}, \qquad (7)$$

Where $\beta_{j,i}^{(t)}$ and $p_{d,i}^{(t)}$ shows the approximations of $\beta_{j,i}$ and $p_{d,i}$ at the tth iteration, and so on. The non-convex constraint in (4) can be approximated by the following convex constraint by integrating these slack variables.

$$\left|\mathbf{h}_{j,i}\right|^2 \alpha'^{d}_{j,i} \geq X_{j,i}^{2\ (t)} \left(\theta_{j,i}^{(t)} - 1\right) + 2\left(\theta_{j,i}^{(t)} - 1\right) X_{j,i}^{(t)} \left(X_{j,i} - X_{j,i}^{(t)}\right) + X_{j,i}^{2\ (t)} \left(\theta_{j,i} - \theta_{j,i}^{(t)}\right), \forall i \in C, \forall j \in K_i, \forall d \in \{j+1, j+2, \ldots . K_i\} \qquad (8)$$

It's worth noting that a linear term is used to approximate the non-convex right-hand side of inequality (4). The estimated convex form of condition (5) is written in the same way:

$$X_{j,i}^{2\ (t)} + 2X_{j,i}^{(t)} \left(x_{j,i} - X_{j,i}^{(t)}\right) \geq \gamma \left(\left|h_{j,i}\right|^2 \sum_{s=1}^{d-1} \alpha_{j,i}^{s} + \beta_{j,i}\sigma_{j,i}^{2} + \tilde{\sigma}_{j,i}^{2} \right) \qquad (9)$$

The attained rate is calculated using these various slack factorseach user(i.e., $R_{j,i}$) can be equivalently approximated by $\vartheta_{j,i}$ with the constraints in (2c), (7), (8), in addition (9). The constraint's non-convexity is then addressed by introducing slack variables$\rho_{i,j}$ and $\varrho_{i,j}$, which is as follows:

$$\left(1 - \beta_{j,i}\right) p_{s,i}^{2} \geq p_{j,i}^{s}, \forall i, \in C, \forall j \in K_i, \forall s \in K_i, \qquad (10a)$$

$$\eta \left|h_{j,i}\right|^2 \sum_{s=1}^{K_i} \rho_{j,i}^{s}, \geq \varrho_{i,j}, \forall i \in C, \forall j \in K_i \qquad (10b)$$

The non-convex condition in (10a) can be solved using the same approximations that were used to solve the prior constraint in (10). (6). Hence,

$$\left(1 - \beta_{j,i}^{(t)}\right) p_{s,i}^{2\ (t)} + 2p_{s,i}^{\ (t)} \left(1 - \beta_{j,i}^{(t)}\right) \left(p_{s,i} - p_{s,i}^{(t)}\right) - p_{s,i}^{2\ (t)} \left(\beta_{j,i} - \beta_{j,i}^{(t)}\right) \geq \rho_{j,i}^{s}, \quad \forall i \in \mathcal{C}, \forall j \in \mathcal{K}_i, \forall s \in \mathcal{K}_i. \qquad \mathbf{(11)}$$

Lastly, the non-convexity of the SIC constraint is addressed by substituting the appropriate linear approximation for each element in the constraint:

$$p_{k_i,i}^{2} \geq p_{k_i,i}^{2\ \ (t)} + 2p_{k_i,i}^{2(t)} \left(p_{k_i i} - p_{k_i,i}^{(t)}\right), \forall i \qquad (12)$$

The non-convex optimization problem formulated as using these numerous slack variable incorporations:

$$\widetilde{\mathrm{O}}\mathrm{P}_{10}: \underset{\Gamma}{\text{minimize}} \sum_{i=1}^{C}\sum_{j=1}^{K_i} p_{j,i}^2 \qquad (13a)$$

$$\text{Subject to } r_{j,i} \geq R^{min}, \varrho_{j,i} \geq P^{min}, \forall i \in C, \forall j \in K_i, \qquad (13b)$$

where Γ covers all of the P-Min design's optimization variables.:

$$\Gamma = \{p_{j,i}, r_{j,i}, \beta_{j,i}, \varrho_{j,i}, \rho_{j,i}, \alpha_{j,i}\}_{i=1}^{K}$$

The beginning variables(i.e., $\Gamma^{(0)}$) must be chosen carefully in order to solve the optimization problem in (13).Therefore, random initial power allocations$\{p_{j,i}^{(0)}\}_{i=1}^{K}$are taken for granted. The initial power splitting ratios are then calculated (i.e.,$\{\beta_{j,i}^{(0)}\}_{i=1}^{K}$)are examined to see if they satisfy the restrictions of the original optimization problem OP_{10}. Furthermore, the slack variables that remain$\rho_{j,i}^{(0)}$ and $\alpha_{j,i}^{(0)}$can be determined by substituting$\{p_{j,i}^{(0)}\}_{i=1}^{K}$ and $\{\beta_{j,i}^{(0)}\}_{i=1}^{K}$in (7) and (8), respectively. Algorithm 1 summarises the algorithm offered to solve the original P-Min problem. When the absolute difference between two sequential optimal values is smaller than a present threshold, the algorithm endsμ.

Algorithm 1: P-Min Design using SCA

```
Step 1: Group users based on (6.13)

Step 2: Initialize all design parameters $\Gamma^{(0)}$

Step 3: Repeat

        1. Solve the optimization problem in (6.25)
        2. Update $\Gamma^{(n+1)}$

Step 3: Until required accuracy is achieved.
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The performance analysis EH design of the hybrid TDMA-NOMA system is compared to that of the regular TDMA system to illustrate its effectiveness. Each time slot in the TDMA system$t_i^{TDMA} = \frac{T}{K}$)is solely used to service one user. The attained rate at ui can be stated as based on this time slot assignment:

$$R_i^{TDMA} = t_i^{TDMA}\log_2\left(1+\frac{\beta_i|h_i|^2p_1^2}{\beta_i\sigma_i^2+\tilde{\sigma}_i^2}\right), \forall \in K \qquad (14)$$

The harvested power, on the other hand,u_i in This conventional TDMA can be written as

$$p_i^{TDMA} = \eta(1-\beta_i)|h_i|^2p_i^2, \forall \in K \qquad (15)$$

In a TDMA system with minimal rate and minimum EH limitations, a comparable P-Min problem is now posed. As anoutcome,

$$\mathrm{OP}_{11}: \underset{\{p_i, \beta_i\}_{i=1}^{K}}{\text{minimize}} \sum_{i=1}^{K} p_1^2 \qquad (16a)$$

Subject to

$$R_i^{TDMA} \geq R^{min}, \forall i \in K, \qquad (16b)$$

$$P_i^{TDMA} \geq P^{min}, \forall i \in K, \qquad (16c)$$

5. DATA ANALYSIS

In this segment, the proposed hybrid TDMA-NOMA scheme's EH capability is proved by evaluating and comparing its effectiveness to that of the conventional TDMA scheme. In these numerical simulations, ten users (i.e., K = 10) are uniformly distributed in a circle 10 metres in radius from the base station. Furthermore, these users are divided into five groups (i.e., C = 5), with T set to one second. Table 1 summarises the various parameters used in simulations. In this segment, the CVX toolbox is also used to generate results.

Table 1:Simulated Parameter

Parameter	**Value**
No. of users (K)	10
No. of groups (C)	5
No. of users in each group (K_i)	2
Path loss exponent (κ)	2
Reference distance (d_0)	1
Signal attenuation at d_0 (η)	-30dB
$\sigma_i^2, \hat{\sigma}_{j,i}^2, \tilde{\sigma}_{j,i}^2$ (dBm)	-100
Efficiency of converter (η)	0.75

Table 2:All users Splitting ratio $\beta_{j,i}$ with a required minimum rate $R^{min} = 10^{-1}$ bit/Hz

Cluster 1		**Cluster 2**		**Cluster 3**		**Cluster 4**		**Cluster 5**	
$\beta_{1,1}$	$B_{2,1}$	$\beta_{1,2}$	$\beta_{2,2}$	$\beta_{1,3}$	$\beta_{2,3}$	$\beta_{1,4}$	$\beta_{2,4}$	$\beta_{1,5}$	$\beta_{2,5}$
0.8740	0.0063	0.5808	0.0064	0.4251	0.0064	0.3345	0.0066	0.2758	0.0065

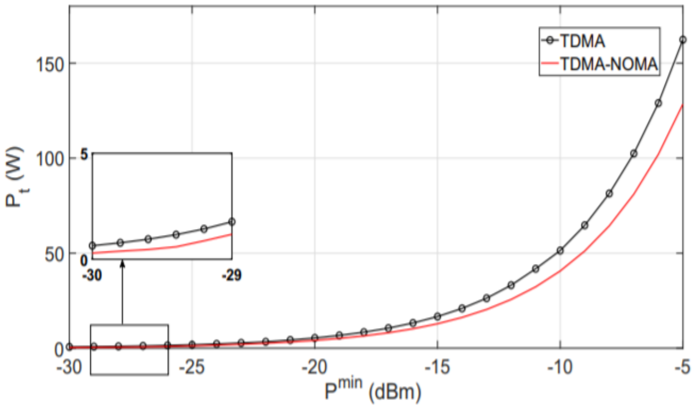

Figure 1:Comparison between requireddifferent minimum harvest powerP^{min} and transmit power with a minimum rate requirement $R^{min} = 10^{-1}$ bit/Hz

The minimum required transmit power (i.e., Pt) is illustrated and compared in Fig. 1 to a range of minimum harvest power requirements P^{min} for hybrid TDMA-NOMA and conventional TDMA systems. As expected, the P_t of both systems rises as P^{min} rises. Furthermore, as illustrated in Fig. 1, the hybrid TDMA-NOMA scheme outperforms the conventional TDMA system by consuming less P_t. In particular, user grouping in the hybrid TDMA-NOMA system introduces higher interference levels, allowing the minimum harvested power requirements to be met with lower P_t than in the conventional TDMA system.

Table 2 presently introduces the splitting ratios $\beta_{i,j}$affiliated with solving the optimization problem OP_{10}. As can be seen, these ratios are affected by the users' channel conditions. Table 3 then shows the effect of the minimum rate requirement R^{min} on the required transmit value. Clearly, as the minimum rate requirements are reduced, the required transmit power decreases.

In Fig. 2, the number of iterations required for the SCA algorithm in solving OP_{10} for two different minimum harvested power requirements is evaluated. As seen, the algorithm converges on the solution after only a few iterations.

Table 3:Transmit power requirement for certain minimum rate R^{min}, with a minimum harvest power requirement $P^{min} = -30$ dBm

R^{min} (bit/Hz)	10^{-1}	10^{-2}	10^{-3}
P_t(W)	2.4154	2.2071	1.6581

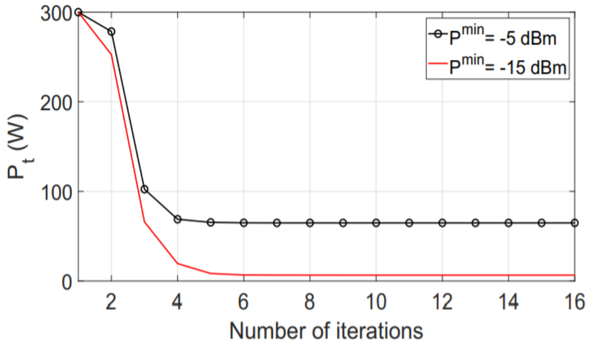

Figure 2:Convergence of the Sequential Convex Approximationfor solving OP_{10} for values of required P^{min},minimum harvest power $R^{min} = 10^{-2}$ bit/Hz

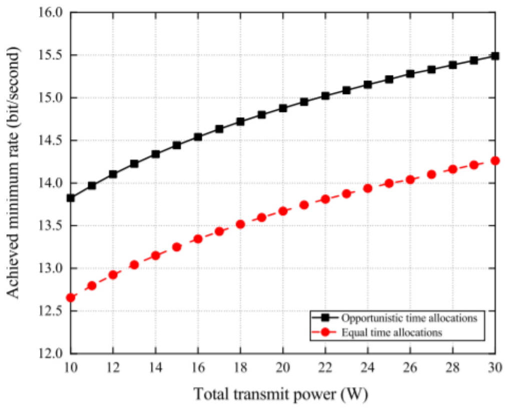

Figure 3:Comparison between total transmit power& achieved minimum rate

Next, Fig. 3 depicts the performance of these schemes in terms of the minimum achieved rate for different transmission power P^{max}. Simulation results confirm that the proposed scheme with opportunistic time allocation outperforms the scheme with equal time allocation in terms of the minimum achieved rate.

6. CONCLUSION

The EH capabilities of ahybrid TDMA-NOMA system are studied in this research. Users are organised into groups in such a hybrid system, with a time slot allotted to each group and NOMA used to service users inside that group. The required minimum power to achieve the minimum rate and minimum harvest energy needs at each user is analysed for the proposed scheme. The suggested hybrid TDMA-NOMA system beats the conventional TDMA system in terms of minimal necessary transmit power, according to simulation results.

Using the SWIPT approach, the EH capabilities of a hybrid TDMA-NOMA are investigated. In a hybrid system like this, users are separated into groups and given a time slot to service each group, while NOMA is used to serve users within each group. In addition, each user divides the received signal into two parts, EH and ID, with the EH component being used to collect energy and the ID part being used to decode information. The minimum transmit power required to achieve the minimum rate and minimum harvest energy requirements at each user is examined in specific. This was accomplished by creating the P-Min design, which determines the allocated power and power splitting ratio for each user. The suggested hybrid TDMA-NOMA system beats the conventional TDMA system in terms of minimal necessary transmit power, according to simulation results.

6.1 Future scope

The research proposed in this paper looked into the use of NOMA techniques in combination, as these combinations are critical in the construction of future wireless networks. Furthermore, for these NOMA systems, multiple resource allocation algorithms have been devised, with various considerations taken into account to make these systems dependable in terms of actual implementation. However, there are a number of future work directions that need to be researched in order to grow further underlying benefits of NOMA systems, as listed below.

- Cluster-based MISO-NOMA/ Cooperative Transmission
- Error Propagation in SIC

- Resource Allocations using Machine Learning

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