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Original research article

A Spatial Modulation-Based Time and Bandwidth Sharing NOMA Framework for Enhanced IoT Connectivity at Cell Edges

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ABSTRACT

The Non-Orthogonal Multiple Access (NOMA) has attracted every wireless communication network based on its flexibility and scalability. However, using the NOMA system for a specific wireless communication system, such as cellular or sensor networks, has become a complicated task. In this present study, the User Pairing Spatial Modulation NOMA (UPSM-NOMA) has been considered, and its efficiency was improved by implementing the novel decision tree Fossa Resource Allocation (DTFRA). Initially, as per the need, UPSM-NOMA was designed in the MATLAB environment, and then a novel optimized resource allocation process was executed with the help of Fossa's optimal best solution. The considered resources for this present study are the spectral sources. Finally, the performance of the designed optimal UPSM-NOMA was compared with other traditional NOMAs in terms of Bit Error Rate (BER) and sum rate band throughput. In every aspect, the proposed NOMA has gained the finest solution.

Keywords: Decision tree; Fossa optimization; Spatial modulation; User Pairing; Wireless communication

1. Introduction

The development of wireless communication technologies and the rapid expansion of the Internet of Things (IoT) have revolutionized contemporary connectivity scenarios dramatically [1]. With billions of IoT devices across the world, there is a need to create efficient [2] and cost-effective wireless access solutions that can handle extremely large device connectivity, provide low-latency communication [3], achieve high reliability, and exhibit superior spectral efficiency [4]. Perhaps the most urgent problem in such a scenario oc-

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curs in cell-edge dominant network areas, where users normally experience poor signal quality [5] because of excessive path loss, shadowing, and inter-cell interference [6]. The traditional cellular infrastructure based on heavy use of orthogonal resource allocation methods is not effective under such circumstances because of [7] spectral reuse limitations, fairness, and energy efficiency limitations [8]. To counter these challenges, recent studies have examined new advanced multiple access and transmission technology [9]. Among them, user-pair Non-Orthogonal Multiple Access (UP-NOMA) has been recognized as a fundamental technology enabler of 5G and future wireless networks [10]. It is developed with time and bandwidth sharing (BS) schemes. [11] It offers improved connection performance, reduced latency, high dependability, and superior spectrum efficiency.

For wireless cellular networks to understand user connections and overall network performance, connectivity analysis is essential [12]. Modelling and 13] assessing connection likelihood, communication success, QoS, and overall network performance are all made possible by it [14]. Compared with conventional orthogonal approaches, NOMA enables multiple users to access the same time and frequency resources through power domain multiplexing and successive interference cancellation (SIC) at the receiver [15]. Although NOMA greatly enhances spectrum usage and user fairness, it is still plagued with performance degradation on the cell edge, mainly due to low signal-to-interference-plus-noise ratio (SINR) and greater SIC complexity for poor users [16]. Additionally, fixed power allocation and strict pairing mechanisms further restrict the flexibility of traditional NOMA schemes in heterogeneous and dynamic IoT networks [17].

Augmenting the time and bandwidth NOMA framework, Spatial Modulation (SM), a MIMO transmission method that turns on a single transmit antenna at a time to transmit spatial-domain information, is integrated [18]. SM provides an attractive performance-complexity trade-off by avoiding the use of multiple chains while enhancing spectral efficiency [19]. This is particularly advantageous for the IoT devices, which often have limited resources and need communication protocols that are lightweight and power-efficient [20]. Using SM also increases channel utilisation and reduces intra-cell interference, and enhances connection dependability. The key contributions of this study are described as follows:

- Designing the UPSM-NOMA system with the needed number of nodes, including antenna users and base stations
- To implement the novel DTFRA mechanism for a better data sharing experience, which maximizes the sum rate and minimizes the error rate.
- At first, the interference signal cancellation was done by the Fossa prey location finding process. Then the optimal resource allocation is done with the help of the Fossa optimal model by the prey hunting behavior.
- Finally, communication is performed, and the outcomes were measured and validated with other traditional NOMA models.

The present research article is organized as follows: Recent studies are reviewed in the second section; Identified

problems are detailed in section 3; Solutions are proposed in the 4th section; Outcome of the proposed solutions is presented in the 5th section; and section 6 concludes the research arguments.

2. Related Work

The development of Non-Orthogonal Multiple Access (NOMA) has significantly improved spectral efficiency and connectivity in next-generation wireless communication systems. Initially, researchers focused on conventional NOMA resource allocation schemes to improve throughput and Quality of Service (QoS), while later studies incorporated spatial modulation and intelligent optimization algorithms to further enhance communication reliability and resource utilization.

2.1 NOMA-based resource allocation

Early studies concentrated on improving spectral efficiency through efficient user pairing and resource allocation. Khan et al. [21] proposed an aligned aggregated spatial carrier NOMA framework that clusters cell-edge users to improve spectral efficiency and QoS using zero-forcing precoding. Although the method effectively mitigates interference, it suffers from high computational complexity. Similarly, Liu et al. [22] introduced a Sparse Code Multiple Access (SCMA)-enabled multicell edge computing framework with cooperative resource allocation and computation offloading. Their optimization strategy reduced system utility consumption but exhibited performance degradation under dynamic network conditions.

2.2 Spatial modulation-based NOMA

Subsequent research integrated Spatial Modulation (SM) into NOMA systems to improve transmission efficiency and security. Panayirci et al. [23] developed a secure SM transmission strategy using precoding techniques to reduce the Signal-to-Interference-plus-Noise Ratio (SINR) at eavesdroppers. Although effective for secure communication, its performance decreases in large-scale deployments. Wang et al. [24] further proposed a multi-subchannel SM-NOMA framework combining multicast and unicast transmission with joint subchannel and power allocation. While the approach achieved higher weighted sum rates, its performance strongly depended on accurate user scheduling.

2.3 Intelligent optimization for IoT networks

Recent studies have increasingly employed intelligent optimization algorithms to enhance resource allocation in IoT-enabled NOMA systems. Alkhaldi et al. [25] proposed a cache-assisted NOMA framework using block coordinate descent and inner approximation techniques to maximize aggregate data rate. The framework demonstrated improved communication efficiency and robustness for smart-city applications; however, adaptive optimization under highly dynamic wireless environments remains a significant challenge.

2.4 Research gap

Although existing approaches have substantially improved spectral efficiency, throughput, and resource utilization, several limitations remain. Most existing techniques either involve high computational complexity, rely heavily on accurate user scheduling, or experience degraded performance in dynamic and dense IoT environments. Furthermore, few studies jointly integrate intelligent learning mechanisms with metaheuristic optimization for effi-

cient resource allocation in Spatial Modulation NOMA systems. To address these limitations, this work proposes a Decision Tree-based Fossa Resource Allocation (DTFRA) framework that combines intelligent user classification with Fossa optimization to enhance spectral efficiency, throughput, and Bit Error Rate performance for cell-edge dominant IoT networks.

3. Problem Statement

The incorporation of IoT devices into future wireless networks is challenging, especially in cell-edge dominant scenarios where users have diminished signal quality and limited spectral efficiency. Solutions to improve connectivity and efficiency have been introduced in previous studies, including NOMA, coordinated multipoint transmission, and massive MIMO. Yet, these solutions tend to have practical implementation problems such as excessive complexity, synchronization overhead, inter-cell interference, and higher energy consumption. Although NOMA enhances spectral efficiency by enabling multiple users to have the same time-frequency resources, it experiences performance loss at the cell edge with bad channel conditions and user pairing constraints. Also, SM has been a promising method of enhancing energy and hardware efficiency through the activation of a single antenna at a time, but its utility in multi-user and cell-edge environments is underexplored.

The current literature does not extend to a thorough investigation of hybrid schemes that combine the advantages of spatial modulation and NOMA, specifically those that combine SM with time and bandwidth sharing NOMA approaches. Most previous studies are either single-featured, focusing only on bandwidth-domain NOMA or studying time-domain NOMA independently, without addressing their combination with SM Time sharing UPNOMA (TS-UPNOMA). In addition, very few studies currently take into account the specific constraints of IoT devices, including low complexity and limited power, in the application of sophisticated access techniques. Moreover, scarce attention has so far been focused on designing these joint methods optimally for fairness and reliability at the cell edge, where performance differences are worst. These shortcomings highlight the necessity for new frameworks that combine SM with both time and bandwidth sharing NOMA to deliver energy-efficient, low-complexity, and high-reliability connectivity for vast IoT deployments in cell-edge-dominant networks.

4. Proposed methodologies: DTFRA

A novel decision tree Fossa Resource Allocation (DTFRA) was introduced in the present spatial modulation NOMA approach to make the effective resource allocation. In the initial phase, the needed node counts were introduced, and the novel solution was executed. Moreover, the monitoring function of the Fossa was activated to evaluate the nodes' requirements for offering sufficient resources. In addition, during the monitoring process, the interference signals were predicted and eliminated.

Once the needed spectral resources were found, the allocation was done optimally, then the data sharing process began, and the performance analysis was conducted with other traditional models. The main intent of this proposed research is to reduce the challenges to processing the data in the spatial domain. The proposed architecture is shown in Fig. 1. In order to get the improved outcome, the designed outcomes were fixed in the memory of the fossa optimal model. During the execution of the

Fossa optimal process, the iterations were processed continuously till the desired outcome was met. This is the major novelty, and it enables effective data transmission by avoiding interference.

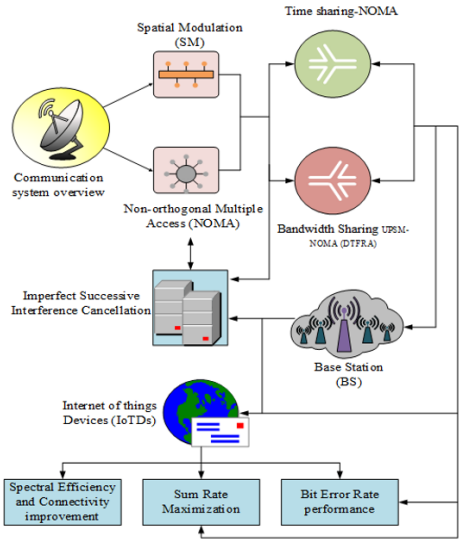


Fig. 1. Proposed model.

4.1 Process of the proposed model

Low-latency communication is becoming more and more important in the Age of IoT due to its critical function in a variety of application areas. Short latency transmission guarantees the efficient operation of technology and machinery, which is crucial for factories where flawless integration and real-time reactivity are essential. The efficient operation of autonomous vehicles and remotely operated equipment is also made possible by autonomous control systems, which mostly depend on a low-latency connection. In the primary phase, to model the SM-UPNOMA, the required node count was designed using the Fossa population initialization function. Here, d defines the nodes, is the node initialization, and determines the number of nodes; the initialization is shown in Eq. (4.1).

$$F(d) = d\{1, 2, \ldots, n\}. \qquad (4.1)$$

In order to enable the successful cancellation of the interference signal, the Fossa monitoring process was initiated by Eq. (4.2). Here, finding the prey (lemur) location process was adopted to track the interference signal. Collisions occur when multiple packet broadcasts arrive at the recipient at the same time. Traditional indication extraction treats all other transmissions as interference and can solely decode the data stream with the clearest signal. The information of interest can't be reconstructed if it doesn't represent the most powerful one.

However, an inferior signal can be recovered with the help of SIC. The most powerful signal's bytes have been decoded identically using SIC. The next greatest signal will be decoded into this remnant after the initial transmission signal equivalent to the respective bits has been rebuilt and eliminated (cancelled) from the composite signal. It is known as successive interference cancellation because it might be an iterative procedure to recover several transmissions. The proposed model with UPSM-NOMA is defined in Fig. 2. The proposed model is designed with the principle of decision trees [26] and Fossa optimization [27].

This study emphasizes the more straightforward scenario of just a couple of packets, so that interference cancellation is only done once. However, we continue to call it SIC because of simplicity.

$$d_{j,k} = by + u(ry - by). \qquad (4.2)$$

Here, d defines the node count in the created NOMA channel d_j determines the monitoring variable and $d_{j,k}$ represents the k^{th} location of the j^{th} monitoring element. Moreover, the decision tree variable



Fig. 2. UPSM-NOMA with proposed model.

is exposed as u and ry are the upper and lower bounds for the monitoring phase. After the prediction of the interference signal, which is neglected from the communication link? After terminating the interference signal, the needed resources of every user have to be predicted before initiating the resource allocation process. Hence, the resource predicting process is executed by Eq. (4.3).

$$E_r = \{d_s : h_s \geq T \text{ and } s \neq 0\}. \qquad (4.3)$$

Here, E_r determines the resource estimation, d_s is the spectral efficiency of the created network, h_s is the required spectral resources for each data sharing, and T is the target weight. In addition, the nodes were movable in the dynamic environment, even in the spectral sharing process. Dynamic spectrum distribution systems, in contrast to conventional fixed allocation algorithms, adaptively distribute subcarriers in response to traffic requirements and real-time network conditions, optimizing spectrum utilization while reducing interference. Adaptive distribution of spectrum technologies promises to increase spectral effectiveness and boost system reliability by taking advantage of electromagnetic white spaces and neural radio features.

$$A_r = \left\{ \begin{array}{cc} f_s & f_s \leq h_{ms} \\ O_r & \text{else} \end{array} \right\}. \qquad (4.4)$$

The resource allocating parameter is determined as A_r, a freely movable node during the spectral sharing is represented as f_s, a stale node during the spectral sharing function is exposed as h_{ms} and O_r is the optimal resources. During the spectral resources' allocation process, if the specific node is dynamically moving, then the same resources of the stable node are allocated to the moving nodes.

Algorithm: 1 DTFRA-NOMA	
Start	
Step: 1	Node initialization Initialize → required nodes The Fossa population initialization process was activated for the node initialization process.
Step:2	Cancellation of the interference signal cancel->additional signal The fossa prey location finding process performs it
Step: 3	Needed resource finding Analyzing the node status and target Chasing the lemur function of the Fossa is utilized for detecting the needed spectral resources for
Step 4	Optimal resource allocation allocate ->optimal spectraldynamic+s1// spectral resources were allocated for both dynamic and static nodes, which is performed by the best Fossa selecting process after the hunting
Step: 5	Data transmission Effective data sharing
Stop	

To gain the desired outcome, the processing steps have to be executed in the order mentioned; the order is mentioned in the algorithmic format, visualized in Algorithm 1.

5. Results

The proposed solution is executed with the help of the MATLAB programming language, with the version MATLAB R2021b, and running on the Windows 10 platform. The needed resources for this execution are an Intel Core i5 processor with 8GB of RAM. The innovative model that is considered to attain the finest outcome is DTFRA-NOMA. The execution parameters are shown in Table 1.

Table 1. Parameter specification.

Parameter	Value
Environment	MTLAB
Version	R2023A
OS	Windows 10
Communication type	Wireless
Carrier frequency	1.9 Hz
SNR	0-10 dB
Transmit Power	50dBm
Bandwidth	10 MHz
Users pair	2 (cell centre, Cell-Edge)
Channel model	Rayleigh
Network area	500x500
Optimization	Fossa
Algorithm	Decision tree
System model	UPSM-NOMA

5.1 Case study

This section explores the UPSM-NOMA method's simulated variables and results. This system, which consists of a single nearest user and 2 farthest users, has been carefully designed to accommodate a varied user context. The goal of the models is to assess the system's effectiveness in both the crucial resource areas of bandwidth and time allocation. Inevitably, it is necessary to precisely locate individuals in relation to the BS to guarantee the accuracy of the models.

The benchmark distance is one meter, and the starting point channel strength is set at -30, 30dB. The proposed communication system is shown in Fig. 3. This navigation, which is developed from conventional path loss estimates frequently used in mobile communication research, is essential for accurately modeling the channel characteristics. The criteria mentioned above are essential for performing accurate simulations that provide outcomes that are indicative of actual operational circumstances. The simulations are designed to demonstrate the relative performance characteristics between the UPSM-NOMA versus other bandwidth and time-sharing based NOMA platforms by conforming to industry standards. The aim is to assess their effectiveness in improving spectrum effectiveness and connection, especially for users situated at the wireless network's edge.

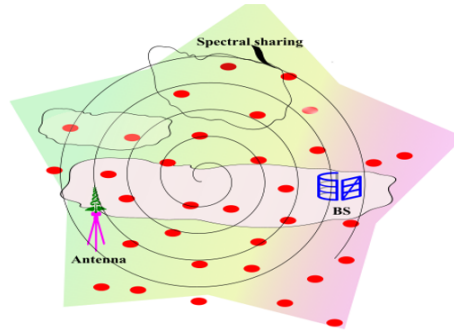


Fig. 3. Proposed communication system.

Table 2 and Fig. 4 show the Bit Error Rate (BER) performance of User 1 and User 2 both in terms of theoretical values as well as simulated values at various SNR values from 0 to 10 dB. User 1 always obtains better BER than User 2, as would normally be the case because User 1 is closer to the base station with good channel conditions.

In contrast, User 2, probably a cell-edge user, suffers more from path loss and interference. Table 3 demonstrates sum rate performance for User 1 and User 2 for various transmit power levels ranging from 0

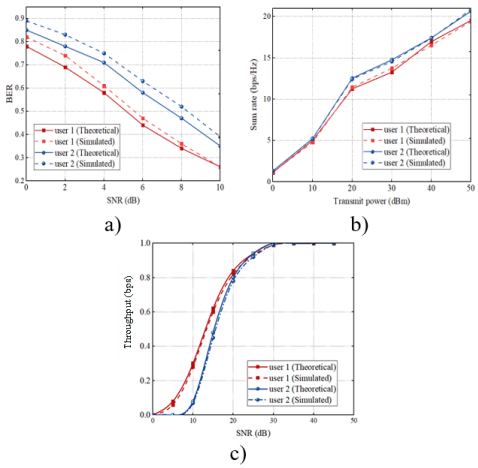


Fig. 4. Performance of proposed: a) BER, b) sum rate, c) throughput.

Table 2. BER analysis for proposed model.

SNR (dB)	BER User 1		BER User 1	
	Theoretical	Simulated	Theoretical	Simulated
0	0.78	0.82	0.85	0.89
2	0.69	0.74	0.78	0.83
4	0.58	0.61	0.71	0.75
6	0.44	0.47	0.58	0.63
8	0.34	0.36	0.47	0.52
10	0.26	0.26	0.35	0.39

to 50 dBm, expressed in terms of theoretical and simulated values. With the increase in transmit power, both users' data transmission rates improve substantially, reflecting improved data throughput and increased spectral resource utilization.

Table 3. Analysis of sum rate.

Transmit power (dBm)	User 1 Sum rate		User 2 Sum rate	
	Theoretical	Simulated	Theoretical	Simulated
0	1.11	1.17	1.31	1.29
10	4.98	4.76	5.22	5.18
20	11.24	11.43	12.53	12.42
30	13.26	13.74	14.76	14.56
40	16.97	16.52	17.42	17.37
50	19.54	19.42	20.65	20.87

Here, the effectiveness was measured in the form of both theoretical and simulation platforms, visualized in Fig. 3 and the statistical information provided in Tables 2, 3, and Table 4.

Table 4. Throughput assessment.

SNR (dB)	User 1 Throughput (bps)		User 2 Throughput (bps)	
	Theoretical	Simulated	Theoretical	Simulated
0	0.00	0.00	0.00	0.00
5	0.08	0.06	0.00	0.00
10	0.30	0.28	0.08	0.07
15	0.62	0.60	0.48	0.45
20	0.84	0.82	0.80	0.78
25	0.94	0.93	0.94	0.92
30	1.00	0.99	1.00	0.99
35	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00

Table 4 shows the throughput performance of User 1 and User 2 with different SNR levels ranging from 0 to 50 dB using theoretical and simulated values. At extremely low SNR levels (0–5 dB), both users have negligible throughput because of weak signal quality. Increasing SNR increases throughput for both users, representing improved link reliability and data rates. User 1 has greater throughput at lower SNRs, due to the favorable channel conditions, and User 2 catches up and equals User 1's performance from approximately 25 dB upwards, demonstrating good fairness in terms of resource allocation.

5.2 Discussion

Time sharing UPNOMA (TS-UPNOMA), Bandwidth Sharing UPNOMA (BS-UPNOMA), UPSM-NOMA, and the proposed model. Here, the proposed model is incorporated in the UPSM-NOMA system. Here, all the described traditional NOMAs were executed in the same pro-

posed platform, and performance was compared with each other.

5.2.1 Validation of BER

The repeated cancellation of the interference procedure is usually assumed to be perfect or flawed while performing the BER assessment. Generally speaking, the scenario with faultless SIC is called a rough estimate, whereas the condition with defective SIC is called exact. This identical reasoning holds true for additional metrics like bandwidth and outage likelihood. A key indicator of the integrity and dependability of an electronic transmission network for mobile communications is the BER. This shows the proportion of bits that were received incorrectly to all bits that were transmitted. Secure communication requires a low BER, which indicates fewer mistakes in the transmission. The comparison of BER is shown in Fig. 5 and Table 5.

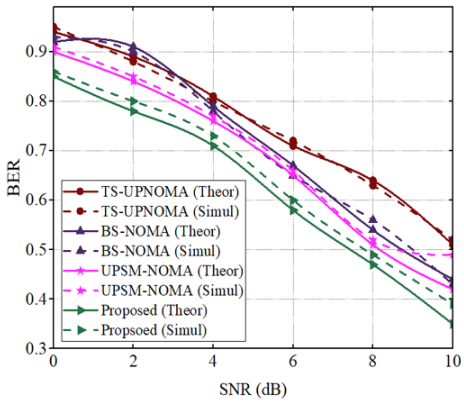


Fig. 5. BER comparison.

Table 5 provides a comparison of the BER performance of four schemes based on NOMA, i.e. TS-UPNOMA, BS-UPNOMA, UPSM-NOMA, and the proposed model, with respect to increasing SNR levels from 0 to 10 dB, for theoretical and simulated values. The expected trend of decreasing BER with higher SNR values has been observed in all schemes, reflecting increasing signal quality and reliability. Among the compared methods, the suggested model always shows the lowest values of BER, particularly at large SNRs, showing its better error performance.

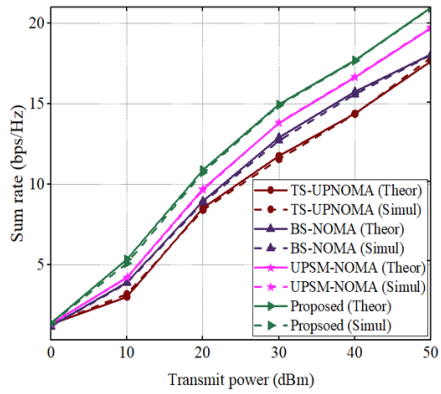


Fig. 6. Comparison of sum rate.

5.2.2 Sum rate validation

It's critical to manage the user interference properly. In order to reduce disturbance and increase sum rate, strategies like beam shaping, power management, and customer scheduling are used. The sum rate, which is determined by adding the unique data speeds of every customer in an environment, is the maximum attainable information rate across everybody in the system. By utilizing power or coding domain multiplex to enable many devices to take advantage of the identical time-frequency assets, NOMA outperforms conventional orthogonal overlapping in terms of sum rates. The sum rate comparison is shown in Fig. 6 and Table 6.

Table 6 shows the sum rate performance of existing and developed techniques over a transmit power range of 0 to 50 dBm using theoretical and simulated outcomes. The sum rate increases as the transmit power increases, demonstrating better

Table 5. Statistics of BER comparison.

SNR (dB)	TS-UPNOMA		BS-UPNOMA		UPSM-NOMA		Proposed	
	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
0	0.94	0.95	0.92	0.93	0.9	0.91	0.85	0.86
0	0.89	0.88	0.91	0.9	0.84	0.85	0.78	0.80
4	0.81	0.8	0.79	0.78	0.76	0.77	0.71	0.73
6	0.71	0.72	0.67	0.65	0.65	0.66	0.58	0.60
8	0.64	0.63	0.54	0.56	0.51	0.52	0.47	0.49
10	0.51	0.52	0.44	0.43	0.42	0.49	0.35	0.39

Table 6. Sum rate statistics.

SNR (dB)	TS-UPNOMA		BS-UPNOMA		UPSM-NOMA		Proposed	
	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
0	1.31	1.29	1.19	1.16	1.32	1.33	1.37	1.34
10	3.00	3.18	3.91	3.86	4.21	4.19	5.34	5.09
00	8.53	8.40	8.96	8.86	9.72	9.65	10.89	10.74
30	11.76	11.56	12.91	12.71	13.81	13.83	14.97	14.91
40	14.40	14.37	15.76	15.60	16.65	16.69	17.71	17.68
50	17.65	17.87	18.07	18.03	19.71	19.74	20.98	20.96

throughput and utilization of the spectrum, for all schemes. Among them, the proposed model always obtains the highest sum rate under all power levels, which indicates its better performance in managing data traffic more efficiently.

5.2.3 Throughput validation

The actual pace at which information is successfully sent via an internet connection or medium in a specific amount of time is referred to as throughput. It is a measurement of the actual amount of info being carried rather than the network's potential maximum data rate (bandwidth). Usually, throughput is expressed in messages per second or bits per second (bps). In addition, achieving a high range of throughput can determine the effective communication. The wireless medium with high throughput attained a lower BER and maximized the packet delivery ratio.

Table 7 and Fig. 7 show the throughput performance at different SNR levels from 0 to 50 dB, with both theoretical and simulated values for existing and proposed methods. At extremely low SNR levels (0–5 dB), all the methods obtain throughput due to weak signal quality. As SNR enhances, throughput continuously improves, with the suggested model outperforming the remaining methods at every level of SNR.

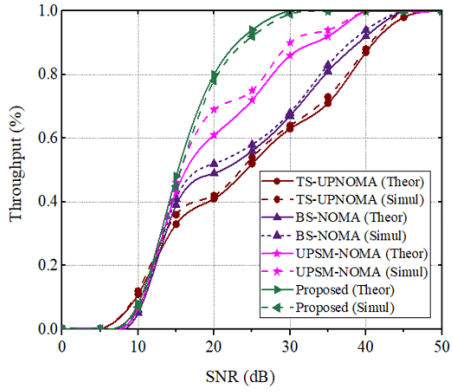


Fig. 7. Throughput comparison.

From all the comparison validations, the novel solution has produced the finest solution, which shows that the proposed solution is the most suitable for the present applications.

6. Conclusion

A novel DTFRA was implemented for the UPSM-NOMA system to improve communication by cancelling the interference signal. Here, the Fossa finest solution has been employed to gain the finest desired outcome by predicting the interference sig-

Table 7. Sum rate statistics.

SNR (dB)	TS-UPNOMA		BS-UPNOMA		UPSM-NOMA		Proposed	
	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated	Theoretical	Simulated
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.031	0.042	0.051	0.062	0.064	0.069	0.08	0.07
15	0.33	0.36	0.39	0.41	0.43	0.46	0.48	0.45
20	0.41	0.42	0.5	0.52	0.61	0.69	0.80	0.78
25	0.52	0.54	0.56	0.58	0.72	0.75	0.94	0.92
30	0.63	0.64	0.67	0.68	0.86	0.9	1.00	0.99
35	0.71	0.73	0.81	0.83	0.92	0.94	1.00	1.00
40	0.87	0.88	0.92	0.94	1	1	1.00	1.00
45	0.98	1	1	1	1	1	1.00	1.00
50	1	1	1	1	1	1	1.00	1.00

nals and neglecting them in the communication medium; this process can maximize the sum rate and reduce the error percentage. In addition, for allocating the spectral resources, the attacking phase of the Fossa was considered, and the spectral sources were allocated optimally for both static and moving users. In execution, the proposed system has revealed that 20.96bps/Hz sum rate, BER 0.39, and throughput is 100bps, which is the best outcome compared to other traditional NOMA. Hence, the present proposed NOMA system has improved the performance by 5%. So, the proposed solution is the most needed task for the NOMA applications. However, the energy management is not discussed in this study, which can affect the network lifetime. In the future, analyzing the energy usage and optimizing the high energy usage will provide the finest optimal outcome.

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