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Original Article

A Novel Resource Allocation with Co-operative Partner Relay Selection (CPRS) in CR- NOMA Networks

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Abstract - *The objective of this paper is to share resources with Co-operative Partner Relay Selection (CPRS) in the co-operative Hybrid Cognitive Radio Network (HCRN), which enables NOMA. An eco-friendly approach in view of an innovative Guaranteed Access Priority (GAP) to ensure maximum utility of users is presented. The prime intention is to share the radio spectrum with less power, less obstruction efficiently, and to increase the data rates of each user. This proposed algorithm's performance metrics are outage probability, system throughput, achievable sum rates and energy efficiency to make the best utilization of the restricted radio spectrum while establishing superior Multi-User (MU) data rate transmission. According to channel states, the power level is attuned and allocated to Secondary Users (SUs). From the simulation, it is observed that Co-operative Partner Relay Selection (CPRS) can attain superior power efficiency, sum rate, and minimum outage probability than the conventional methods.*

Keywords - *Co-operative HCRN, GAP, NOMA, Resource allocation.*

1. Introduction

Cognitive radio communication has gained wide attention due to the maximum resource utilization, in which Primary Licensed Users (PLU) share their resources with unlicensed secondary users under a predefined interference threshold. Efficient access to an overcrowded spectrum by the user plays a significant role. NOMA-enhanced Cognitive Radio Relaying communication is one of the 5G enabler technologies supporting numerous wireless connections efficiently. By using NOMA all the multiple signals that are added into one signal are identified based on power level. Resource allocation by relaying scheme is shown in Figure 1.

The primary objective of this paper is to enhance resource utilization using CPRS, maintaining good QoC (Quality of Communication) and spectrum sharing in NOMA co-operative HCRN. Reliability can be increased through an efficient selection of suitable Relays (SU) by primary users to assist the secondary transmitter's data transmission. This is implemented with a decode and forward processing scheme with the QoS constraints of both PUs and SUs to maximize the system throughput with minimum system outage probability.

Modern wireless communication approaches coordination in communicating information. The selection of a relay ensures cooperation between the sources with the selected relay node (SU) instead of multiple relay nodes with Diversity Gain (DG). Relay plays a significant role in retransmitting the received signal from the primary user after processing to the secondary source, even when the line of sight communication between the primary source and secondary source is good. Retransmission of the relay reduces spectral efficiency and indulges in wasting network resources, which denotes the demerits of the selected relay node. Hence designing and selecting the best one is very vital for attaining maximum performance.

Dynamic allocation of spectrum resources requires the simple relay selection to achieve energy-efficient cooperation between users with high Diversity Gain (DG). An energy-efficient and robust relay node enhances spectral efficiency and reliable communication. To obtain diversity gain in a system virtual MIMO concept is a pre-requisite. This is because the users with a single antenna share their resources with other users instead of using physical MIMO. Existing systems have higher latency and lower diversity gain; to mitigate this use of Co-operative Partner Relay Selection Protocol (CPRSP) is enabled as it assists in the progress of the efficiency of user's communication. The highest throughput is obtained in spectrum sharing between PU and SU cooperation in a CRN. Multiple SU establishes a connection with the licensed PU for data transmission using the stable relay node. PU and SU are mutually benefitted by sharing their underutilized spectrum resources. Improvisation in spatial diversity in wireless networks can be obtained by enabling a cooperative virtual MIMO system.

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In these multi-user environments, challenges occur in selecting the best SU (relay) and spectrum allocation and hence both spectrum efficiency and interference limitation must be taken into consideration with interference control by proper power allocation.

In a CRN, each SU travels at a certain power level. When power is more, throughput is more but with an increased level of interference at the primary network. Hence, the main objective is optimal power allocation at SU (relay) nodes, providing end-to-end maximum throughput satisfying interference constraints.

In order to lessen the interference that is placed on PUs and between SUs, the secondary transmitter's strength is reduced. To accommodate all the SUs, co-operation among SUs is needed to establish primary to many secondary user connections; the distributed co-operative SS (Spectrum Sensing) is engaged to gather PU's occupancy detection. This paper presents an innovative Co-operative Partner Relay Selection (CPRS) scheme for Cooperative underlay resource sharing in NOMA based CRN based on channel coefficients, which include SINR, broadcast link distance and an efficient LOS communication.

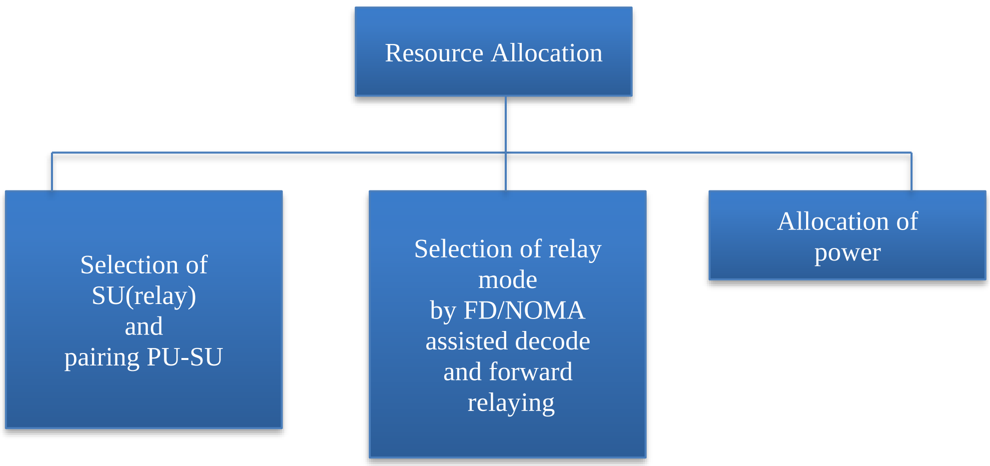

Fig. 1 Resource allocation by relaying scheme

2. Related Works and Motivation

Recently, in cognitive radio research primary and secondary user cooperation has gained lots of attention. In the existing methods, PU-SU direct communications without relay selection with partial and fixed relay selection methods are proposed.

In the former case, PU does not select any relay for retransmission; instead, it approaches the neighbor base station for connection with SUs if possible. It entirely depends on the connection capacity of neighbor base stations. This approach suffers from channel impairments for direct communication, and all the PUs are not mapped with the secondary users for resource sharing, hence the data rate is lesser.

In order to maximize utility among multiple users, existing work does not take the MU pairing relay selection into account. However, when there are more SUs in the network, there is more competition between PUs and SUs as well as among SUs themselves, which causes interference and lowers the usefulness of SUs. Hence, to mitigate the interference signal best co-operative pair for relaying the information is selected with interference threshold I_{max} defining the tolerable level of intrusions caused by SUs to PUs.

The main objective is to find the best stable relay for a two hop path to reach multiple SUs from the source PUs. SU gets mapped with the PU based on its channel connection capacity, higher data rate and its nearest neighbor. In the existing case, fixed relays are used for cooperation, which does not provide much network coverage. Channel conditions are changed due to various impairments occurring in this dynamic environment as channel capacity communication is not established.

In [1] authors have proved enhancement of spectral efficiency (SE) by CR-NOMA comparing individual technologies of CR or NOMA. In order to boost spectrum efficiency and system capacity in 5th-generation wireless networks, CR-NOMA approaches are crucial. The process of simplifying the applications of NOMA into CRN is examined in this paper, along with the most recent research findings.

Co-operating underlay forward-decode CR-NOMA network is utilized in [2] to derive the precise formulas for the outage events of subordinate users of NOMA. The best power allocating terms are found to be intended for various ranges of users, fulfilling outage probability fairness. The objective of this paper is to demonstrate CR-superiority NOMAs to the co-operative OMA technique.

The interferences which occur in CR-NOMA reduce the sum rate and spectrum utilization [3]. However, these can be mitigated by co-operative relaying with the use of NOMA in a down-linked CR-NOMA system. The CR-NOMA built-in spatial diversity is the focus of a cooperative transmission strategy that uses relaying between several Secondary Users (SU). The technique employed in this cooperative transmission scheme, when more SUs are used in the relaying process, gives superior diversity gain and maximum diversity order.

In [4,5], authors proposed that extrinsic information transfer charts with irregular convolution coding were used to track people involved in cooperative relaying to improve the transmission rates and diversity gain of the NOMA system. Spectrum allocation by non co-operative game theory. By examining the effects of relay selection, the research examines current trends in PD-NOMA-based cooperative network spectrum allocation.

[6,7] examines the Coordinated Multi-point interference management strategy (CoMP) with SIC (Successive Interference Cancellation) that makes the secondary users mitigate their interfering signals. Introduces (MD-SIC) Multiple Decision SIC technique to conflict the error propagation, as it uses multiple code words for multi-user detection, it performs better than conventional technique with computational complexity.

The feature of NOMA technology to improve spectrum utilization is discussed in that MU with varying power levels assigned to them with SIC within the receiver to decode the signal. To improve system performance, NOMA cooperative networks drew attention to improve user quality as proposed in [8]

The system Energy-Efficiency (EE) can be enhanced using the joint PA and sub channel allocation approach with a suboptimal method for optimizing macro and small cell resource allocation upon considering dual decomposition techniques has been discussed in [9,10]. The (SE) of Co-operative NOMA has been improved with successive user relaying with a pair of half duplex users for optimizing power and enhancing user performance during outages.

In [11], Bi layer optimization problem with (GEE) Global Energy Efficiency of a DF relay system to investigate optimal power allocation in a co-operative relaying system is proposed. The determination of the most favorable power ranges of a co-operative NOMA system with the decoding and amplifying protocols was developed by [12] referring co-operative NOMA with AF-HD and FD relay power allocation made to raise user rates in the system's two- and multi-user configurations. In [13,14], the performances of FD/HD relay selections on the cooperative NOMA system were developed. In the low SNR region FD-RS outperforms HD-RS than in the high SNR region. In the existing Partial Relay Selection strategy (PRS), the relays which are selected for retransmission use only the conventional fixed power allocation scheme. This dynamic environment fixed method is not that effective. The proposed method mitigates all these drawbacks, considering dynamic power allocation.

The combined PA with link-selection users-clustering was developed in [15] increasing the (WSR) of a co-operative NOMA. It evaluates a co-operative NOMA in (VLC), Visible Light Communication, to raise the system's fairness and average rate of return. In [16], Dynamic (SWIPT) cooperative NOMA was proposed to adjust the time and power resources dynamically.

The system was presented to acquire the time and power ratio by joint optimization for cell-center and edge users. In [17], NOMA with FD relaying is discussed with the realistic hypothesis of The suggested Full duplex(FD) cooperative NOMA method outperforms the HD-Cooperative NOMA scheme despite having inadequate Self-Interference Cancellation(SIC) in the moderate SNR regime. The error performance and the joint optimization of power and time for cooperative NOMA have been discussed in [18], and analyzed error performance of co-operative NOMA with BER probability has been analysed.

Two-way cooperative relays based on NOMA that communicate in both directions for two users perform better than traditional C-NOMA systems when time and power are optimized. In [19,20], analyzing the large-user system while taking into account the practical configuration of user symbol energies, the dynamic user-decoding order in SIC is evaluated. [21] Proposed that the maximum SNR of SUs can be achieved with the antenna selection strategy in MIMO CR-NOMA. It is possible to increase the SNR of cognitive users under the PUs QoS at the expense of a high implementation cost.

3. System Model

In these multi-user environments, challenges occur in selecting the best SU (relay) and spectrum allocation and hence both spectrum efficiency and interference limitation must be taken into consideration with interference control by proper power allocation. Hence, the main objective is optimal power allocation at SU (relay) nodes, providing end-to-end maximum throughput satisfying interference constraints. As depicted in Figure 2, NOMA is used in the (HCRN) having Primary Base Station (PBS) and Small Cell Base Station (SBS) containing Secondary users (SU_1, SU_2, SU_3….SU_K) and primary users (PU_1, PU_2, PU_3….PU_l) In contrast to the "(OMA)" technique, NOMA allocates resources non-orthogonally based on the position of the PUs and SUs with regard to the base station. Additionally, the broadcast power is assigned based on the channel conditions.

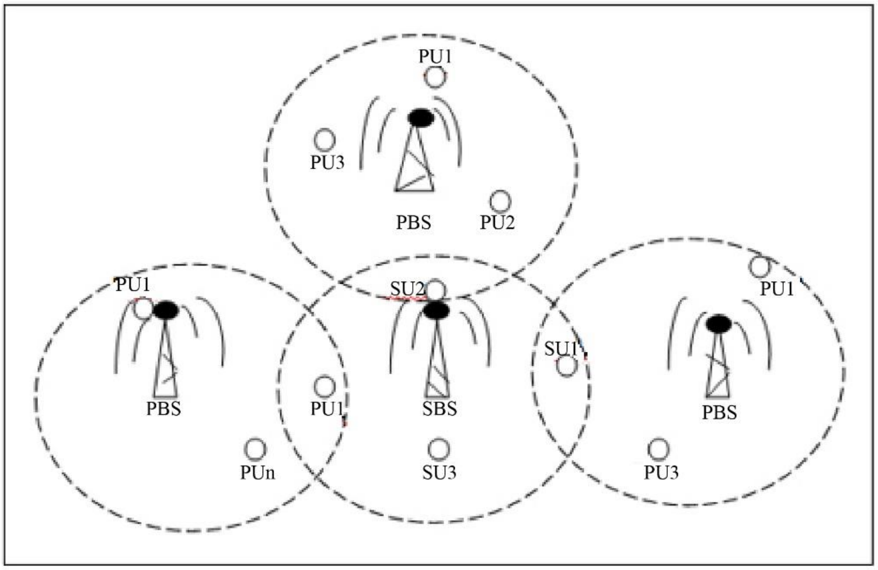

Fig. 2 System model

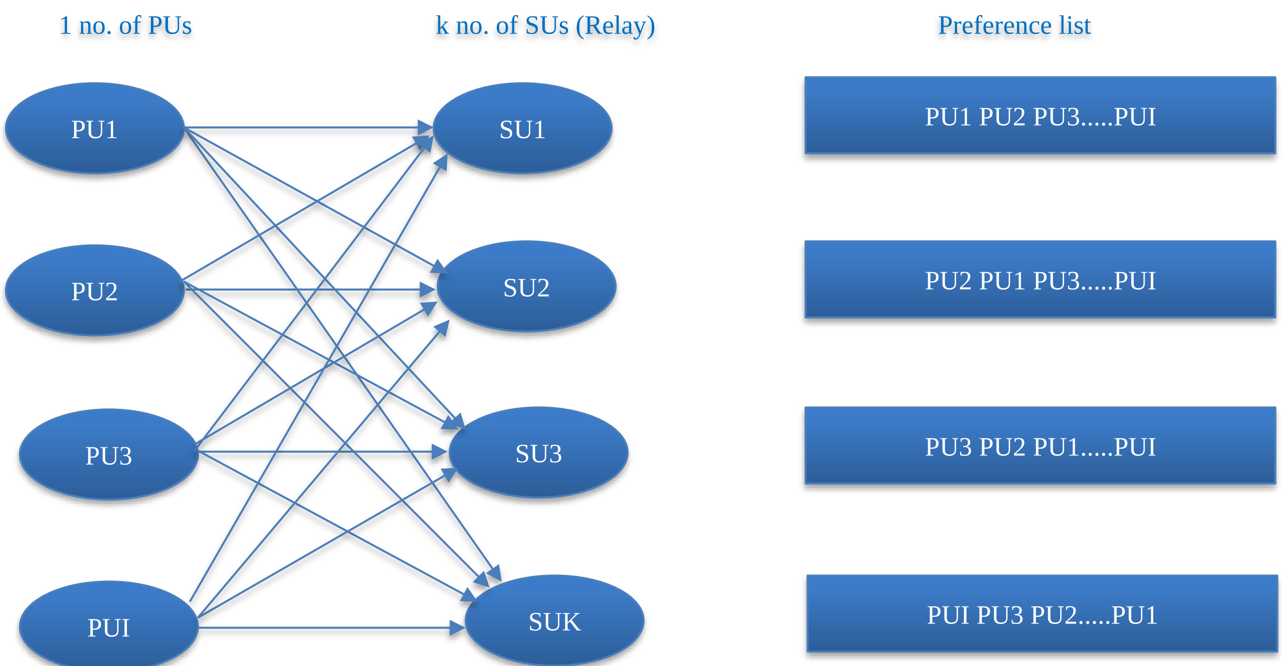

Fig. 3 CPRS (Co-operative Partner Relay Selection)

SU maintain two modes in channel sensing. If the Direct Connection (DC) is in good condition, SU performs underlay sharing concurrently with a licensed user. If the DC cannot sustain the transmission rate because of low SNR, channel capacity and bad transmission conditions, SU performs cooperation for transmission with PU.

SU switches between two actions in accessing the channel based on the conditions of the PU channel. SU can access licensed spectrum without interfering, or it can opportunistically access it.

Data transmission rates throughput of primary and secondary users are increased in co-operation. Co-operation is established on the basis of the channel's quality (Channel gain and link distances) between the primary source and secondary destination. SU with small transmission power concurrently access the spectrum only when the good transmission conditions of the primary link are met.

In this paper, information from PU to SU is transmitted via a best-selected relay, which processes the signal to maximize throughput and to utilize resources with (Decode and Forward) DF relaying protocol with reduced energy consumption to increase efficiency.

The proposed protocol, as shown in Figure 3, considers two sets of l number of PUs and k SUs; the SUs perform sensing for transmission opportunities, and NOMA allocates power, increasing the SUs throughput with constraints of maintaining PU QoS. The resource requirements of the PUs and SUs are presented to the spectral management system. In this scenario, PUs in the network provide a chance for each SU to allocate the best spectral bandwidth and accessible time with the PU's and SU's resource constraints.

Existing work does not consider the MU pairing relay selection in order to increase the maximum utility among multiple users. However, with the increased number of SUs in the network, competition between PUs and SUs, as well as between the SUs, arises with interference, too, which reduces the utility of SUs. Hence, to mitigate the interference signal best co-operative pair for relaying the information is selected with interference threshold I_{max} defining the tolerable level of intrusions caused by SUs to PUs. Power control with NOMA is essential to ensure PU protection from excessive interference from unlicensed users. SU relaying takes advantage of reliability, user diversity and capacity in wireless communication. When direct communication is impossible due to huge shadowing, relaying takes advantage of retransmitting.

Consider a NOMA enhanced Cognitive Radio Relaying network comprising of l PUs and k SUs employing decode and forward protocol. Assuming every node is built with an antenna. Initially primary source transmits information signal x1,x2,x3… with the transmit power P1,P2,P3…,the superimposed signal is derived as

$$S_{transmit} = \sqrt{P1}x1 + \sqrt{P2}x2 + \sqrt{P3}x3 + \cdots. \quad (1)$$

The signal acquired by the chosen relay is denoted as

$$R_{received} = h_{SR}(\text{Stransmit}) + n_r$$
$$= h_{SR}\left(\sqrt{P1}x1 + \sqrt{P2}x2 + \sqrt{P3}x3 + \cdots\right) + n_r \quad (2)$$

The signal received by the relay is retransmitted after decoding to the destinations with the transmit power of a regenerated signal as P_{11}, P_{22}, P_{33}…
the retransmitted signal is expressed as

$$R_{retransmits} = \sqrt{P11}x1 + \sqrt{P22}x2 + \sqrt{P33}x3 + \cdots. \quad (3)$$

Efficient power allocation can be achieved as

$$\underset{P1,P2,P11,P22\ldots}{MAX} \quad \eta_{EE}$$
s.t. $R_i \geq R^{min}, i = 1,2,3$ ....
$P_1+P_2+P_3\ldots \leq P_S^{max}$
$$P_{11}+P_{22}+P_{33}\ldots. \leq P_r^{max} \quad (4)$$

Where R^{min} is the link's minimum data rate, P_S^{max} *and* P_r^{max} are the maximum allowed relay and source transmission powers.

3.1. Relay Selection Methods with (GAP)

To improve system performance, relay selection plays a major role in mitigating higher latency and low diversity. Cooperative systems make the PU source transmit with a selected node instead of multiple nodes, which guarantees the diversity gain.

Relay selection enables retransmitting data to its corresponding receiver under SNR constraint and link priorities. The former one with improved outage probability and extended network coverage, and the latter can improve throughput and reduced latency. Relay is enabled only when DL fails due to channel impairments. To achieve high diversity gain with relays, multiple SUs co-ordinate the signals transmitted by the PUs.

For allocating resources from PU-SU in a NOMA-based HCRN with relay selection, initially from k number of relay nodes (SU) best available relay is chosen depending on maximum channel co-efficient, improved SINR of relay node, minimum link distance from S-R, which acts as a relay selecting criterion.

The selected relay assists the primary base station in broadcasting the superimposed signal to secondary users based on the decode and forwarding protocol. These (SU) relays are efficiently selected by PUs to assist ST's data transmission with decode and forward protocol. That is, SUs need to learn the PUs activities to avoid interfering with PU. SU (relay) acquires CSI since the relay considered here is dynamic (the position of the relay is not fixed), and based on the location of the relay, performance can be improved. As the relays are dynamic, fixed power allocation is not an optimal way for allocation.

To enhance the SU opportunities for accessing the idle spectrum and to increase the PU data delivery, selecting the intermediate relay nodes with higher channel coefficients to the secondary user is the best way.

The SU utility function is obtained from received signal information from the source. SUs are matched with the corresponding PUs by dynamic relaying under transmission criteria. SUs access the spectrum by underlay method or cooperatively. Sum rate, SU utility, throughput and minimum transmission power constraints are satisfied.

Relay selection plays a major role because system resources get wasted if the link between SR and RD is in deep fade if the selected node is not satisfied with transmission constraints. Hence, the main principle involved is to choose the best one which can increase or decrease the desired functions of transmission, such as SNR, throughput, and user transmission power. To meet higher efficiency in selecting nodes, balancing is important because not all the relay nodes are satisfactory. We aim to select the best one considering the balance between signal qualities of PU- SU opportunistically.

$$R_{best} = \arg\max_{i\in 1,N}\{min(\gamma_{PU,SU_i})\}$$

$$R_i \leq C_{i,j} \quad (5)$$

The information signal is transmitted only when it meets the data rate and channel capacity criteria.

3.2. Guaranteed Access Priorities (GAP)

These Guaranteed Access Priorities establish the mapping of PUs and SUs pairs for spectrum access.

1. Each SU prefer increased bandwidth with less access time.
2. Each PU prefers more access time.
3. Establishing many-to-one mapping between PU and SU.
4. If SU (relay) is close to PU, signal strength is good.
5. If SU (relay) is far away from PU, signal strength is poor. The information signal cannot be decoded perfectly. Hence, PU selects SU (relay) with the nearest possible SUs with max $_{SNR}$-based path selection. i.e $\boldsymbol{\gamma}_{PU\text{-}SU} > \boldsymbol{\gamma}_{Th}$
6. PUs increase their utility by choosing the most suitable SU for relaying.
7. SU gets paired with the PUs, which approach first.
8. In each sensing round, SUs may get accepted or rejected by PUs due to channel impairments.
9. Each PU will get mapped with the SUs based on their sum rate estimated SNR level. SUs get mapped only when the PUs are in the preference list, or else it rejects the mapping.
10. SU (relay) with a target sum rate with optimal power can be achieved.

GAP Algorithm

Step 1: Start
Step 2: All nodes share CSI and spectral information
Step 3: SU requires PU to allocate spectrum
Step 4: Check $SINR_{PU}$=PU Utility
Step 5: If PU Utility=MAX
PU co-operates SU
Else
PU rejects SU
Step 6: SU search for another PU
End

3.3. Interference Model and SINR Problem Description

A multiuser network can accommodate more users, but the problem is spectrum scarcity. Herein radio frequency can be reused but with co-channel interference. In spectrum sharing SU access PU's radio frequency spectrum simultaneously causes interference to PU. SINR of PU should not degrade until a certain limit. Hence, the QoS of PU is obtained by changing the transmit power of SUs.
When channel impairments occur (path loss, shadowing and fading effects), the proposed method of best stable relay assignment provides more capacities for multi users. The flow chart is shown in Figure 4.

$$(SINR_{PU})_i=\left(\frac{P_m G_{n,m}}{\sum_{n=1,n\neq m}^{l} P_n G_{n,m}+\sum_{j=1}^{k} P_j G_{j,m}+\sigma^2}\right) \quad (6)$$

$$(SINR_{PU})_i=\left(\frac{P_m G_{n,m}}{\mathrm{I}_l^C+\sigma^2}\right) \quad (7)$$

Where $(SINR_{PU})_i$ is instantaneous SINR of PU with l PUs and k SUs. P_m is broadcast power of mth PU. $\sum_{n=1,n\neq m}^{l} P_n G_{n,m}$ be interference by other PUs except mth PU, $\sum_{j=1}^{k} P_j G_{j,m}$ is interference by k SUs and σ^2 is noise power.

The SU's transmit power directly impacts the data rate, SINR and the interference imposed on PUs. The total interference to the PUs on channel c is related by.

$$\mathrm{I}_l^C \leq \mathrm{I}_{\max} \quad (8)$$

$\mathrm{I}_{\max}$ is the maximum acceptable interference predefined threshold on PUs.

4. Simulation Results

MATLAB software is used to analyze the proposed methodology. The NOMA-HCRN with (SU) Co-operative Partner Relay Selection (CPRS) accessing scheme is used in the simulation, ensuring Guaranteed Access Priority(GAP), having K small cells with numerous secondary users (SUs) to be found at random all through the macro cells by way of licensed users (PUs).

With an overall central station broadcast power of 40W, the coverage region is 500 meters, respectively. The system bandwidth, in this case, is 4 Mega Hz among 40 unlicensed users (SUs) in the system. Table 1 shows the simulation values. The method considered multiple secondary users; sensing of information signal by an SU is not very effective in a multi-user environment.

A multiuser network can accommodate 60 users, but the problem is spectrum scarcity. Here in, a radio frequency of 4MHz can be reused but with co-channel interference. In spectrum sharing SU access PU's radio frequency spectrum simultaneously causes interference to PU. SINR of PU should not degrade until a certain limit. Hence, the QoS of PU is obtained by changing the 30dBm transmit power of SUs.

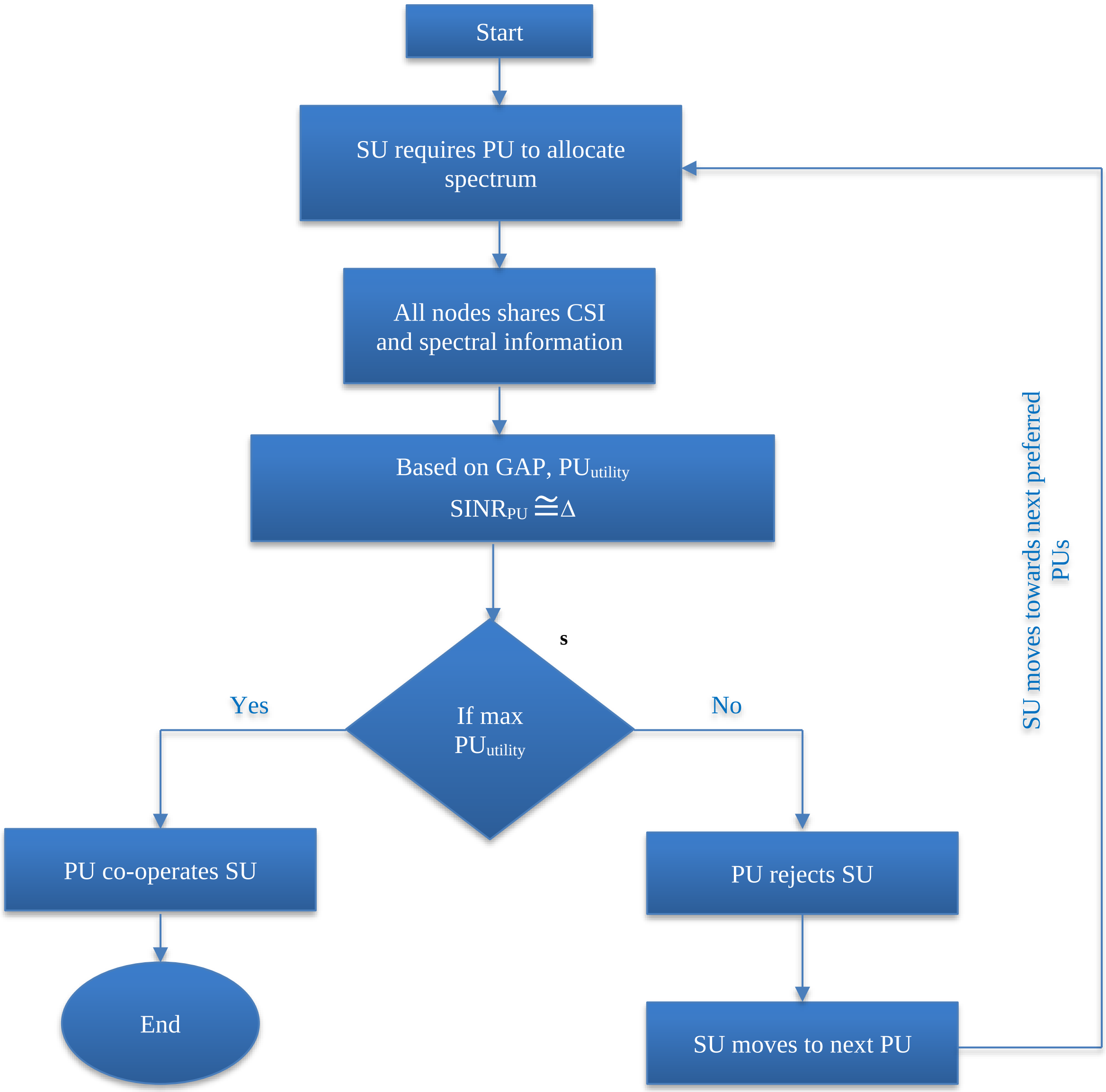

Fig. 4 Proposed algorithm's flow chart

Table 1. Simulation values

Simulation Parameters and values	
SecondaryUsers (SUs)	40
Primary Users(PUs)	20
Bandwidth(w)	4MHz
P_S^{max}	30 dBm
Multiplexing mode	NOMA
γ_{SNR}	3dB
Network region	500m
Total users	40
Channel propagation model	Rayleigh fading channel
Noise power	-174 dBm per Hz

In Figure 5, the Signal Detection Probability of the licensed Primary users (PU) is compared between the proposed approach of co-operative secondary users-spectrum Sensing with the individual secondary user-spectrum sensing with the transmit signal power SNR(dB). By using the basic energy detection method, the energy statistics of the incoming information signal are compared with the dynamic threshold to ensure good signal strength with the PUs. The method considered multiple secondary users; sensing of information signal by an SU is not very effective in a multi-user environment. Hence, the co-operation between the SUs is maintained to detect the PU presence in the spectrum sensing method. It is ensured that the co-operative Secondary users-spectrum Sensing attains a good probability of detection compared with the individual secondary user spectrum sensing.

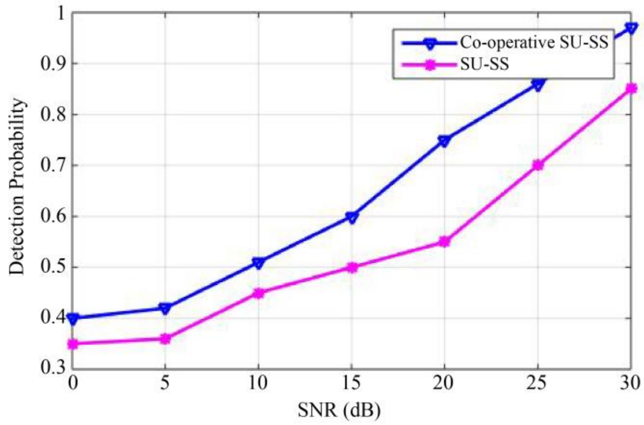

Fig. 5 Signal detection probability vs SNR

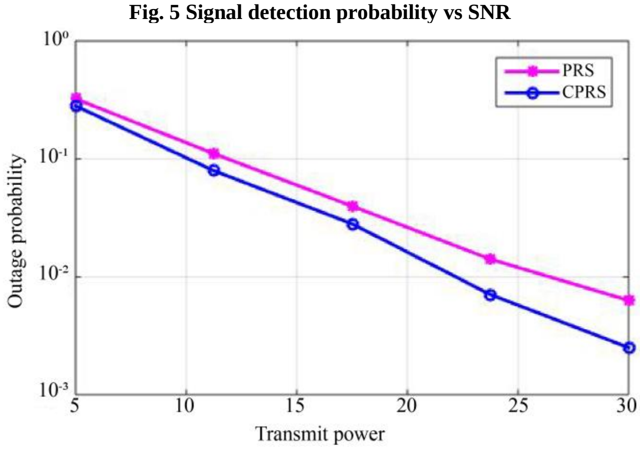

Fig. 6 Outage probability (OP) vs transmit power(dBm)

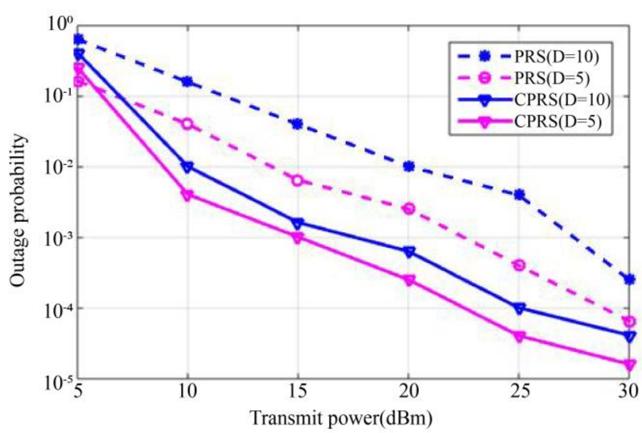

Fig. 7 Outage probability (OP) analysis vs Transmit power

Figure 6 shows the comparison of PRS and CPRS's Outage Probability (OP) with transmission power for the proposed approach and partial approach. It is an important performance metric to determine whether the system is in an outage condition. OP metric is used in the relay selection method for retransmitting the information signal from the primary source to the secondary destination. OP performs better at the increasing transmit power SNR. The system is reported to be outage if the prospect of instantaneous SNR ($\boldsymbol{\gamma}$) expected drops below a pre-defined threshold. From the above performance metric, it is ensured that the proposed Co-operative Partner Relay Selection (CPRS) for multi-user resource allocation in a NOMA-HCRN obtains better outage probability than the conventional Partial Selection Method (PRS).

Figure 7 shows the comparison of the Outage Probability (OP) of CPRS and PRS vs transmission power, which is employed in turn to compare the proposed Co-operative Partner Relay Selection (CPRS) and the conventional (PRS) with locations of the (secondary users) relay around the secondary base station. It is ensured that the proposed CPRS with the nearest and farthest distance attains less OP compared with the partial selection approach with the nearest and farthest distance.

The geographical location of PU, and SUs assigns transmission power with respect to base stations. Power is increased if they are in impairments to achieve good SNR, on contrast low power to nearer one to save resources.

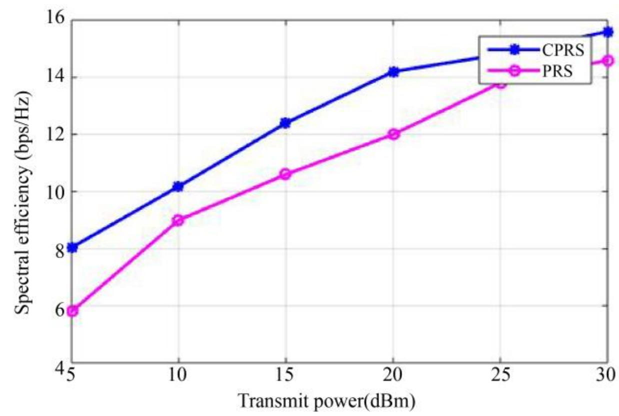

Fig. 8 Spectral efficiency vs transmit power

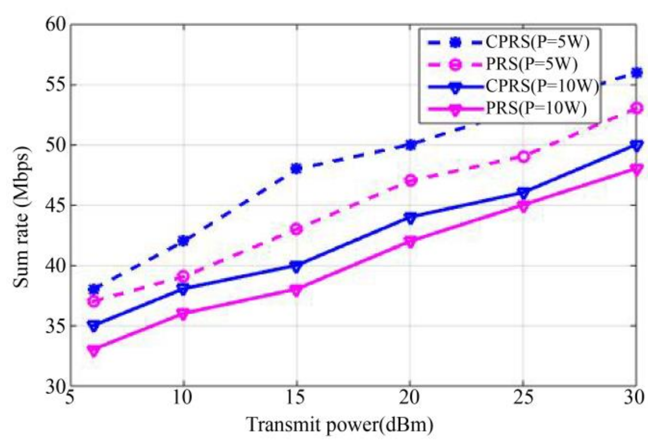

Fig. 9 Sum rate vs Transmit power

In Figure 8, Spectral efficiency vs transmit power is compared for the proposed Co-operative Partner Relay Selection (CPRS) with partial approach(PRS), and it is noted that the proposed CPRS achieves better Spectral efficiency of

15.9 bits/s/Hz for the near SU relay compared with the existing partial approach(PRS) with 14.1 bits/s/Hz. User fairness is achieved by allocating lower power to a strong user with a good channel condition than a weak user.

Figure 9 shows the system's sum rate variation with transmit power allocation and is compared for the proposed CPRS and existing PRS by setting the transmission power of primary users as 5W and 10W. The system sum rate increases with an incrementing power allocation. However sum rate is more for less transmit power of 5w. CPRS achieves a better sum rate of 56.9 Mbps for less transmit power of 5w than the existing method.

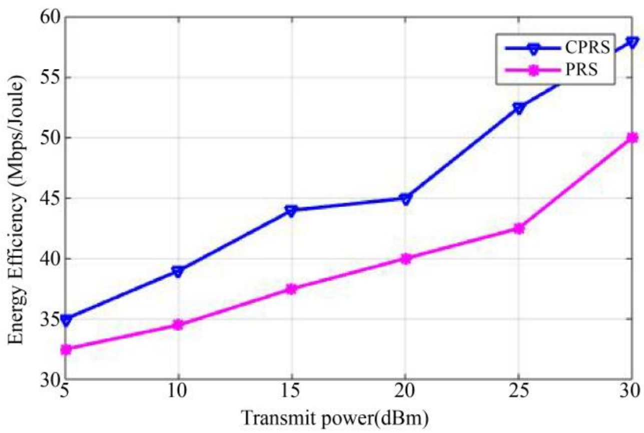

Fig. 10 Energy efficiency vs Transmit power

Figure 10 ensures that the energy efficiency for the proposed method of co-operative partner relay selection approaches a good efficiency compared with the existing partial selection approach with the (P_S^{max}) maximum transmit power of 30 dBm. Here the CPRS approach achieves 27.3 Mbps/joule efficiency than the existing with 20.2 Mbps/joule. From the proposed method it is noted that energy utilization is reduced with better throughput and improved SINR than the previous methods. Hence, the proposed CPRS (Co-operative Partner Relay Selection) for resource allocation is an apposite method for next-generation wireless communications to enhance the performance of the network.

Table 2. Comparative analysis of the results

Metrics	CPRS	PRS
Outage probability	0.005	0.009
Sum Rate (Mbps)	56.9 Mbps	51.2 Mbps
Energy Efficiency(Mbps/Joule)	27.3 Mbps/joule	20.2 Mbps/joule
Spectral Efficiency(bps/Hz)	15.9 bits/s/Hz	14.1bits/s/Hz

5. Conclusion

A novel spectrum allocation strategy for (NOMA-Co-operative HCRN) with co-operative partner relay selection (CPRS) with Guaranteed Access Priority (GAP) was presented. With primary and secondary users' QoS and power transmission constraints, performance analyses like outage probability, energy efficiencies, and transmission rates were assessed. This advanced technique of Co-Operative Partner Relay Selection (CPRS) provides maximization in the sum rate gain, obtains superior energy efficiencies in comparison with the existing partial selection, and provides minimum outage probability and maximum diversity gain.

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