ISSN (e): 2250 – 3005 || Volume, 08 || Issue, 11|| November – 2018 ||
International Journal of Computational Engineering Research (IJCER)

Optimal Power Allocation Strategy for Maximizing the Transmission Power of Cognitive Relay Nodes with S-AF Scheme

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ABSTRACT
In this paper, the power allocation strategies of the wireless system is studied to minimize the outage probability subject to total and individual power constraints for cognitive relay nodes and subject to interference constraints for primary user nodes. The proposed system uses a two-step distributed relay-secondary user selection scheme. Specifically, a relay terminal Rp is first selected from a relay candidate set $\mathcal{M}1$ to assist the primary system in achieving a primary request target rate by serving as a DF relay. When the selection for Rp succeed, a secondary transmitter Rs which minimizes the secondary outage probability, is selected from a secondary transmitter candidate set$\mathcal{M}2$ to access the spectrum band along with Rp, with a constraint that its transmission does not degrade the outage performance of the primary system. On the other hand, if the selection for Rp fails, a secondary transmitter Rs' which minimizes the secondary outage probability is selected from $\mathcal{M}2$ to access the spectrum band while the primary system remains silent. The simulation results indicate that the AF with OPA and S-AF with OPA have significantly better outage behaviour and average throughput than AF and S-AF schemes respectively. The results shows that S-AF with OPA achieves a higher throughput, and hence lower outage probability than AF with OPA.
KEYWORDS: Optimal power allocation(OPA),Amplify and forward(AF),Selection AF(S-AF),Cognitive relays, Outage probability

Date of Submission: 15-12-2018 Date of acceptance: 31-12-2018

I. INTRODUCTION

The Cognitive Radio (CR), a key technology for future wireless communication is capable of sensing and adapting to environments. The CR is an intelligent radio that can be programmed and configured dynamically. The dramatic growth of wireless application and steadily increasing demands for higher quality of service have led to a perceived dearth of available radio bandwidth, which necessitates the search for more efficient utilization of spectrum resources. In this paradigm the wireless nodes can sense the spectrum adapt the transmission/reception to the available spectrum, and dynamically share the spectrum with other applications. Cognitive Radio Networks (CRN) is encouraged by the apparent lack of spectrum under the current spectrum management functionalities. In order to address the critical problem of a spectrum scarcity FCC (*Federal Communications Commission*) has recently approved the use of unlicensed devices in licensed bands (Akyildiz F etal, 2014). The emergence of cognitive and software defined radio concepts, multiple antenna and multi carrier techniques as well as Ultra Wide Band (UWB) technologies and mesh network topologies provide a technology panacea that proponents of this approach used to support their arguments. CR network however, impose unique challenges due to the high fluctuation in the available spectrum as well as diverse quality of service (QoS) requirement (S.Lee,R.Zhang (2016)). CR technology is entirely built using Multihop ad hoc architecture which is shown in Figure 1.1

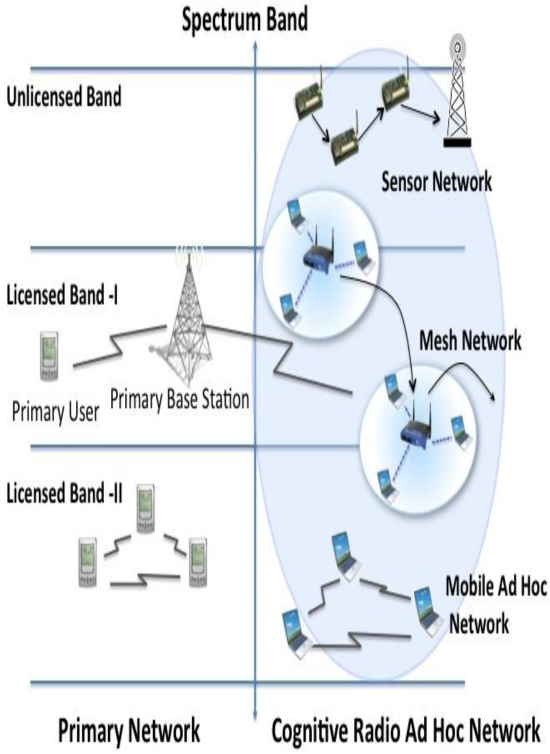

Figure: 1.1 Cognitive Radio Ad-Hoc Network

A CR user can communicate with other CR users through Ah-Hoc connection on both licensed and unlicensed spectrum bands. Specifically, in CRAHNs the distributed multi-hop architecture, the dynamic network topology, and the time and location varying spectrum availability are some of the key distinguising factors. These challenges necessitate novel design techniques that simultaneously address a wide range of communication problems spanning several layers of the protocol stack. Cognitive Radio technology is the future technology that enables a CRAHN to use spectrum in a dynamic manner which is shown in Figure 1.2. It can adjust its transmission parameters to opportunistically access available spectrum bands without interfering with primary users (PUs). In general, secondary user (CR user) can access the spectrum bands that are not used by Pus. The ultimate objective of the cognitive radio is to obtain the best available spectrum through cognitive capability and re-configurability as described before.

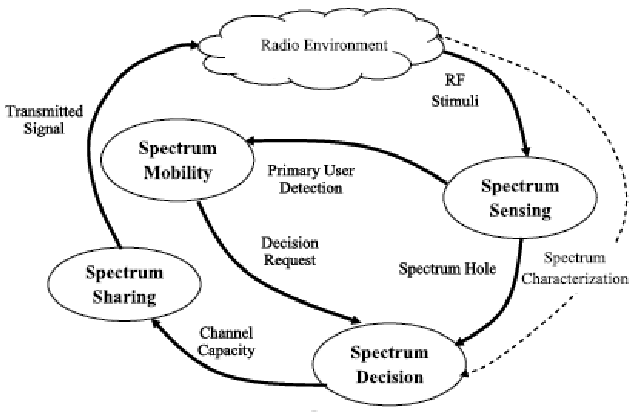

Figure: 1.2 Cognitive Radio Cycle

II. PROPOSED SYSTEM

The two previous strategies focus on the power consumption and transmit rate independently. However, the power consumption and transmit rate are correlated, i.e., the larger the transmit power is, the larger the throughput it obtains, but it also increases the interference to other users, therefore, decreasing the throughput of the other users. As a result, the other users would require you to low the transmit power, or improve their transmit power to guarantee the QoS. Specifically, we should consider the transmit power and transmit rate jointly to make system much more energy efficient. Therefore, the strategy 3 to the following optimization problem is formulated as the AODV (Adhoc On-Demand Distance Vector) protocol is designed by considering a general scenario where i) the primary system is a dual hop selective relaying network and (ii) nodes in the secondary system may either act as relays in the primary system or serve as secondary access transmitters as shown in Figure.2.1

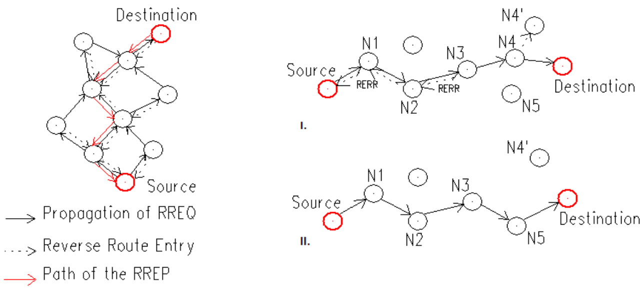

Figure 2.1 AODV routing method

The selective relaying primary system, comprising of a primary transmitter (PT) and primary receiver (PR) as well as M relays Ri,iE{1, 2. . ..M}. One primary transmission from PT to PR is accomplished over two transmission phases via a best relay RP-relay assistance which is been selected from the M candidates. The secondary system is a multiuser system whereby N transmitters Ri, i E {M+1, M+2. . . M+N} attempting to communicate in an orthogonal fashion in a time with a common receiver SR on a secondary basis in this spectrum band, with the constraint that its operation does not affect the primary system performance. The secondary system corresponds to a standard multiple access scenarios. In this proposal the secondary system is able to take advantage of the failures of the primary relay selection and access the spectrum without any interference constraint. In this proposal a distributed relay-secondary user selection scheme is used, which optimizes the performance for the secondary system, without degrading the performance of the primary system. The relay-secondary user selection consists of two steps. In the first step, one relay Rp, P ∈ M1 is selected to assist (relay) the primary transmission in achieving a request target rate (if possible). When the selection of Rp succeeds, due to relay assistance from Rp, the primary system is then robust against interference lower than a certain threshold in the relaying phase, without compromising its outage performance. Accordingly, a secondary transmitter Rs, s∈ M2 is then selected to access the spectrum simultaneously with R□ in the relaying phase (if possible). Note that Rs has to comply with an interference constraint to ensure that the outage performance of the primary system is not degraded as compared to the case where there is no secondary spectrum access. Under this interference constraint, Rs is selected such that the outage performance for the secondary system is optimized.

III. COOPERATIVE COMMUNICATION

The proposed technique deals with cooperative wireless communication which is concerned with a wireless network, of the cellular or ad hoc variety. The wireless agents are called as call users which are used to increase the effective quality of service (measured at the physical layer by bit error rates, block error rates, or outage probability) via cooperation. This method is perhaps closest to the idea of a traditional relay. In this method a user attempts to detect the partner's bits and then retransmits the detected bits. The partners may be assigned mutually by the base station, or via some other technique. For the purposes of this tutorial, consider two users partnering with each other, but in reality the only important factor is that each user has a partner that provides a second (diversity) data path. The easiest way to visualize this is via pairs, but it is also possible to achieve the same effect via other partnership topologies that remove the strict constraint of pairing. Partner assignment is a rich topic whose details are beyond the scope of this paper.

3.1 DECODE AND FORWARD COOPERATIVE RELAYING PROTOCOL

In this scheme, two users are paired to cooperate with each other. Each user has its own spreading code, denoted c_1 (t) and c_2 (t). The two user's data bits are denoted bi (n) where i=1, 2 are the user indices and n denotes the time index of information bits. Factors $a_{i,\,j}$ denote signal amplitudes, and hence represent power allocation to various parts of the signaling. Each signaling period consists of three bit intervals. Denoting the signal of user1 $X_1(t)$ and the signal of user 2 $X_2(t)$,

$$X1(t) = [a_{11}b_1\,(1)\,c_1\,(t), a_{12}b_1\,(2)\,c_1\,(t), a_{13}b_1\,(2)\,c_1\,(t) + a_{14}b_2\,(2)\,c_2\,(t)] \qquad (4.1)$$

$$X_2(t) = [a_{21}b_2\,(1)\,c_2\,(t), a_{22}b_2\,(2)\,c_2\,(t)\; a_{23}\,\hat{b}_1\,(2)\,c_1\,(t) + a_{24}b_2\,(2)\,c_2\,(t)] \qquad (4.2)$$

In other words, in the first and second intervals, each user transmits its own bits. Each user then detects the other user's second bit (each user's estimate of the other's bit is denoted $\widehat{b}(i)$. In the third interval, both users transmit a linear combination of their own second bit and the partner's second bit, each multiplied by the appropriate spreading code. The transmit powers for the first, second, and third intervals are variable, and by optimizing the relative transmit powers according to the conditions of the uplink and inter-user channels, this method provides adaptability to channel conditions as shown in Figure.3.1

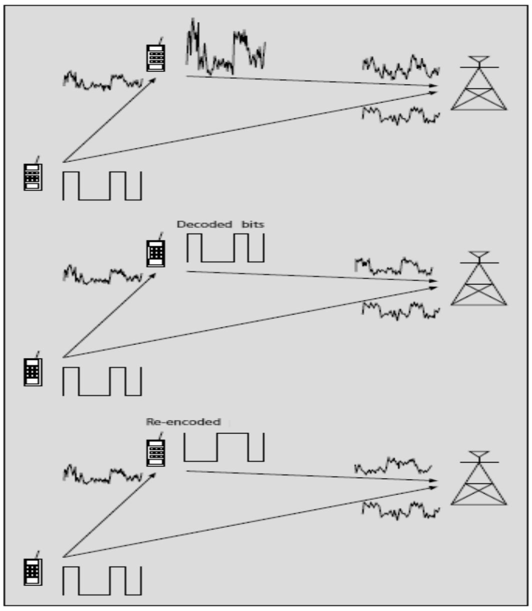

Figure 3.1 Decode and Forward Relay

Firstly summarize two previous power allocation strategies in the cognitive relay networks. The first previous strategy focused on minimizing the transmitting power consumption; the second previous strategy focused on maximizing the transmit rate. Followed we propose a novel strategy jointly considering the power consumption and transmit rate, and focus on the energy-efficient power allocation because of limited battery power. Unlike to the two previous strategies, the proposed power allocation scheme is nonlinear, and cannot be solved in the same way to the previous strategies. As a result, we select the Lagrange dual method to solve it effectively.
As the architecture of the cognition cycle is modified according to the proposed scheme. Compared to the traditional cognition cycle, the sensing part is moved outside of the traditional cognition cycle. Spectrum sensing is the responsibility of the dedicated WSSN network. The dedicated WSSN network will decide the spectrum band, the channel bandwidth, the maximum data rate, and the maximum allowable transmission power. Further, if the PU starts transmission on the specified spectrum, the FC can stop the SUs transmission. In other words, cognitive terminal complexity has been lowered by eliminating the sensing portion from the SUs architecture. Spectrum Mobility. Spectrum mobility refers to the spectrum change made by a cognitive user when a PU starts data transmission on its licensed band. The purpose of spectrum mobility is to guarantee smooth and fast channel changeover, resulting in minimum performance degradation.
The important prerequisite of spectrum mobility is information regarding the available spectral holes and the time duration required for smooth channel transitions. The availability of the spectrum ensures in-time and fast transitions in spectrum mobility.(Zheng BaYu,(2015)) show through Markov chain analysis that the channel reservation and spectrum handoff significantly increase the throughput of cognitive users. In a performance evaluation, they present that the channel reservation reduces the force termination probability with a small increase in the blocking probability. In the proposed WSSN-assisted CRN system, the FC provides SUs with the backup reserved spectrum information based on its IT measurements. Thus, having the spectrum information, ongoing communication can be well-preserved with minimum performance degradation and enhanced throughput
The optimum number of reserved channels and system modeling based on the Markov chain are beyond the scope of this work. Hidden and Exposed Terminal Problems. Consider the case, in which the PU transmitter transmits data to the PU receiver. If the SU is equipped with sensing capability, it is still unable to detect the PU transmitter, due to the hidden terminal problem. In the proposed scheme, the SU will request the FC of the WSSN network for the spectrum. The sensing network consists of several nodes that continuously sense the spectrum and update the FC accordingly. If there is a PU transmitter, the FC is aware of its existence, even in

the situation in which the SU cannot sense the PU. Hence, by deploying WSSN nodes, the hidden terminal problem is solved without any additional sensing arrangement. On the other hand, the exposed terminal problem is considered a missed opportunity and is defined as the situation in which the spectrum is available but is mistakenly sensed as being occupied by the PU. Consider the scenario, in which the PU transmitter is transmitting data to the PU receiver. Here, the PU transmitter is near to the SU transmitter, while PU receiver is far away from the SU transmitter.

IV. SIMULATION

The 4-hop propagation delay describes the time elapsed between transmitting a TCP packet by the TCP source node and receiving the packet at the node which lies 4 hops apart from the source node along the path to the destination. The novel TCP variant is denoted as *TCP with* Adaptive Pacing (TCP-AP). Opposed to previous proposals for improving TCP over multihop IEEE 802.11 networks, TCP-AP retains the end-to-end semantics of TCP and does neither rely on modifications on the routing or the link layer nor requires cross-layer information from intermediate nodes along the path. TCP-AP achieves up to 84% more throughput than TCP New Reno, provides excellent fairness in almost all scenarios, and is highly responsive to changing network traffic conditions. In particular, TCP-AP provides fair sharing of the available bandwidth, even when competing flows are not within each other's transmission range, but within each other's interference range, since the proposed algorithm relies on the end-to-end measurement of the interference experienced by a TCP connection the hidden terminal problem in wireless multihop networks and experimentally showed that for a chain topology the optimal windows size, for which TCP achieves best throughput, is roughly given by 1/4 of the hop count of the path.
Adaptive pacing to distribute traffic on the link layer among intermediate nodes in a more balanced way and link layer RED to throttle TCP senders when incipient congestion is detected. Using simulation, they showed that depending on the scenario, these link layer enhancements improve TCP good put by 5% to 30% due to better spatial reuse. Nodes forming a neighborhood manage a virtual distributed queue in order to coordinate the packet drops of individual nodes. Using simulation, the authors showed that NRED could substantially improve fairness in multihop wireless networks. TCP-AP just requires slight modifications on the transport layer and does neither require modifications on the routing layer as and link layer as nor extra communication between neighboring nodes. As a consequence, TCP-AP can be incrementally deployed. Furthermore, TCP-AP integrally improves both fairness and good put without provoking packet losses. We introduced two new special-purpose transport protocols for multihop wireless networks.

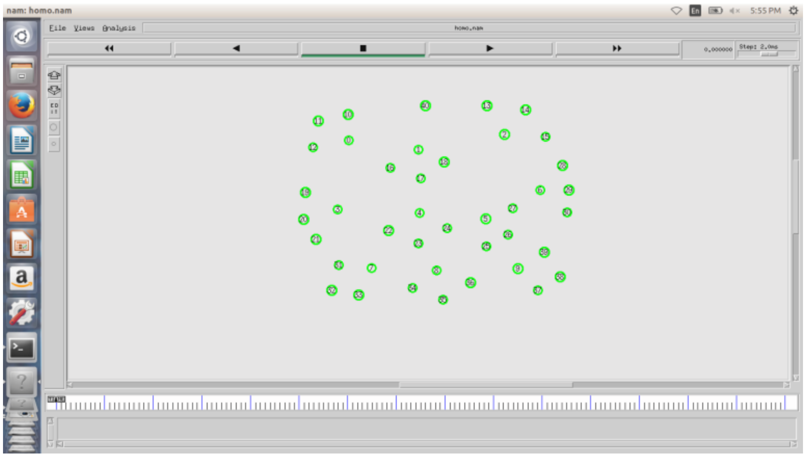

Figure 4.1 Creating of Node in a Network Simulator Environment

The proposed technique deals with cooperative wireless communication which is concerned with a wireless network, of the cellular or ad hoc variety. The wireless agents are called as call users which are used to increase the effective quality of service (measured at the physical layer by bit error rates, block error rates, or outage probability) via cooperation.

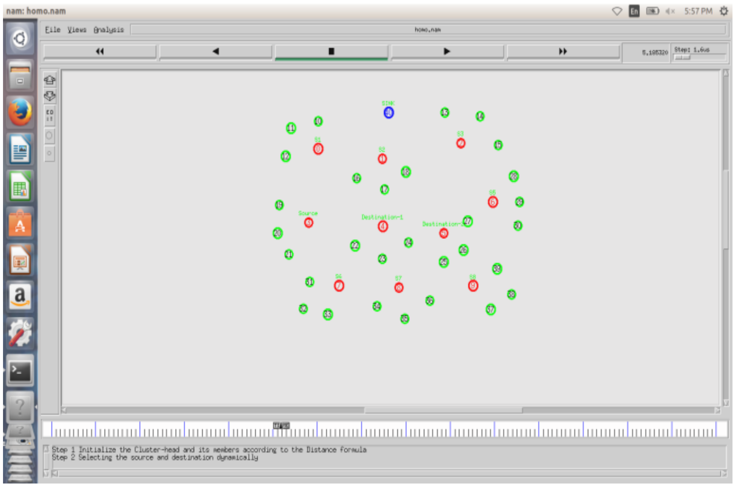

Figure 4.2 Indicating nodes, sink, source, destination1 and destination2

4.1 PACKET DELIVERY RATIO

The Packet Delivery Ratio is defined as the number of packets sent by the transmitter to the number of packets received For an ideal network it should be 1, but it is not possible practically. In our simulation it is 0.993 is the highest value at the minimum number of nodes and if the number of nodes increases the packet delivery is reducing which is shown in Figure 4.3.

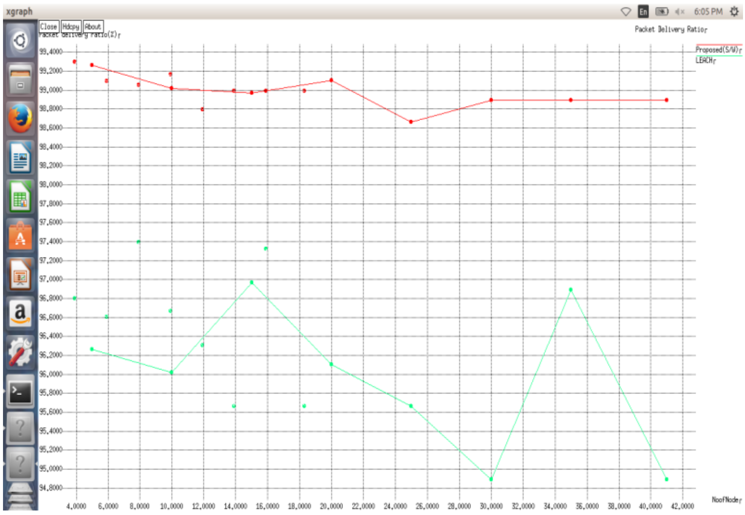

Figure 4.3 Packet Delivery Ratio at CR node

4.2 OUTAGE PROBABILITY

Outage probability is defined as the probability that information rate is less than the required threshold information rate. It is the probability that an outage will occur within a specified time period. Calculation of the outage probability for the proposed system with increasing the number nodes is simulated and it is given in Figure 4.4. Due to this the total coverage of a system also increases. By the number of secondary transmitters the outage performance also changes.

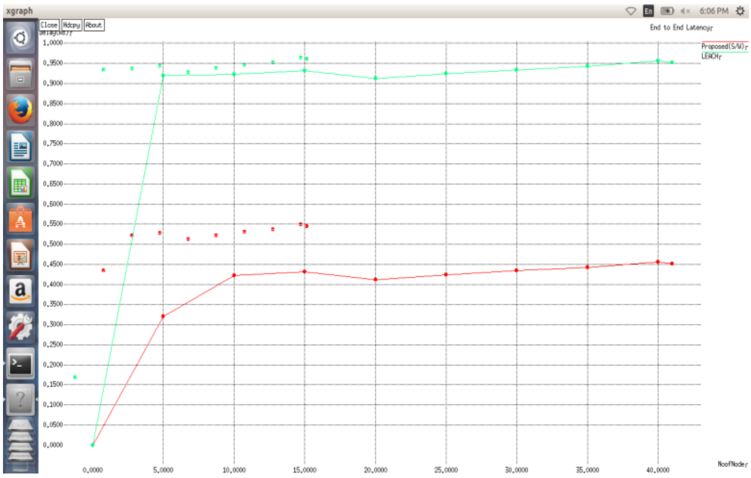

Figure 4.4 Outage Probability with Decreasing Packet Drop

4.3 THROUGHPUT

Throughput is the rate of successful message delivery over a communication channel. The Throughput of the proposed system is calculated with the increasing number of nodes. Our proposed system gives better throughput which is doubled when compared to the existing methodology and the simulated result is shown in Figure 4.5.

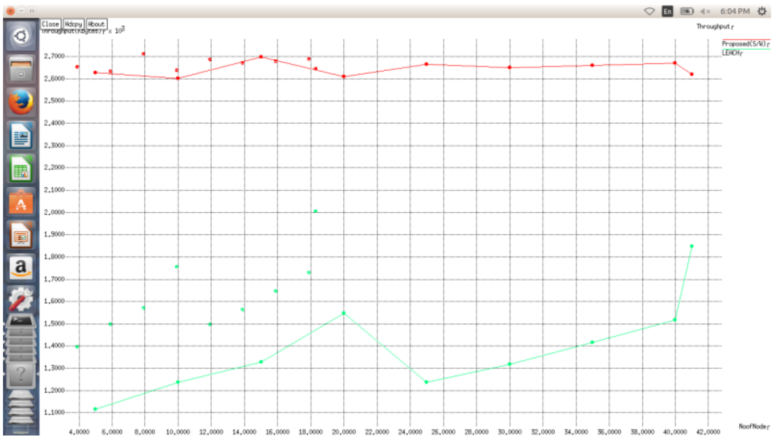

Figure 4.5 Throughput with Increasing Number of Nodes

V. CONCLUSIONS

Cooperative spectrum sharing protocol with a selective relaying primary system considered in this paper. The proposed system uses a two-step distributed relay-secondary user selection scheme. Specifically, a relay terminal Rp is first selected from a relay candidate set $\mathcal{M}1$ to assist the primary system in achieving a primary request target rate by serving as a DF relay. When the selection for Rp succeed, a secondary transmitter Rs which minimizes the secondary outage probability, is selected from a secondary transmitter candidate set$\mathcal{M}2$ to access the spectrum band along with Rp, with a constraint that its transmission does not degrade the outage performance of the primary system. On the other hand, if the selection for Rp fails, a secondary transmitter Rs' which minimizes the secondary outage probability is selected from $\mathcal{M}2$ to access the spectrum band while the primary system remains silent. In this work derivation of closed-form expressions for the outage probability of both the primary and secondary systems are shown that by adjusting Q, i.e. the number of secondary transmitters which are designated for assisting the primary system, the secondary system is able to access the spectrum band while maintaining or improving the outage performance of the primary system by a certain desired margin. Result shows that the outage performance for both the primary and secondary systems improves as the number of secondary transmitter's N increases.

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M.Poonguzhali" Optimal Power Allocation Strategy for Maximizing the Transmission Power of Cognitive Relay Nodes with S-AF Scheme. "International Journal of Computational Engineering Research (IJCER), vol. 08, no. 11, 2018, pp 12-19.