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PERFORMANCE ANALYSIS OF UNDERLAY SECONDARY NETWORKS USING BINARY SCHEDULING ALGORITHM

P.Caroline Priyanka Evelyne
PG Scholar, Communication Systems
Arunai College of Engineering,
Tiruvannamalai, Tamilnadu

V.Babu
Assistant Professor,Department of ECE
Arunai College of Engineering,
Tiruvannamalai, Tamilnadu

ABSTRACT

Cognitive radio is a technology which extent the concept to include the interaction with the environment and to address the spectrum scarcity. The underlay network makes use of the secondary users (SU) is defined by primary users (PU) and in order to meet the requirement by considering the different activity SU protocol to limit the SU's. The proposed frame work based on the scheduling algorithm such as the binary search algorithm (BSA) to find the position of the target value within a sorted array and the energy efficiency as the motivation of the paper to increase the higher speed, accuracy and the input performance that includes the moment generating function (MGF) of the guard zone, co-operation and the threshold protocol as a special case. Hence the average number of active SU's with the protocols subject to the BSA algorithm and the analysis of the CR networks with the utilization of the SU users to compare the effect on the SU users.

Keywords— *cognitive radio, cognitive network, spectrum management, aggregate interference, outage probability, BSA algorithm*

I. INTRODUCTION

Cognitive radio networks is a technology to address the spectrum scarcity and the inefficient spectrum [1]-[4]. Cognitive radio networks which allows the secondary users and access to the primary users. Depending on the spectrum access strategy, the network paradigms which defines the underlay network. The SU concurrently use the spectrum occupied by PU guarantees that PU is below the requirement which allows to communicate with each other [17]where there is tight interaction and the active cooperation of the PU's and the SU'S.

The SU's uses the signal processing to maintain the transmission which has additional bandwidth[20].

The main desire in the underlay networks is to investigate the interference between PU and SU. The main framework is to determine the aggregate interference[12] under Rayleigh fading channel. This is used widely in the cellular networks where the PU located inside the region of the network and the SU within the shaped region.

The aggregate interference and the outage influenced by the position where the generated SU is to satisfy the interference threshold and the simplest solution is to control the interference generated by the SU's is to employ the SU's activity protocols by considering the guard zone protocol, threshold protocol and the co-operation protocol.

Hence a general frame work for analyzing the performance of the SU protocols are defined by the major considerations for this paper. The utilization of the cooperation among SU's in the underlay networks and utilizes the local information exchange among SU's and includes the other protocols. Hence a approximate MGF of the aggregate interference from SU with the cooperation protocol and the other protocols is derived. In addition, a closed form result for the average number of SU is derived. To the extent the performance of the underlay with the SU's is defined and the average no of SU's subject to the outage constraint.

The system model and assumptions describes the different SU activity protocols. The analysis for the interference and the average number of SU's presented respectively. Numerical and simulation results to study the average number of a SU's, outage probability, Energy efficiency, transmit power, and the MGF are discussed[10]and conclusions are presented.

The following notation is used in this paper. The transmit power (P_T) and the aggregate values (I_{agg}) respectively.

II. SYSTEM MODEL

We consider underlay cognitive networks comprising of a PU transmitter and a receiver separated by a distance[6]-[10].The location of the PU-Tx(Transmitter) and Rx(Receiver) and can be located anywhere inside the network. The SU's decide whether to transmit or not depending on the activity protocol where the users have a single antenna and the wireless communication channel is defined as a loss and fading channel[13]-[14].

The SU's decide whether to transmit depending on the SU protocol and assume that the nodes operates in the frequency division duplex mode. Let the Ri(i=1,2,…m) is the random distance between the i-th SU and the PU-RX with the PDF. Let the Gi represents the instantaneous power gain and the interference at the PU-RX generated from the i-th SU given by

$$I_i = P_{T_i} G_i R_i^{-\alpha} 1(condition), \quad (1)$$

1(condition) =1, if condition is true; 0, else if condition is false

$$I_{agg} = \sum_{i=1}^{M} P_{T_i} G_i R_i^{-\alpha} 1(condition). \quad (2)$$

In the following subsections, we present the definition of each SU activity protocol.

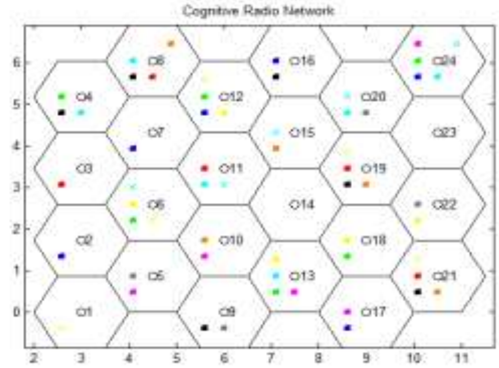


Fig.1.CR Network

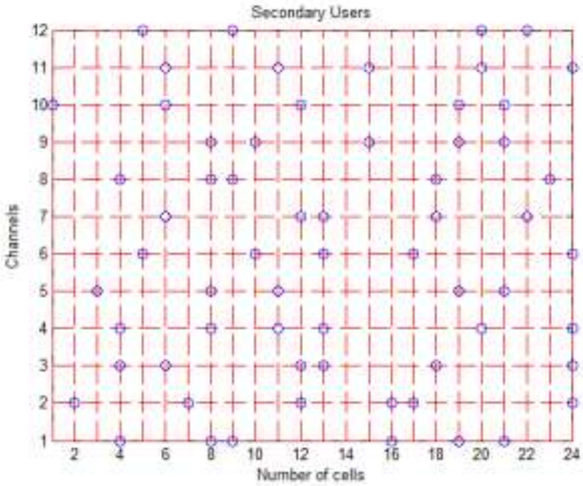


Fig.2.Utilization of the secondary users

A. Guard zone protocol

In this protocol, the SU's are inside the guard zone region where it is prohibited from transmitting. This is illustrated in Fig.3. Consequently, the two SUs that are inside this region are inactive and do not generate any interference and can be written as

$$Iagg=M\sum i=1 \quad (3)$$
$$PTiGiR-\alpha i1(Ri>rf)$$

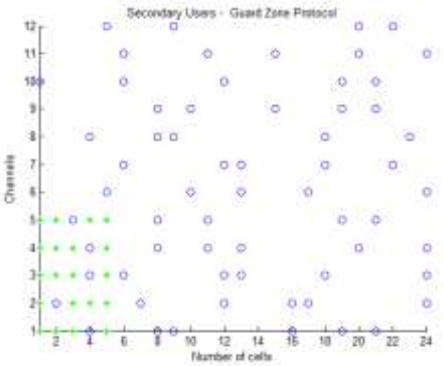


Fig.3.Guard Zone Protocol

B. Threshold-Based Protocol

In this protocol, the range varies accordingly as that the outage depends on the activation threshold and the zonal parameters where it is independent and can be written as

$$Iagg=M\sum i=1$$
(4)
$$PTiGiR-\alpha\ i\ 1(PTSHiR-\alpha\ i \leq \gamma).$$

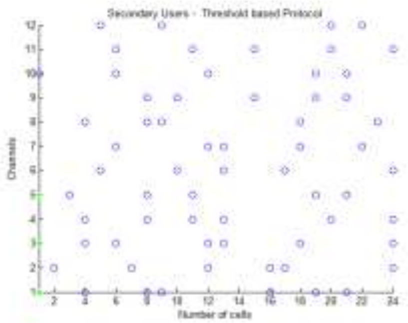


Fig.4. Threshold Protocol

C. Co-operation-based protocol

This is the new protocol proposed in this paper and the basic idea of this protocol is inspired from the cooperative spectrum sensing in interweave cognitive networks, where cooperation among nodes helps to improve the detection of licensed spectrum occupancy[3]. The notion of cooperation among SUs is also similar in spirit to base station cooperation in cellular networks broadcast to other SUs. For analytical convenience. we assume that, for each SU, it can only correctly receive the initial decisions from other SUs within a certain range, which is known as its cooperation range rc. Finally, in order to decide whether it is active or not, each SU applies the AND rule on the received initial decisions from other cooperating SUs and its own initial decision. Consequently, for a considered SU, it is permitted to be active as long as its preliminary decision is to be active, and the initial decision of all SUs which fall into this SU's cooperation range is also to be active [6]-[10]. Mathematically, the aggregate interference generated at the PU-Rx is

$$Iagg=M\sum i=1$$
(5)
$$PTiGiR-\alpha\ i\ 1(\Pi d(Di(rc)\times A)=/\ 0),$$

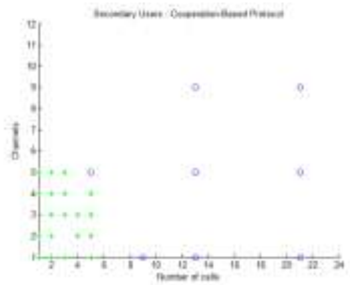


Fig.5.Cooperation Protocol

III. MATHEMATICAL FRAMEWORK

It to represent the outage and the other interference parameters in underlay cognitive networks with different SU activity protocols, fading channel gains. Since there is no available general expression for the PDF of the aggregate interference[7]. we adopt the moment generating function approach to analyze the interference and outage in this paper. Previous paper has also adopted the MGF approach but not to the specific protocols with scheduling. However, their focus is on analyzing the performance of the secondary users and the results are limited to specific. Alternatively, the guard zone protocol can also be implemented using cooperative localization techniques[9].

A. Moment Generating Function

It is defined by MIagg(s)=EIagg exp(−sIawhere E Iagg{·} denotes the expectation with respect to the RV Iagg. Assuming that the interference from each SU is independent and can be rewritten as [M Iagg(s)=(MI(s)) and MI(s)=EI{exp(−sI)}corresponds to the MGF of I where µI(n) can also be directly related to MI(s) by [32] µI(n)=(−1)n dn MI(s) ds n ls=0l.

B. Outage Probability

The outage probability is an important metric to evaluate the impact of SU activity protocols on the performance of the primary users over fading channels. It is given by Pout = Pr(SINR <β)=Pr PT0r−α 0 G0 N+Iagg <β, where β is the SINR threshold and N is the additive white Gaussian noise power. In this paper, we are interested in the spatially averaged outage probability where the fading on the desired link (from PU-Tx to PU-Rx) follows the general distribution.

IV. INTERFERENCE ANALYSIS

In this section, the general expressions characterizing the MGF in accordance to the protocols.

A.Guard Zone Protocol

It defines the located PU-Rx due to an independently and uniformly distributed SU

Corollary 1: For the guard zone protocol, the n-th moment of the interference is µI(n)=Pn TEG{Gn}Ecpt R {−nα,rf,rmax}.

Remark 1: In the full activity protocol, a SU located within the maximum range of ε and rmax generates interference to the PU-Rx. In the guard zone protocol, a SU located within the smaller range of rf and rmax generates interference to the PU-Rx.Thus, when the guard zone range rf is set to equal to ε, the guard zone protocol reduces to the full activity protocol.

Remark 2: When L→∞, Wp →W and the regular L-sided hexagon approaches a disk region. The full activity protocol is the most popular scenario and has been widely analyzed in previous works . Under the Nakagami-m fading assumption[15]-[16], the MGF calculated by setting rf = ε (i.e., full activity protocol) and Wp = W (i.e., the integration term reduces to zero) is identical to the result. In addition, the n-th cumulant calculated from(replacing rf by ε and Φ(Wp)=Φ(W)).

B.Threshold-Based Protocol

The instantaneous signal power received on the sensing channel is defined.

Remark 3: For the threshold-based protocol, assuming the sensing channel is fully uncorrelated with the SU and MI(∞) where FH(·) denotes the CDF of the fading power gain on sensing channel.

Remark 4: For the threshold-based protocol, the n-th moment of the interference at an arbitrarily located is

µI(n)=PnTEG{Gn} (6)

Remark 5: For the disk region, with L = ∞. However, the method of calculating the n-th cumulant is only applicable for the special case that PU-Rx is located at the center of the disk region.

C. Cooperation- Based Protocol

For the cooperation- based protocol, the activity of each SU is determined by itself as well as other SUs within its cooperative range. Thus, the interference due to each SU is not independent and is not strictly valid[6]-[7]. The analysis in the presence of correlated interference is an important open research problem

For the cooperation-based protocol, the MGF of the interference at an arbitrarily located PU-Rx due to an independently and uniformly distributed SU inside an arbitrarily shaped finite region is approximated by shown at the bottom of the page.

Remark 6: For the cooperation-based protocol, the n-th moment of the interference at an arbitrarily located PU-Rx due to an independently and uniformly distributed SU inside an arbitrarily-shaped finite.

V. AVERAGE NUMBER OF ACTIVE SECONDARY USERS

The aggregate interference at the PU-Rx and the resulting outage probability are metrics to evaluate the performance of the primary network, which was the common focus of most prior studies on cognitive networks[18]-[19]. Ideally, the performance of the secondary network should also be evaluated [12]. Furthermore, this should be done subject to a quality of-service (QoS) constraint that the SINR of each active SU is maintained higher than a desired level. One way to do this analytically is to determine the SU throughput which can be defined as the expected spatial density of successful SU transmission and depends on (i) the number of active SUs over a certain region and (ii) whether each active SU is in outage or not, i.e., whether its SINR is above a certain threshold. The exact SINR distribution of an active SU (and consequently the SU throughput) in an arbitrarily-shaped underlay cognitive network is difficult to obtain because of two main reasons. Firstly, for an arbitrarily-shaped region with a fixed number of nodes, the Binomial Point Process is non-stationary

μI(n)=PnT (7)
(mg +n−1)! mn g(mg−1)!
2π (2−nα)

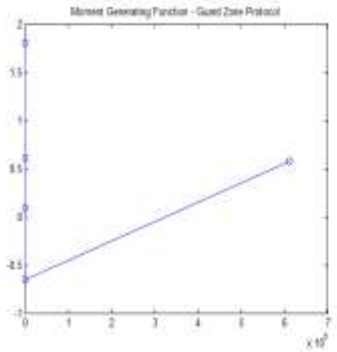
MI(s)≈ ∞ 0 rmax nd an active SU's SINR is, therefore, location-dependent. Thus, the SINR of an active SU at a certain location (say origin) does not reflect the SINR of other active SUs. The difficulty in analytically averaging the active SU's SINR over all possible locations in an arbitrarily-shaped region poses a significant challenge for analytical analysis. Secondly, with the consideration of the different SU activity protocols, only the active SUs generate interference to other SUs and PU-Rx. This means that when accounting for the interference to a SU-Rx (which is the desired receiver for a certain SU), the distance between an interfering SU and PU-Rx is correlated to the distance between this interfering SU and the SU-Rx. This distance correlation poses a second significant challenge for analytical analysis[5]. In this work, in order to evaluate the performance of the secondary network in underlay cognitive networks, we study the average number of active SUs. The average number of active SUs is an analytically tractable performance metric, which can indirectly measure the SU throughput under certain conditions. Each SU is sufficiently close to its desired receiver, it is possible that almost every active SU can transmit successfully. Under such conditions, the average number of active SUs plays the dominant role in determining the aggregate through the average number of active SUs which is dependent on the SU activity protocol, is obtained and substituting n=0. For the protocols considered in this work, the value of μI(0) can be easily computed respectively.

Remark 7 : Intuitively, there is tradeoff between the primary network performance (i.e., in terms of the outage probability in the primary network) and the secondary network performance (i.e., in terms of the average number of active SUs) [4].For example, increasing rf in the guard zone protocol or decreasing the activation threshold γ in threshold-based and cooperation based protocols can reduce the outage probability. However, this would decrease the number of active secondary users, which means the licensed spectrum is not efficiently reused. In this context, provides an analytical means for evaluating this tradeoff in the performance of both the primary and secondary networks.

VI. NUMERICAL AND SIMULATION RESULTS

In this section, we present numerical results to investigate and compare the performance of the SU activity protocols. In order to validate the numerical results, we also present simulation results which are generated using MATLAB and are averaged over 1 million simulation runs. For the simulation results, we use the following procedure to uniformly distribute the SUs inside an arbitrarily-shaped region : (a) Generate a bounding box which is generally the minimal rectangle that can entirely enclose the hexagonal shape, (b) Randomly and uniformly generate a point in this bounding box,(c)Check whether this point is inside the required hexagon , (d) Repeat steps (b) and (c) until the required number of nodes are obtained. Hence, here the performance of the SU users with the different protocols is considered.

Binary sequential algorithm is used to find the position of the target value within a sorted array and to increase the transmit power. From the simulation results we conclude that the outage and the interference increases with the transmit power with the increase in the SU antennas. The result obtained shows that the increased and improved performance in the SU protocols when the BSA is used as a scheduling protocol. The aggregate values with the different SU protocols is plotted.



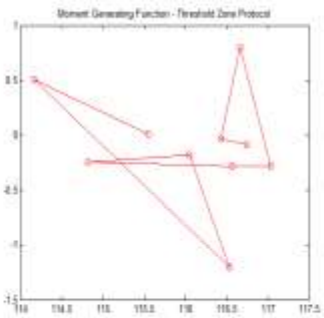


Fig.6. MGF of Guard Zone Protocol Fig.7.MGF of Threshold Based Protocol

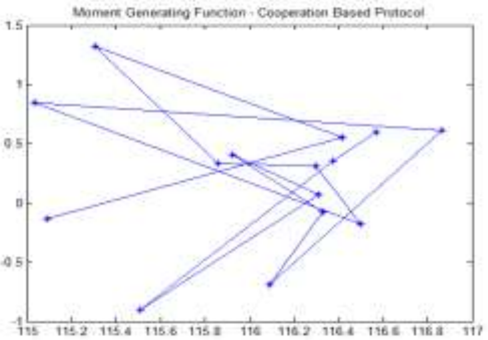


Fig.8. MGF of Cooperation Based Protocol

The Fig (6),(7),(8) represents the Transmit power and the instantaneous power along the X axis and the Y axis.

VII. CONCLUSION & FUTURE WORK

In this paper, the maximized secondary users enabled cognitive network by using Binary Sequential Algorithm. Further, the interference between the primary and secondary user is eliminated. This is different from the existing technology, which requires the coordination between the primary and secondary user. Since a primary user is a licensed one there is no interference is created in primary user, traditional approaches based SU protocols can be used to increase the performance analysis of the different required parameters or Sequential Search algorithm was proposed for the higher transmit power of the Cognitive link in the future with the QOS constraint and the higher consumption of energy will be attained. However we propose the increased energy efficiency and sum rate maximization in a Cognitive network, these results can also be applied to practical systems like Cognitive radio, small cell deployment in macro network etc.. In future, we can extend in such a way that secondary user can also transmit without monitoring the primary link and also utilized by limiting the secondary active users with the higher performance of the scheduling algorithms.

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