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Sequential Interference-Aware Admission Control in Underlay Cognitive Radio Networks

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Abstract—**In this paper, a new joint admission and power control scheme is introduced for wireless cognitive radio networks. It is assumed that the Cognitive Users (CUs) arrive sequentially in time and exploit the spectrum simultaneous to the licensed primary users. The objective is to minimize the blocking probability of the new arriving CUs while the interference limit constraint of primary users is not violated and the quality of service (QoS) requirements of the current admitted CUs is satisfied. To these aims, an algorithm is developed for CUs admission in which the power of the new arriving CU gradually increases according to two predefined parameters, Primary Interference Margin (PIM) and Secondary Interference Margin (SIM). In addition to protect the QoS of the current CUs, their powers are boosted by a particular parameter, which is calculated based on PIM and their maximum allowable power. Moreover, the PIM guarantees the protection of the primary users during the admission phase of the new arriving CU. Two admission control algorithms have been proposed, a safe admission which tightly admits a new CU and a moderate one which loosely accepts a new CU. Simulation results are provided to evaluate the performance of the proposed algorithms in terms of the blocking and outage probability and compared with recent proposed schemes. These results show that the proposed algorithms outperform the similar schemes while they are more suitable for a practical scenario.**

Keywords- Cognitive Radio Network, Underlay Transmission, Admission Control, Power Control

I. INTRODUCTION

The scarceness of radio resources is the major limit of the recent explosive wireless technologies. However, the recent measurements by Federal Communications Commission (FCC) show that current wireless technologies do not exploit spectrum in an efficient manner [1]. This inefficiency results in wasting of the valuable spectrum. To overcome this problem and improve the spectrum utilization, some new technologies including dynamic spectrum assignment and cognitive radios have been proposed recently [2]. In a Cognitive Radio Network (CRN), cognitive or secondary users have the capability of sensing their environment and adjusting their transmission parameters accordingly during the sensing process, they try to find out the spectrum bands that are not used by licensed or primary users (PUs) and operate in these frequency bands. The main requirement for operation of cognitive users (CUs) is keeping the harmful interference on active PUs below an acceptable threshold. Therefore, the objective is to

maximize the CUs exploitation from the licensed spectrum subject to limiting the harmful interference on PUs. Different architectures are proposed in the recent years to achieve this aim which can be categorized in two main classes namely Overlay and Underlay. In overlay schemes, the CUs try to find out and exploit spectrum holes that are not used by PUs. Spectrum sensing plays a major role in this approach. In contrast, in an underlay approach, which is also considered in this paper, CUs are allowed to simultaneously transmit in the same spectrum as the primary system subject to keep the interference on PUs below a given interference threshold, called inference temperature, and guarantee their quality of service (QoS) [3],[6],[8]. Therefore, for a CRN which operates in underlay mode, the number of CUs and their transmission power are very important. That is, admission control, to control the number of admitted CUs, and power control to adjust their transmission power are the two main issues in these networks [3],[6],[8].

The admission control problem in cognitive wireless network not only needs to provide QoS guaranteed service for the admitted CUs, but also, it should guarantee the interference constraints of CUs on the primary network. In general, in a wireless communication system, there is always a tradeoff between two types of error that should be considered in the admission process. Type I errors occur when a new user is accepted incorrectly and cause excessive interference and hence outage of the ongoing users. Type II errors occur by tight admission rules which results in blocking [4], [5]. In a cognitive radio network, loose constraint in admitting new CUs which is referred to as ``all-admission" [4] may cause excessive interference on PUs or other CUs. On the other hand tight admission rules leads to low utilization of opportunities and high blocking probability. The former leads to violation of the PUs interference constraints and the latter will increase the outage probability of current CUs.

The most related works on admission control for cognitive wireless networks are summarized in the following. An admission method in an underlay cognitive network based on single or multiple link removal has been investigated in [6]. This method includes two phases: power control and links removal. In first phase, the steady state powers of all CUs are determined. Then, in the second phase, one or multiple CUs are removed based on an ``interference measure" values until the remaining subset of CUs fulfill the QoS requirement and the interference threshold of primary network. The interference measure definition is based on the similar work in [7], where the users have been removed gradually from network until the remaining set of CUs could be supported.

In [8] different revenues have been considered for CUs. Then, the problem is how to find a subset of CUs such that the total revenue output of the networks is maximized. To this purpose the problem is formulated in the optimization theory framework to maximize the CUs revenue subject to the interference constraint on the PU and QoS requirement of CUs.

These works and most of the existing, e.g. [6],[8],[10],[11], however, try to choose the best subset of CUs which can fulfill the two constraints of underlay scheme, the inference temperature on PUs and QoS of CUs, regardless of their order of arrival. That is, the admission procedure has been simultaneously done for a set of N CUs. Therefore, there is no guarantee on satisfying interference limits of the PUs or the QoS of current CUs during the admission process. Furthermore, these schemes result to zero blocking and high outage probability for cognitive network. However, in a real scenario of wireless networks, simultaneous arrival of users is a rare event and typically follows a statistical distribution in time.

In this paper, in contrast to the previous works we do not find a specific set of cognitive users out of N CUs in a batch manner. That is, we consider the arrival process of CUs which better models the real scenarios. On the other hand, in this model, some of the new arriving CU may suffer blocking and consequently, with non zero blocking probability of CUs their outage probability will decrease. Our idea are relies on some similar scenarios in a traditional wireless cellular network [4],[5] where an interactive admission decision has been developed according to Signal to Noise Ratio (SNR) of existing calls and iterations of the power control updating. Interactive call admission control directs the evolution of the power transmitted by the new user in order to protect the transmission quality of ongoing calls from dropping below a desired level. To prevent SINR deterioration of the active users, their transmission powers are boosted by a particular value at the moment where the new user begins to transmit [4], [5].

The objective of this paper is to consider the sequential arrival of new CUs during the admission process. In addition, the final admission decision should be made after the power updating, while the QOS of existing CUs is guaranteed and the interference threshold on PUs are adequately protected. In this regard, we proposed a Sequential Interference Aware Admission Control (SIAC) algorithm where a newly arrived CU is admitted according to the current status of the networks, i.e., the aggregate interference on the PUs and, the QoS of current active CUs. In SIAC algorithm, the interference on primary receivers and QoS of current CUs are protected during the admission process by gradually increasing the power of the new user and at the same time adjusting the power of current CUs. In following sections, in addition to analytically discussing on the roots of the proposed algorithm, simulation results are also provided for performance evaluation. These simulations are compared to the most related method in [6] which shows that SIAC outperforms the developed method in [6].

The rest of this paper is organized as follows. The system model and problem statement are given in Section II. In Section III, the basics of sequential admission control is explained. In section IV, two SIAC algorithms, namely safe-SIAC and moderate-SIAC are proposed. Simulation results are provided and discussed in section V, before concluding the paper in section VI.

II. System Model and Problem Statement

A centralized CDMA based primary network is considered in which the CUs are allowed to utilize the primary's spectrum in an underlay mode (Fig 1.). It is assumed that the CUs arrive sequentially and an interference margin threshold on PUs receiver should be guaranteed. Also, the QOS of the current admitted CUs should be considered which is modeled by another interference threshold for these CUs.

At the beginning, it is assumed that N cognitive users have been accepted in the primary cell. These N accepted CUs which are assumed to sustain the required QoS, should also satisfy the constraints of interference imposed on primary users. The set of all active CUs, when a new CU arrives, is denoted by $\mathbf{N} = \{1, \cdots, N\}$. We assume that both primary and cognitive networks use the same base station. The Signal to Interference plus Noise Ratio (SINR) at the i'th receiver ($i \in \mathbf{N}$) is given by

$$\mu_i = \frac{B}{R_i} \cdot \frac{g_i p_i}{\sum_{\substack{j=1 \\ j \neq i}}^{N} g_j p_j + \eta_i} \qquad (1)$$

where p_i is the transmission power of the i'th transmitter, g_i is the link gain from the i'th transmitter to the base station receiver, B is the system bandwidth and R_i is the transmission rate, respectively. In addition, η_i is considered as the sum of the background noise power, N_i, and the aggregate PUs interference power, I_p, on each cognitive receiver in the base station, i.e., $\eta_i = N_i + I_p$.

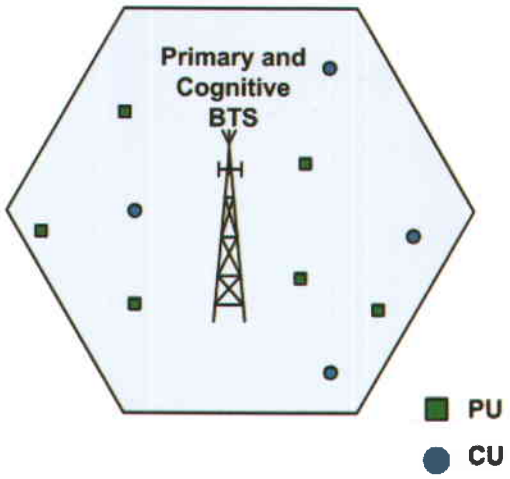

Figure 1. System Model

To guarantee the QoS of each active CU, its SINR should be above a target SINR level, γ_i

$$\mu_i \geq \gamma_i \quad i = 1,2,\cdots,N \qquad (2)$$

In addition, to fulfill the interference level constraints on the primary receiver, CUs aggregate interference imposed on the PUs should not exceed a pre-defined threshold, T ,i.e.,

$$\sum_{i=1}^{N} g_i p_i \leq T \qquad (3)$$

Taking into account the above constraints, the admission problem will be how to admit a new cognitive user without violating the problem constraints, (2) and (3) during the admission process. For this purpose, two variables are defined to specify the current status of the cognitive network, Primary Interference Margin (*PIM*) and Secondary Interference Margin (*SIM*).

The maximum tolerable interference on the primary network that cognitive users can utilize is denoted by PIM_{max} and is defined as

$$0 \leq PIM_{\max} = T - \sum_{i=1}^{N} g_i p_i \qquad (4)$$

It is clear that negative value of PIM_{max} indicates the violation of interference threshold.

Additionally, SIM_i denotes the maximum interference margin that can be tolerated by the i'th active CU to protect his QoS. It can simply derived from (2) by considering the minimum required SINR, γ_i . That is, we should have

$$\frac{B}{R_i} \cdot \frac{g_i p_i}{\sum_{\substack{j=1 \\ j \neq i}}^{N} g_j p_j + \eta_i + SIM_i} \geq \gamma_i \qquad (5)$$

Therefore,

$$SIM_i \leq \left(\frac{B}{R_i} \cdot \frac{g_i P_i}{\gamma_i} - \sum_{j=1, j \neq i}^{N} g_j p_j - \eta_i \right) \qquad (6)$$

We are trying to choose the proper value for PIM and SIM_i ($\forall i \in \mathbf{N}$) in such a way that the aggregate interference on primary receiver are kept below the certain level during the admission phase and besides, the QoS of current CUs are also guaranteed.

In the following we formulate the admission control problem deploying the introduced parameters *PIM* and SIM_i. The objective is to minimize the CUs blocking probability by removing some active cognitive links.

III. Power and Admission Control Problem

A. Power control

To satisfy the QoS constraint, each cognitive user has to adapt his transmission power to meet the desirable SINR. Therefore, an efficient power control algorithm is needed. We use Distributed Constraint

Power Control (DCPC) algorithm in [9] as an iterative power control algorithm with a maximum power constraint. According to DCPC algorithm, the power of the *i*'th CU in the *l*'th iteration is computed by [9]

$$p_i(l+1) = \min\left\{p_i^{\max}, p_i(l)\frac{\gamma_i}{\mu_i}\right\} \qquad (7)$$

where $p_i^{\max}$ is the maximum allowable power for the *i*'th CU. Starting with any initial power vector, DCPC will coverage to a unique stationary power vector $\mathbf{p} = [p_1^*, p_2^*, \cdots, p_N^*]$ if any solution exists [9].

B. Admission Control problem

We are interested in a scenario in which the CUs arrive sequentially in time. The problem is how to admit a new cognitive user when N active CUs exist. On the other hand, both constraints in (2) and (3)(3) have to be satisfied during the admission procedure.

Consider the case when a new cognitive user arrives, the power vector of all current CUs is set to $\mathbf{p}^*$ and a positive value for PIM_{max} is assumed. Let the index of the new cognitive user is denoted by zero. When the new cognitive user begins to transmit at power p_0, the interference on the base station's primary receiver will change to $\sum_{i=1}^{N} g_i p_i + g_0 p_0$, and the SINR of the current CUs will change to

$$\mu_i = \frac{B}{R_i}\cdot\frac{g_i p_i}{\sum_{\substack{j=1\\ j\neq i}}^{N} g_j p_j + \eta_i + g_{i0}p_0} \quad \forall i \qquad (8)$$

These extra interferences may violate the QoS of the current CUs and the interference constraint on primary receivers.

To combat the SINR degradation of the current CUs, they can increase their transmit power to reach the target SINR. But increasing the powers in an uncontrolled way may increase the aggregate interference introduced on the PUs beyond the interference threshold. Moreover, both (2) and (3) have to be satisfied during the admission phase. Therefore, the power of current CUs must be increased by a proper boosting factor, which is defined according to current network status. To this aim, we use a proper set of PIM and SIM_i s to define the value of boosting factor. To apply these concepts in a cognitive network the following represented lemmas from [5] are used.

Lemma 1 [5][5]: Assume a stationary power vector $\mathbf{p}^*$ exists for N active user that meets their target SINR. When an additional noise is introduced, these users could still be supported by boosting their powers with some factor ε if $(1+\varepsilon)\mathbf{p}^* \le \mathbf{p}^{\max}$. In addition, if ξ and κ be the additional and the current noise on each user, respectively, then the value of boosting factor, $(1+\varepsilon)$, should satisfies $\zeta \le \varepsilon\cdot\kappa$ for $\varepsilon > 0$.

Lemma 2 [5]: Starting with the boosted power vector, $(1+\varepsilon)\mathbf{p}^*$, and executing the DCPC algorithm in previous lemma will converge to a smaller stationary power vector, i.e., the vector that all its elements are smaller that corresponding elements in $(1+\varepsilon)\mathbf{p}^*$.

Therefore, our objective is to find out the proper boosting factor according to current CUs situation and interference threshold on Pus. To this aim the appropriate boosting factor is calculated for our setting in terms of minimum and maximum values of the PIM and the maximum power of CUs by deploying the above lemmas. The maximum value of the *PIM*, i.e. $PIM_{\max}$ is given by (4) and its minimum value, $PIM_{\min}$ is chosen as

$$PIM_{\min} = \delta(\varepsilon).PIM_{\max} \qquad 0 < \delta(\varepsilon) < 1 \qquad (9)$$

Where $\delta(\varepsilon)$ is a constant which should be selected according to ε. In fact, $PIM_{\min}$ indicates the minimum value of *PIM* after the powers are boosted by the boosting factor, $(1+\varepsilon)$.

In addition, this parameter should be selected large enough to reflect the minimum tolerable interference of primary system for admitting a new cognitive user, i.e.

$$\begin{aligned} PIM_{\min} &\le T - \sum_{i=1}^{N} g_i(1+\varepsilon)\cdot p_i \\ &= T - \sum_{i=1}^{N} g_i p_i - \sum_{i=1}^{N} g_i\cdot\varepsilon\cdot p_i \\ &= PIM_{\max} - \varepsilon\cdot\sum_{i=1}^{N} g_i p_i \end{aligned} \qquad (10)$$

Therefore, ε should be selected according to

$$\varepsilon \le \frac{PIM_{\max} - PIM_{\min}}{\sum_{i=1}^{N} g_i p_i} \qquad (11)$$

On the other hand, according to the maximum allowable transmitter power of current CUs, $(1+\varepsilon)$ should satisfy

$$(1+\varepsilon) \le \min\left\{\frac{p_{\max}}{p_1}, \frac{p_{\max}}{p_2}, \ldots, \frac{p_{\max}}{p_N}\right\} \qquad (12)$$

That is, the proper value of ε should be selected by (11) and (12) following choosing $PIM_{\min}$ in (9). Figure 2. illustrates the procedure of calculating the proper values of ε.

On the other hand, the transmission power of the new CU is normally below his target value during the admission phase. We should decide how to adjust his power when the current CUs boosting their powers. According to lemma 2 by applying the DCPC algorithm on the boosted power vector, the power of current CUs will decrease in consecutive iterations. This decrement is an indicator of available capacity for admitting a new CU and suggests updating $PIM_{\min}$. Also to protect the QoS of the current admitted CUs, SIM_i ($\forall i \in \mathbf{N}$) should be updated according to this decrement based on (6). Therefore, an appropriate value for the initial power of the new user, p_0, is given by

$$p_0 = \min\left\{\left(\frac{PIM_{\min}}{g_0}\right),\left(\frac{SIM_{\min}}{g_0}\right)\right\} \qquad (13)$$

where the minimum value of SIM is obtained by

$$SIM_{\min} \le \min_i\left(\frac{1}{\gamma_i}.\frac{B}{R_i}g_i\tilde{p}_i - \left(\sum_{j=1,j\neq i}^{N} g_j\tilde{p}_j + \eta_i\right)\right) \qquad (14)$$

where $\tilde{\mathbf{p}}=[\tilde{p}_1,\tilde{p}_2,\cdots,\tilde{p}_N]$ is the power vector of CUs following the DCPC algorithm convergence. Applying these values for ε and p_0, the aggregate interference on the PU will be kept below the interference threshold and the same time, the QoS of current CUs are maintained during the admission phase.

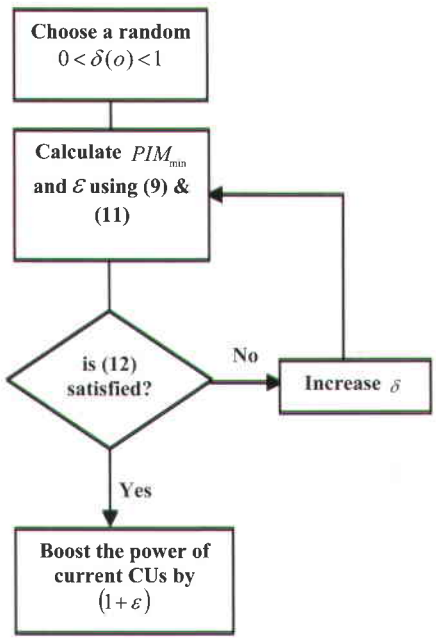

Figure 2. calculate the proper values of ε

IV. Sequential Interference-Aware Admission Control (SIAC) Algorithm

Based on our previous discussion, two admission algorithms are defined in this section namely Safe-Sequential Interference-Aware Admission control (S-SIAC) and Moderate-Sequential Interference Aware Admission Control (M-SIAC). These algorithms employ PIM and SIM_i. as two important parameters during the admission procedure of a new CU. The idea is that the power of current CUs are boosted by a factor of $(1+\varepsilon)$ and the power of the new CU is adjusted according (13).

In S-SIAC algorithm, a tight rule is applied on admitting a new cognitive user. Consequently, current CUs do not suffer outage while the aggregate interference on primary network does not violate the threshold in (3). However, CUs may meet high blocking probability due to tight acceptance rule. The key features of the S-SIAC algorithm is that it can support both of the QOS of CUs as well as the interference limit of PUs.

Consider a scenario in which some of the current admitted CUs cause severe interference on primary and secondary users. In this situation, the maximum tolerable interference on the primary network which is shown by $PIM_{\max}$ will be decreased and in addition the minimum interference margin of the cognitive network, i.e. SIMi, will be increased. Hence, a new cognitive user that has a better link quality with respect to the current CUs may suffer blocking. The inherent tradeoff between blocking and outage probability can be used in S-SIAC algorithm to mitigate this problem. To this purpose, M-SIAC is presented as a moderate version of S-SIAC. It also applies a tight protection on the aggregate interference on PUs but some of the active cognitive links may be removed, i.e., that is we allow some outage probability.

S-SIAC is presented in Alg. 1. At the first step, lines 2-5, when a new CU arrives, the initial condition is checked by PIM_{max}. Then current users' powers are increased by calculated boosting factor. At the second step, lines 6-11, the procedure of power updating is done for current and new users. Two criteria are used to terminate this procedure, 1) the SINR of current CUs and 2) the maximum allowable power of new CU. Admission decision is made in lines 12-19 at the third step, where its output is to accept or reject of the new CU. Admission criterion is the target SINR of the new CU. That is, he will be accepted if $\mu_0 \ge \gamma_0$, otherwise he will be rejected.

The M-SIAC algorithm is achieved by replacing the lines 12 to 19 in Alg.1 with codes presented in Alg.2. In M-SIAC, three outcomes are possible. The first one is immediate rejection of a new CU according to the lines 12-13. That is, the new CU is rejected because his target SINR does not satisfied and his power reaches PIM_{max}. The second outcome will be accepting the new CU without removing any of previously admitted users. The third one is related to accepting a new CU with removing some of the current admitted CUs. The latter two cases are

presented in lines 15-23 of Alg. 2. The removal process decision is made in lines 19-21. The link removal scheme in this algorithm is based on the links' quality, noise and interference. This tradeoff between outage and blocking probabilities can be made by tuning the boosting factor.

Algorithm 1) S−SIAC Algorithm

1: *Initializing*: Set $\bar{p}=[p_1, p_2, \cdots, p_N]$ Calculate $PIM_{\max}$ by (4)
2: *if* There is a avalid $PIM_{\max}$ *then*
3: *if a new cognitive user request admission then*
4: Find proper ε according to the flowchart in Fig 2
5: $\bar{p}=(1+\varepsilon)\bar{p}$
6: *while* $\mu_i \le \gamma_i$ & $p_0 \le p_0^{\max}$
7: Calculate SIMs
8: do DCPC for N CUs
9: Calculate the power of the new CU using (13)
10: Compute μ_0
11: *end while*
12: *if* $\mu_0 < \gamma_0$
13: rejecct the new user
14: do the DCPC for the rest
15: *else if* $\mu_0 \ge \gamma_0$ *then*
16: accept the new CU
17: $N = N+1$
18: do the DCPC for the N CUs
19: *end if*
20: *end if*

Algorithm 2) M − SIAC

12: *if* $\mu_0 < \gamma_0$ *and* $p_0 = p_0^{\max}$ *then*
13: rejecct the new user
14: do the DCPC for the rest CUs
15: *else if* $p_0 < p_0^{\max}$ *then*
16: accept the new CU
17: $N = N+1$
18: do the DCPC for the N CUs
19: *for* $i = 0$ *to* N
20: *if* $\mu_0 < \gamma_0$ *then*
21: remove i_{th} CU
22: *end if*
23: *end for*
24: do the DCPC for the rest CUs
25: *end if*
26: *end if*

V. SIMULATION RESULTS

In the simulations, we consider a CDMA-based primary network, where the PUs and CUs are communicating with their corresponding BS. PUs and CUs are located in a circle area with radius d_{max}=600m, where their distances to the BS are uniformly distributed in [d_{min} , $d_{\max}$] where d_{min} is a minimum distance between a user and BS e.g. d_{min}=10 *m*. The multipath channel between the *i*'th CU and his receiver is modeled by a Rayleigh fading channel which is generated by a complex Gaussian random variable.

In first experiment, we investigate the effect of boosting parameter, $(1+\varepsilon)$, on PIM which shows the tolerable interference. The simulation scenario consists of 7 CUs which satisfy the system constraints with $\gamma_i = 10\,dB$. By changing the boosting factor, the corresponding PIM is depicted in Fig. 3. Figure 4 shows that increasing the boosting factor, leads to decreasing $PIM_{\min}$. This emphasizes that tight protecting of PUs leads to higher blocking probability of cognitive users. The blocking probability has been calculated as the ratio of average number of rejected links to the average number of requested calls.

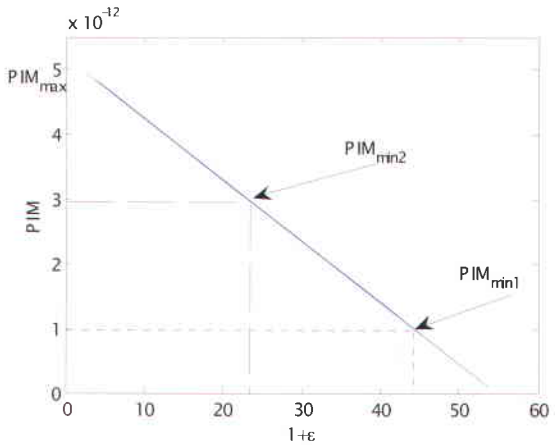

Figure 3. Relationship between boosting factor $(1+\varepsilon)$ and PIM

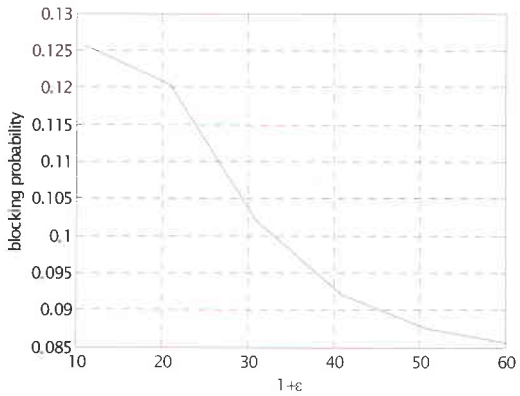

Figure 4. Relationship between boosting factor, $(1+\varepsilon)$, and blocking probability (SINR = 8 dB, 10 PUs , 7 CUs)

Figure 5 illustrates the variation of blocking probability versus target SINR in different values of $(1+\varepsilon)$ using S-SIAC algorithm. From this figure, we can see again that increasing the boosting factor $(1+\varepsilon)$ leads to lower blocking probability.

The tradeoff between blocking and outage probabilities using S-SIAC and M-SIAC algorithms is demonstrated in Fig. 6. The outage probability of CUs is increased in M-SIAC while still the blocking probability is lower than the S-SIAC. On the other hand, the S-SIAC algorithm protects the current CUs without removing the current admitted CUs. This trend is more highlighted in higher target SINR.

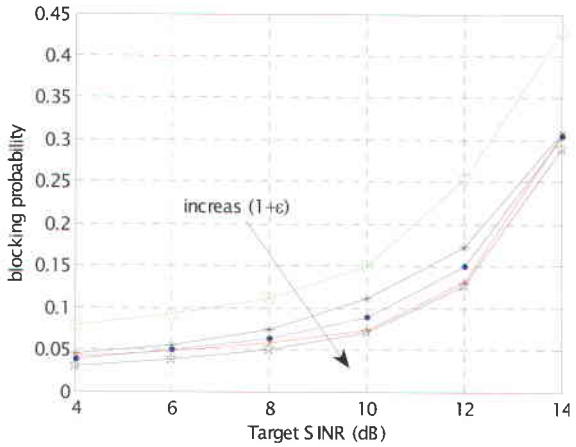

Figure 5. Blocking probability of S-SIAC versus target SINR for different values of $(1+\varepsilon)$

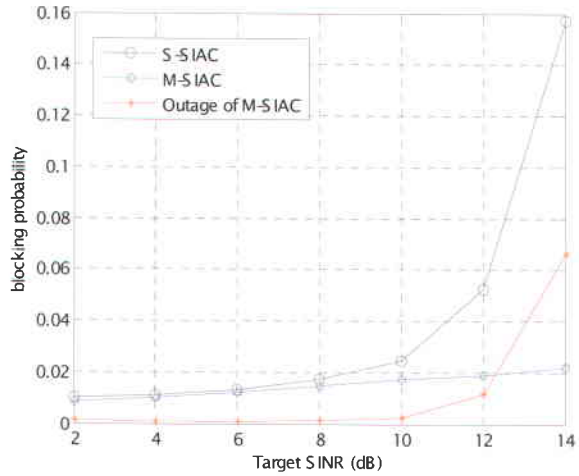

Figure 6. Outage and Blocking probabilities of S-SIAC and M-SIAC versus target SINRs

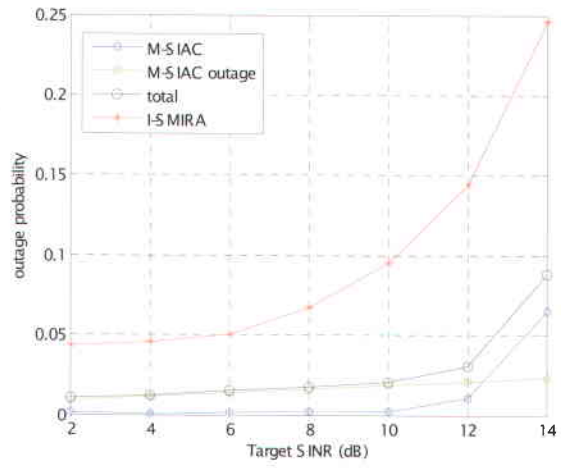

Figure 7. Outage probability of SIAC and I-SMIRA versus target SINR

We compare the results of the M-SIAC algorithm with an admission control scheme in [6]. This scheme, named as I-SMIRA, is based on a link removal approach admission control which is called SMIRA [10]. The admission decision in I-SMIRA is applied based on all-admission scheme, where it tried to find out the best subset of N cognitive links, while the QoS constraints for cognitive users and interference constraints of primary users are satisfied. It is clear that the blocking probability of I-SMIRA is zero; however, it suffers from higher outage probability. In I-SMIRA, they remove a CU which causes the highest interference on the PUs and is incurred the most interference. In contrast to M-SIAC, the I-SMIRA executes link removal process for the all admitted CUs simultaneously and does not consider their priority of arrival. Moreover, I-SMIRA with zero blocking probability suffers high outage probability, while M-SIAC is using the inherent tradeoff between outage and blocking probability to reduce the outage. The comparison between SIAC and I-SMIRA is illustrated in Fig.7. To have a fair comparison, the sum of outage and blocking probabilities of the SIAC, which is labeled by 'total' in the figure, is compared with the outage probability of I-SMIRA. As we can see, the M-SIAC outperforms I-SMIRA regarding the outage and blocking probabilities of admitted and rejected CUs. That is the average number of admitted CUs, which utilizing the spectrum opportunities is increased with respect to I-SMIRA.

VI. CONCLUSION

In this paper, two new algorithms have been proposed for cognitive user admission in an underlay cognitive network. In the proposed algorithms, the primary user protection and cognitive user QoS are guaranteed defining primary and secondary interference margins, respectively. These parameters are computed according to the current interference status of the networks. They depend on the tolerable interference of primary network as well as the number of current admitted cognitive users and their powers. S-SIAC is presented as a tight admission algorithm, where primary users are protected and the current cognitive users' QoS are not violated during admission procedure. Therefore, CUs suffer high blocking. M-SIAC is presented as a moderate version of S-SIAC, where some of active CUs with weak link quality than the new one, may be removed. Hence, with non zero outage probability, blocking is reduced in this algorithm. Blocking and outage probabilities are considered as the performance criteria for algorithm development and evaluations. Simulation results are provided to evaluate and compare the proposed algorithms with similar schemes. These results show that the proposed sequential interference aware admission controls method outperform the related method.

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