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CHANNEL ALLOCATION STRATEGY FOR MULTIUSER COGNITIVE AND LOCATION AWARE SPECTRUM ACCESS

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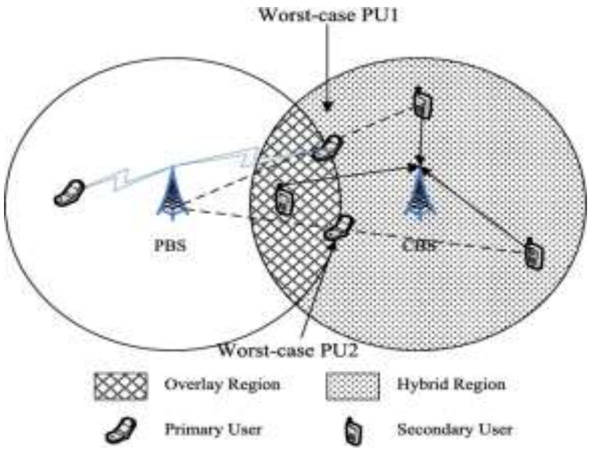
ABSTRACT: This paper considers a new power strategy and channel allocation multiuser cognitive radio network. Where the coverage area of the secondary network is divided into overlay region and hybrid region. Secondary users in the overlay region follow overlay spectrum access method, in the hybrid region use sensing-free spectrum access method. General resource allocation algorithm that optimizes power and channel allocation to secondary users who follow these different spectrum access methods, depending on their locations. To enable sensing-free spectrum access, propose a new algorithm that incorporates an interference violation test to decide the parameters in the general framework. The proposed scheme utilizes frequency and space opportunities and avoids unnecessary spectrum sensing, and minimizes overall power consumption while maintaining the quality of service of a primary system. Simulation results give the effectiveness of the proposed method in terms of energy efficiency. Use multiple access and data reconstruction in wireless sensor networks based on compressed sensing technique the relative noise error must be reduced and improves the channel capacity.

Key-terms: cognitive radio, energy efficiency, location aware strategy, orthogonal frequency division multiplexing, resource allocation.

1. INTRODUCTION

Allowing secondary users opportunistically access the underused Spectrum of primary licensed networks, cognitive radio is a promising technology to improve the spectrum utilization efficiency and meet the requirements in future wireless networks. Depending on the spectrum policies lay by a primary system, the dynamic spectrum access and underlay spectrum access. In an overlay-based system, secondary users access the spectrum only when it is not being used by the primary system, whereas in an underlay-based system, SUs coexist with the primary system and transmit with power constraints to avoid unacceptable interference and guarantee the quality of service of the primary system. Recently, power and channel allocation in orthogonal frequency division multiplexing based cognitive radio systems have received a great deal of attention Different spectrum access methods require distinct resource-allocation strategies. For the overlay-based systems, harddecision resource allocation and probabilistic resource allocation, taking into account spectrum sensing errors, are studied in and the references therein. For the underlay-based system, interference management among SUs and primary users plays a key role in the resource allocation. To protect the primary system, most literature constrains the interference caused by us below a threshold in either average instantaneous (short-term) sense Unlike the previous literature that takes into account the amount of interference to the primary system as the protection criterion, the authors of reconsider the protection to the primary system and SUs through different levels of

Protection in signal-to-interference-and noise ratio. In addition, many researchers consider resource allocation with joint overlay and underlay spectrum access. For instance, subcarrier-and-power-allocation schemes for a joint overlay and underlay spectrum access mechanism are proposed in for a downlink transmission scenario in a centralized multiuser CR network, where both unused and underused spectrum resources are utilized and the interference introduced to the PU is kept below given thresholds with a certain probability. In the authors employ a hybrid overlay/underlay spectrum sharing scheme for a distributed CR network, allowing an SU to adapt its way of accessing the licensed spectrum according to the status of the channel. If the selected channel is detected to be unoccupied, the SU works in an overlay mode; otherwise, it works in spectrum underlay. An auction-based power allocation scheme is proposed to solve power competition of multiple SUs. These aforementioned studies are based on the maximum data rate design subject to an overall power constraint. On the other hand, energy-efficient design has attracted more attention from researchers recently. The energy efficient power-allocation problem of OFDM based CR systems is studied in where energy efficiency defined as the ratio of data rate to power is taken as the objective function in the optimization for the purpose of holding the promise of advancing green communications. In all these aforementioned studies, every SU uses the same type of spectrum access methods, be it overlay, underlay, or hybrid. In reality, it is natural for SUs at different locations to use different spectrum access methods. For example, SUs close to or inside the primary system cannot share the channels with PUs and hence should use overlay spectrum access, whereas SUs located far from the PU system may use overlay or even sensing-free spectrum access proposed in. In fact, space opportunity, which an enhance the spectrum and energy efficiency, was not considered in most of the existing work. In our previous work a novel location aware power-allocation framework that intelligently utilizes frequency and space opportunities of the spectrum was proposed. However, in we only considered the power allocation for the single-SU case Resource-allocation strategies for a secondary network consisting of SUs with location dependent heterogeneous spectrum access have not been studied in the literature. The first contribution of this paper is to extend to consider multiple SUs spread out in a secondary network and devises a general problem formulation that incorporates all the spectrum access methods and allows different modes for distinctly located SUs by setting the parameters in this formulation. Unlike the single-user case, channel allocation and power allocation should be included in this formulation. Meanwhile, to achieve an energy efficient design, we minimize the total power consumption with a given date rate requirement in this problem formulation. Our resource allocation incorporates the hard-decision-based approach for overlay spectrum access, the spectrum sharing-based approach for underlay spectrum access, and the sensing-free-based approach.



2. SYSTEM MODEL AND PROBLEM FORMULATION

This paper considers a scenario that one CR system coexists with one primary system, where K mobile SUs are communicating with a cognitive base station in the uplink and PUs are receiving signals from a primary base station in the downlink, as the circle to the left represents the service range of the primary system, and the shaded circle to the right represents the service range of the CR system. The intersection of the two circles constructs what we call the overlay region. The remaining part of the CR service region is called the hybrid region. To ensure the efficacy of the scheme proposed in this paper, we assume that, for each SU in the hybrid region, there is a corresponding worst-case PU location (located at the intersection of the PBS service region boundary and the line between the PBS and the SU itself), which is the closest to this SU. We believe that, if the worst-case PU (regardless whether this PU is actually present or not) is protected, all the PUs within the coverage area of the primary system are also protected from the transmission of the corresponding SU in the long term. The problem formulation and analysis thereafter apply similarly to the secondary downlink scenario and hence, this paper focuses on the secondary uplink. We assume that the primary system and CR system are OFDM-based systems, with the licensed spectrum being divided into N sub channels of the same bandwidth with each sub channel experiencing flat fading. It is also assumed that there is no spectrum sensing error, and hence, the case of imperfect sensing is out of the scope of this paper. As we shall show, depending on the location of SUs, resource-allocation design should exhibit an adaptive structure, allowing diverse spectrum access methods when the SUs fall into different service regions.1 To avoid mutual interference among SUs, we assume that each sub channel can be at most allocated to one SU and that each SU may be allocated more than one sub channel. In addition, it is assumed that $N \geq K$ and the number of unoccupied channels is larger than the number of

SUs located in the overlay region. Finally, we assume that the CBS coordinates channel and power allocation and spectrum sensing (if necessary) in a centralized manner. Transmit power control plays an important role in energy-efficient communication to prolong the lifetime of the network and achieve the goal of green communication. Therefore, instead of maximizing the system data rate over limited power resource, as most of the relevant works do, we formulate here a complementary QoS problem with the objective of minimizing the overall power consumption subject to a minimum data rate requirement. The cognitive resource allocation problem permitting different spectrum access methods for SUs can be formulated by a general framework as The resource-allocation problem **P1** needs the sub channel availability information, i.e., sets A and N, which can be obtained by spectrum sensing. For a given network topology, CBS calculates each SU's distance to PBS and determines which region the SU falls into. An SU in the overlay region only accesses sub channels in A, whereas an SU in the hybrid region can be assigned sub channels in both A and N.

3. LOCATION-AWARE

MULTIUSER RESOURCE

ALLOCATION

With the location information on the SUs, the key part of the proposed resource-allocation scheme in this paper is determining parameters for **P1**, e.g., A, N, and $\alpha(k)$, and solving it. Here, we focus on solving **P1** assumption that all the parameters have been determined. Problem **P1** can be infeasible due to the presence of the total power interference. This occurs when the total power budget Pk max or interference capped power cannot support the target minimum rate Rmin for a given set of channel realizations. We can add a slack variable in to find the minimum *P*max or *I*max *i* that makes **P1** feasible. When **P1** is feasible, it cannot be directly solved since it is a non convex problem. To solve **P1**, we utilize the dual decomposition approach, and the dual problem of **P1** can be given as

4. ADAPTIVE RESOURCE ALLOCATION WITH INTERFERENCE VIOLATION TEST

Assuming that all sub channels can be used without sensing. It is worth noting that *I*max *i* for the sub channels allocated to the SUs located in the overlay region should be set to 0, and thus, the according sub channels have to be sensed. With the obtained power- and channel-allocation results, the generated interference to PUs for those sub channels in *N* is maintained. This is called the interference violation test. Those sub channels that cannot support the primary system QoS will be added into the channel set V SFRA is not applicable for those sub channels belonging to *V*. As a result, spectrum sensing is required. According to the spectrum sensing results, *A* and *N* are updated. In addition, if a sub channel in *V* is sensed to be unoccupied by PUs, it can be removed from *V*. Then, next iteration of optimization is required with interference constraints so that the new optimization solution satisfies the primary systems QoS in previously violated sub channels. The subsequent interference violation test will update *V* if new unscented sub channels are found to violate the interference constraints, followed by spectrum sensing for the new members of the set *V* and the update on *A* and *N* according to the sensing result. This iterative optimization procedure stops when there is no sub channel being added into *V* after the interference violation test. Then, the optimal solution for resource allocation can be obtained. The algorithm for the proposed adaptive resource-allocation scheme is given in Algorithm 1, as subsequently shown. When Algorithm 1 converges, the obtained solution satisfies all the constraints in **P1**. Therefore, this solution is at least a suboptimal solution (the optimal solution is obtained by solving **P1/P2** with all the sub channels sensed). The proposed

Algorithm avoids unnecessary spectrum sensing and, hence, reduces the energy consumption at the price of more optimization computation. This provides a trade off between sensing energy consumption and signal processing power consumption.

5. SIMULATION RESULTS

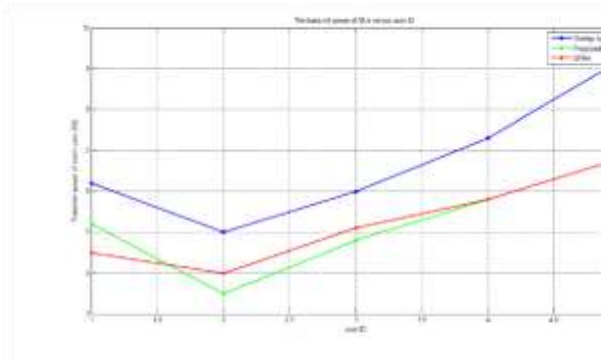


Fig 1. Transmit power of secondary users versus user id with different resource allocation strategies

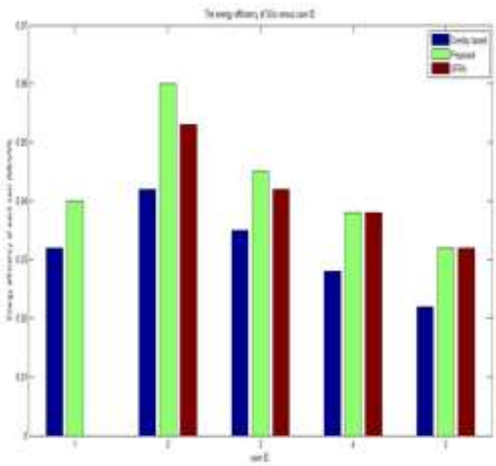


Fig 2..Energy efficiency of secondary users versus user id with different resource allocation strategies

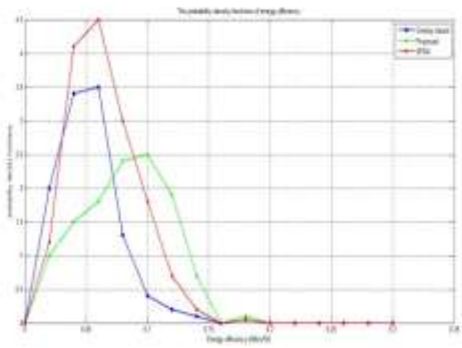


Fig 3. Probability density function of energy efficiency with different resource allocation strategies

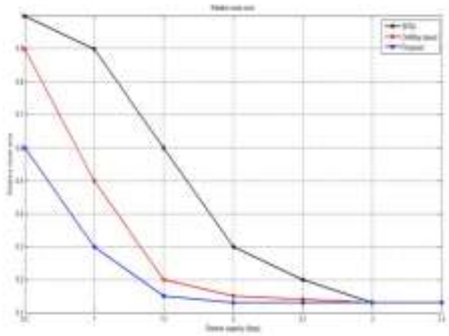


Fig 4. Relative noise error versus channel capacity

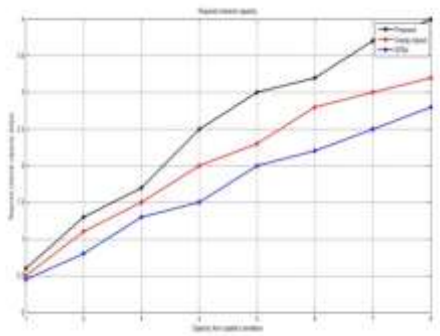


Fig 5. Required channel capacity versus sparsity from spatial correlation

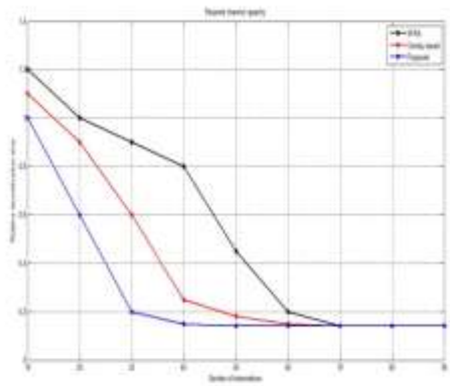


Fig 6. Relative reconstruction error versus number of observations for different number of active users

6. CONCLUSION

This paper has elaborated the role of adaptive resource allocation in CR networks in terms of energy efficiency since energy-efficiency oriented design is increasingly more important for wireless communications. Based on the existing research on resource allocation for OFDM-based CR networks, this paper proposes an adaptive hybrid resource-allocation strategy to enhance the energy efficiency by utilizing spectrum and spatial opportunities. A novel adaptive power- and channelallocation algorithm has been proposed to fulfil the proposed resourceallocation strategy based on the interference violation test. As a comparison between the existing schemes that do not consider SUs' locations and the proposed resourceallocation scheme, we have found that resource allocation by considering spatial information enhances the energy efficiency and avoids unnecessary spectrum sensing.

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