Dynamic Resource Allocation with Imperfect Channel Sensing –Heterogeneous Services in Cognitive Radio Network

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ABSTRACT
In cognitive radio networks (CRN), resource should dynamically be assigned to the users with respect to sensed radio atmospheres. Many works has been done for dynamic allocation but it is not practically easy because the secondary network is very difficult to know the right knowledge of dynamic radio atmospheres in CRN. In this object we study the different methods of dynamic resource allocation in CRN for diverse services. We proposed the joint power and channel allocation problem using the discrete stochastic optimization method. The simulation result provided significant improvements of effectiveness of the proposed system.

Keywords
Cognitive radio, discrete stochastic optimization method, imperfect channel sensing, heterogeneous service

I. INTRODUCTION
Cognitive radio (CR) is a new emerging technology to improve the radio spectrum utilization effectively. The primary task of CR is that the secondary users (SUs) senses the spectrum dynamically and allocate the unused radio spectrum to SU when the primary users (PUs) are idle. The secondary users in cognitive radio network (CRN), the resource should be allocated dynamically with respect to sensed radio atmospheres for improvement of effective utilization of radio spectrum. This technology makes it limited interference to Pus. CRN is a new technology and has more attention recently [1] [2]. The dynamic resource allocation in underlay radio spectrum technology have been studied according to this every SU has a minimum quality-of-service (QoS) requirement [3]. The distributed multichannel power allocation with QoS guarantee is studied in [4], they are proposed a distributed power allocation algorithm by using the Lagrangian dual decomposition to guarantee the QoS of SUs [3] [4]. The distributed price-based radio spectrum management in cognitive radio network has modeled resource allocation problem by using a noncooperative game, and a price-based iterative water-filling algorithm is considered to maximize the SU’s utility function [5]. Dynamic resource allocations are done based on cross-layer perspective. The authors are mainly concentrated on the radio spectrum sensed by SUs. Generally, it is very difficult to know proper knowledge of dynamic radio atmospheres by SUs due to hardware restriction, tiny sensing time, and network connectivity problems in CRNs, where imprecise channel-state information (CSI), as well as missing detections and false alarms of PUs, can occur [10]. Many existing works has been concentrated on a single type of service carried by SUs. Recently CRN need support to heterogeneous services with diverse QoS requirements. In this paper we study the previous problem and formulated the joint power and channel allocation problem using the discrete stochastic optimization and implemented joint access control and resource allocation to maximize the total system capacity and minimize the interference to PUs while there are sensing faults in the secondary network [11].

Let assume that we collect the predetermined channels information based on this information the secondary base station formulates dynamic resource allocation with heterogeneous service for secondary users. We can consider the QoS requirements for heterogeneous services. For an example the secondary users with minimum guarantee and SUs with best effort service. Now we considered the minimum-rate constraint condition for secondary users (SUs) by minimum-rate guarantee. For SUs with best effort service, each SU may acquire diverse resources due to the divergence of channel quality. The possible unfairness problem is solve by...
initiates a proportional-fairness constraint. Based on the proportional-fairness constraints and imperfect channel information, we formulate joint access control and resource allocation with a mixed-integer programming problem.

The rest of this article is organized as follows. The cognitive radio system model is existed in section II. The joint power and channel allocation scheme is proposed in Section III, the simulation results are illustrated in Section IV. Finally, we conclude this paper in Section V.

II. SYSTEM MODEL

The system model contains primary networks and secondary networks; these are worked based on time-slotted technology. The secondary network contains a secondary base station and K\textsubscript{tot} SUs with the heterogeneous services. These are request in secondary network; both networks are operating on orthogonal frequency-division multiple access (OFDMA) technology. The primary network contains a base station and M primary users as shown in the figure (fig 1).

The secondary network should sense the M channels and opportunistically exploit the unused channels for heterogeneous services. The secondary networks time slots contains the sensing time, resource allocation time and data transmission time. The available m channels are sensed by secondary network and which are licensed to the primary network and identifies the available unused spectrum channels [12] [13]. Cooperatively centralized sensing algorithm is also used for utilization of available spectrum.

We assume that the overall test statistics for M channels is \( E_{m}^{\text{tot}} \) with decision threshold \( e_{m} \). The optimal balance will be finding between \( P_{m}^{f} \) (Probabilities of false alarm) and \( P_{m}^{d} \) (the probability of detection)

The expression is \( P_{m}^{f} = \Pr\{E_{m}^{\text{tot}} > e_{m}|H_{0}\} \), \( P_{m}^{d} = \Pr\{E_{m}^{\text{tot}} > e_{m}|H_{1}\} \)

Where, the idle channels are denoted by \( H_{0} \) hypotheses and busy channels are denoted by \( H_{1} \) hypotheses. There are four possible scenario based on the probability of false alarm and probability of detection of sensing of m channels.

They are
1. Channel m is idle, and the decision for channel m at the secondary base station is idle.
2. Channel m is busy, and the decision for channel m at the secondary base station is idle.
3. Channel m is idle, and the decision for channel m at the secondary base station is busy.
4. Channel m is busy, and the decision for channel m at the secondary base station is busy.

We have been achieved accurate channel sensing at scenario one and four, False alarm detection at scenario three and miss detection at scenario at two. In this article we considered the scenario one and two because our main goal is resource allocation for SUs, without loss of generality. Let assume that the secondary base station senses N, N ≤ M, the idle channels in the time slots. There is a spectrum access scheme that meets the collision constraints of PUs, based on which we propose the power and channel resource allocation formats. at the point when the detected unmoving channels incorporates the second scenario we can see the second scenario as a detecting fault and has an impedance for SUs amid asset distribution, which will bring about
execution debasement because of detecting blunders. At that point, amid the asset portion time, only \( K \leq N, K \leq K_{tot} \), SUs with heterogeneous administrations could be gotten to, and the quantity of conceded SUs alludes to the confirmation control and clients booking, which will be considered later on [17].

Consider, \( K \) SUs have heterogeneous service requirements and divides into two categories are

- \( K1 \): SUs with minimum-rate guarantee;
- \( K2 \): SUs with best effort service.

The relating sets of these two classes of SUs can be meant as \( K_A \) and \( K_B \) respectively. We consider as the secondary base station does not know the perfect channel information for these \( K \) SUs on \( N \) channels during the resource allocation. We know the information about the estimated channels.

At the point when the auxiliary base station gets the appraisal of channel data, it will do the ideal asset designation for SUs with heterogeneous administration necessities. To tackle the asset distribution issue, we have the accompanying suppositions.

Let every channel be allocated to one SU. We use the binary index \( \rho_{k,n} \in \{0,1\} \) to represent the channel allocation, and \( \rho_{k,n} = 1 \) denotes that channel \( n \) is allocated to \( SU_k \); otherwise, \( \rho_{k,n} = 0 \).

Total power constraint [20] [21] the secondary base station total power is denoted by \( P_{total} \) and the SUs in each time slot. The transmit power for SU \( k \) on channel \( n \) denoted by \( p_{k,n} \)

The equation is

\[
\sum_{k=1}^{K1+k2} \sum_{n=1}^{N} \rho_{k,n} p_{k,n} \leq P_{total} \quad (1)
\]

Minimum-rate guarantee: a minimum rate threshold guarantees its transmission performance for SU \( k \) in \( K_A \). The minimum-rate threshold is denoted by \( R_{k}^{\text{min}} \). The SU \( k \) transmission rate should meet the equation

\[
R_{k} \geq R_{k}^{\text{min}} \quad \forall k \in K_A
\]

Proportional-fairness constraint: To ensure the fairness for SU \( k \) in \( K_B \), we present the standardized relative reasonableness variable

\[
\frac{R_{k}}{\sum_{i \in K_B} R_{i}} = \gamma_{k} \quad \forall k \in K_B
\]

Where \( \gamma_{k}, \forall k \in K_B \) are predefined values?

The capacity of the bandwidth for SU \( k \) should be

\[
R_{k} = \sum_{n=1}^{N} \rho_{k,n} \cdot W \cdot \log_{2} \left( \frac{1 + 1.5 \frac{p_{k,n} G_{k,n}}{n_{0}}}{1 + 0.2 \text{BER}_{\text{tar}}} \right) \gamma_{k} \quad \forall k \in K_A \cup K_B
\]

Table 1: Variable used in equation 4

<table>
<thead>
<tr>
<th>Variables</th>
<th>Meanings</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Transmission on each channel</td>
</tr>
<tr>
<td>BER_{\text{tar}}</td>
<td>Target bit error rate</td>
</tr>
<tr>
<td>G_{k,n}</td>
<td>Signal-to-noise ratio</td>
</tr>
<tr>
<td>h_{k,n}</td>
<td>Channel gain for SU( k ) on channel ( n )</td>
</tr>
<tr>
<td>n_{0}</td>
<td>Additive Gaussian white noise with zero mean</td>
</tr>
<tr>
<td>\sigma^2</td>
<td>Variances</td>
</tr>
</tbody>
</table>

The optimization equation is

\[
\max_{p_{k,n}} \sum_{k=1}^{K1+k2} R_{k}
\]

Subject to

\[
\sum_{k=1}^{K1+k2} \sum_{n=1}^{N} \rho_{k,n} p_{k,n} \leq P_{total}
\]

\[
p_{k,n} \geq 0 \quad \forall k, \forall n, \quad p_{k,n} \in \{0,1\} \quad \forall k, \forall n
\]

\[
\sum_{k=1}^{K1+k2} R_{k,n} = 1 \quad \forall n, \quad R_{k} \geq R_{k}^{\text{min}} \quad \forall k \in K_A
\]
Joint power and channel allocation using the aggressive discrete stochastic approximation algorithm

**Step 1: Initialization:**
Find out the number of available unused channels $N$ and SUs $K_1$ and $K_2$.

**Step 2:**
Every SU estimates the CSI and feeds it back to the secondary base station.

**Step 3:**
The secondary base station selects a channel allocation indicator matrix $X^{(1)} \in \Phi$. Set $\pi_{1, X^{(1)}} = 1$, $\pi_{1, X} = 0$ for all $X \neq X^{(1)}$.

**Step 4:**
For $l = 1, 2, ...$

a. Given $X^{(l)}$ combined with another uniformly chosen $\tilde{X}^{(l)} \in \Phi \setminus X^{(l)}$ at iteration time $l$, the secondary base station does the power allocation and computes $r[l, H[X^{(l)}]]$, $r[l, H[\tilde{X}^{(l)}]]$.

b. If $r[l, H[X^{(l)}]] < r[l, H[\tilde{X}^{(l)}]]$, set $X^{(l+1)} = \tilde{X}^{(l)}$; else set $X^{(l+1)} = X^{(l)}$.

c. The secondary base station updates all channel allocation subset occupation probabilities, $(\pi_{l+1} = \pi[l] + \epsilon[l] (D[l+1] - \pi[l]))$, with the decreasing step size, $\epsilon[l] = (1/l)$.

d. If $\pi_{l+1, X^{(l+1)}} > \pi_{l+1, X^{*}(l)}$, the base station sets $X^{*}(l+1) = X^{(l+1)}$; otherwise, it sets $X^{*}(l+1) = X^{(l)}$.

e. Output the channel allocation combination and the corresponding optimal power allocation.

f. Set $l \leftarrow l + 1$. End for.

**IV. Simulation result**
We utilize ns-2 reproduction bundle to mimic the proposed calculation utilizing the intellectual radio. At the MAC layer, we utilize IEEE 802.11. The system field considered for the reproduction is 1000m X 1000m over a level area for 70 seconds of reenactment time. All hubs have the same transmission scope of 250 meters. The mimicked movement is Constant Bit Rate (CBR) with a bundle size of 512 B. The reenactment settings and parameters are condensed in Table 1.

<table>
<thead>
<tr>
<th>No. of Nodes</th>
<th>20, 40, 60, 80, and 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area Size</td>
<td>1000m X 1000m</td>
</tr>
<tr>
<td>Mac</td>
<td>IEEE802.11</td>
</tr>
<tr>
<td>Transmission Range</td>
<td>250m</td>
</tr>
<tr>
<td>Simulation Time</td>
<td>70 sec</td>
</tr>
<tr>
<td>Traffic Source</td>
<td>CBR</td>
</tr>
<tr>
<td>Packet Size</td>
<td>1000B</td>
</tr>
<tr>
<td>Sources</td>
<td>4</td>
</tr>
<tr>
<td>Attackers</td>
<td>2</td>
</tr>
<tr>
<td>Nodes Speed</td>
<td>5, 10, 15, 20 and 25 m/s</td>
</tr>
</tbody>
</table>

Table 1: Simulation Environment


V. Conclusion
In this article, we have concentrated on the issue of asset portion in CRNs that backing heterogeneous administrations with blemished channel detecting. We have formulated the problem of resource allocation as a mixed-integer programming problem of joint access control and asset allotment to boost the aggregate framework limit and minimize the impedance to PUs when there are detecting blunders in the auxiliary system. The simulation results give a significant minimum rate guarantee. In future we can implement this algorithm and find the fairness of the performance under sensing errors.

REFERENCES
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