Estimation of Horizontal Handover Opportunity for SUs in Cognitive Wireless Networks

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Abstract

This paper analyzes horizontal handover opportunity issues of secondary users (SUs) in Cognitive Wireless Network. In order to enhance service quality with seamless spectrum handover in multiple cognitive wireless networks, we analyze handover opportunity for SU to determine drop and block probability. Then, we determine the number of sensed channels for guaranteeing quality of horizontal handover. Final are some numerical results.

I. Introduction

Cognitive Wireless Network (CWN) or Cognitive Radio Network (CRN) or Dynamic Spectrum Network (DSN) is technique allows Secondary Users (SUs) (low-priority) access to licensed spectrum of Primary User (PU) (high-priority) thereby significantly improving overall spectrum efficiency [1,2,3,4]. In order to seamless services, SUs have to perform handover calls when they move to other location in the system. So, handover opportunity estimation is an important issue in CWN. In this paper, the horizontal handover opportunity is analyzed based on queuing theory. Moreover the channels are reserved for performing horizontal handover to decrease the blocking and dropping calls.

The remainder of this paper is organized as follows. The system model is presented in section II. The performance of analysis of SUs' horizontal handover opportunity in CWN is considered in section III. Numerical results are showed in section IV. Finally, Section V conclusions this paper.

II. System model

In CWS, there are two types of network: primary and secondary network. The primary network has N licensed channels. The secondary network (SN) consists of cognitive base stations (CBSs) and SUs. Moreover, in each SN, CBS and SUs can connect to each other (CBS is a network's gateway). Each of them can use one of subsets N_k of N channels of PN for sensing channel and transmitting data. All of them are equipped with a cognitive radio transceiver that has the ability to sense at most L channels in sequence and access at most K channels simultaneously based on its hardware and technology constrains. CBS_k takes a role as a first winner [5]. Mean that, by using a local dedicated common control channel (CCC), CBS_k can send beacon messages to SUs to synchronize the network and exchange network information. When SUs want to joint into a network, they have to send Request to Register (RTR) and RTR_ACK message to CBS_k to get its dynamic ID number.

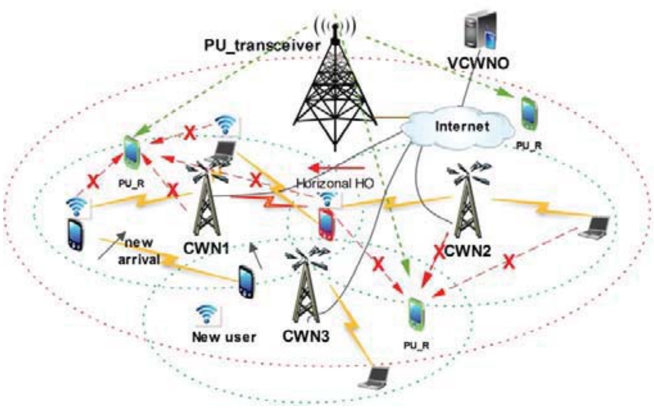

Figure 1: system model

In this paper, we propose a Virtual Cognitive Wireless Network Operator (VCWNO that can coordinate spectrum for lease among CWNs (spectrum broker), manage SUs,.etc. When transmitting data, SUs can move from this network to another one. So, in order to guarantee QoS of data transmission, SUs have to do handover horizontally. In next section, we will consider more detail to horizontal handover problem.

III. Performance analysis of horizontal handovers

In this session, in order to guarantee QoS for handover calls, we reserve dedicated channels for handover only. Assume that by assigning a portion of unlicensed channels exclusively for handover calls among N_k available channel in a CWN horizontal handover calls is more prioritized than originating calls. The arrival rate of original and horizontal handover calls, service rate of channel is λ_o, λ_h, μ respectively.

Firstly, under sensing algorithm and under number of channel N_k (allocated channels by VCWN for CWN_k), we find the expected number available channel. Then we estimate the blocking probability and handover dropping probability for handover calls.

A. Sensing algorithm

A management the detecting of the spectrum opportunities is required by spectrum sensing policy. This policy should assisted to identify which and how many channels are available to be used by the SUs. Therefore, when the percentage of the sensed channels out of the N_k channels increases, the throughput of the secondary network is increased, too..

Let $\overline{N_k^a}$ be the random number of the available channels of CWN_k at time slot t, it can be estimated as following:

$$\overline{N_k^a} = \sum_{n=0}^{N_k P_{sense}} n \binom{N_k P_{sense}}{n} (1-\delta)^n \, \delta^{(N_k P_{sense} - n)} \quad (1)$$

Where $N_k P_{sense}$ is number of the sensed channels out of N_k channels, δ_i is the probability of PUs on each channel. To simplify, let $\delta_i = \delta$ (for all i). Based on the system model, the P_{sense} highly depends on M_s and L. So, we need determine P_{sense} and L to maximize throughput of CWNs. By using DSP algorithm as [5], the percentage of the sensed channels P_{sense} and optimal number of channels L for each sensed SU can determined as following:

$$P_{sense} = \begin{cases} \dfrac{LM_s}{N_k} & , M_s < \left\lceil \dfrac{N_k}{L} \right\rceil \\ 1 & , M_s > \left\lceil \dfrac{N_k}{L} \right\rceil \end{cases} \quad (2)$$

$$L = \min\left(\left\lceil \frac{N_k}{M_s} \right\rceil, \left\lceil \frac{T_{max} - T_c}{2 t_s} \right\rceil \right) \quad (3)$$

Where $\left\lceil \dfrac{N_k}{L} \right\rceil$ is the N_k channels divided into distinct non-overlapped channel groups, M_s is number of sensing user (include of original users and horizontal handover secondary users), t_s is the sensing time requirement of each SU, T_{max} is the overall time slot duration, T_c is the time duration for the control messages. Each sensing user chooses independently and uniformly one of the groups and starts to sense L channels beginning by the first channel of the chosen groups.

Thus, when SUs want to joint into CWN, they should be preloaded by a sensing algorithm that determines how long to sense each channel, how many channels to sense, which channels to sense based on the sensing policy, how and which channels they can access to. From (1,2,3), the expected number of available channel for CWN_k can be estimated.

B. Vertical handover analysis

Let x be rate of available channel for reservation handover SUs. So, we have the number of available channel for reservation handover is $N_k^h = \left\lfloor x\overline{N_k^a} \right\rfloor$ .Number of channel is assigned exclusively for handover calls among expected N_k channels in a CWN_k (assume N_k^a is integer number): $\overline{N_k^r} = \overline{N_k^a} - \left\lfloor x\overline{N_k^a} \right\rfloor$. So, by applying birth and death model [6], we have the local balance equations:

$$\begin{aligned} n\mu P_n &= (\lambda_o + \lambda_h) P_{n-1} \ , \ 0 \le n \le \overline{N_k^r} \\ n\mu P_n &= \lambda_h P_{n-1} \qquad , \ \overline{N_k^r} < n \le \overline{N_k^a} \end{aligned} \quad (4)$$

The steady-state probability is:

$$P_n = \begin{cases} \dfrac{(\lambda_o+\lambda_h)^n}{\mu^n n!} P_o & , \ 0 \le n \le \overline{N_k^r} \\ \dfrac{(\lambda_o+\lambda_h)^{\overline{N_k^a} - \left\lfloor x\overline{N_k^a} \right\rfloor} \lambda_h^{n - \overline{N_k^a} + \left\lfloor x\overline{N_k^a} \right\rfloor}}{\mu^n n!} P_o & , \ \overline{N_k^r} < n \le \overline{N_k^a} \end{cases} \quad (5)$$

Where P_o calculated as following:

$$P_o = \left(\sum_{i=0}^{\overline{N_k^a} - \left\lceil x\overline{N_k^a} \right\rceil} \frac{(\lambda_o+\lambda_h)^i}{\mu^n i!} + \sum_{i=\overline{N_k^a} - \left\lceil x\overline{N_k^a} \right\rceil + 1}^{\overline{N_k^a}} \frac{(\lambda_o+\lambda_h)^{\overline{N_k^a} - \left\lceil x\overline{N_k^a} \right\rceil} \lambda_h^{i - \overline{N_k^a} + \left\lceil x\overline{N_k^a} \right\rceil}}{\mu^i i!} \right)^{-1}$$

(6)

Let P_b and P_d denote blocking probability and handover dropping probability. Then these are given by:

$$P_b = \sum_{n=\lfloor x\overline{N_k^a} \rfloor}^{\overline{N_k^r}} P_n \qquad (7)$$

$$P_d = P_{\overline{N_k^a}} = \frac{(\lambda_o + \lambda_h)^{\overline{N_k^r}} \lambda_h^{\lfloor x\overline{N_k^a} \rfloor}}{\mu^{\overline{N_k^a}} \overline{N_k^a}!} P_o \qquad (8)$$

From these equation (1,4,5,6,7,8), we can see that the blocking and dropping probability of handover SUs depend on a number of handover SUs and number of available channel. So, in order to reduce the blocking and dropping probability, CWN_k has to increase the number of sensing channels. Based on game theory approach, operator collects information of all CWNs and adjust spectrum size for balancing performance of overall system.

IV. Numerical results

In this section, we determine the expected number of the identified available channels. By performing the resource allocation with reservation for handover calls, we estimate the relation between admitted and accessed SUs with simulation results. Assume that, the number of channel that CWN_k leased from spectrum broker N_k = 12, 20, 36. To minimize sensing time and maximize throughput requirement, from (1) we estimate the expected number of available channels with $\overline{N_k^a}$ = 6, 10, 18, (N_k = 12, 20, 36) respectively. In figure 2, (let x = 15% and consider case $\overline{N_k^a}$ =10), when the number of the horizontal handover SUs is increase, the blocking probability increases gradually until all of them are blocked. By consequently, we decrease number of channels to sense is 12 and increase the number of channel to sense is 36, we can control blocking probability (increase or decrease). Due to limitation of space, we don't present the dropping probability here.

V. Conclusions

In this paper, we analyzed horizontal handover problem by applying continuous time Markov Chain Birth and Death process. Based on that, we determined the blocking probability and handover dropping probability. We proved that, by controlling threshold we can coordinate spectrum leasing in CWN system to guarantee quality of service for SUs. In the future work, we will consider more details about performing coordinated allocated spectrum to guarantee QoS for all CWN based on game theory approach.

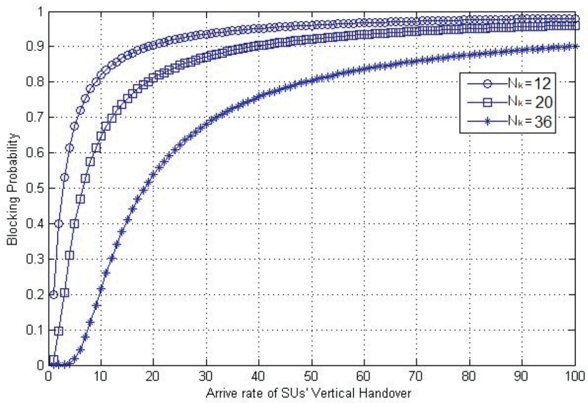

Figure.2. Blocking probability of Sus' vertical Handover

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Reference

[1] I.F.Akyildiz et al., "A Survey on Spectrum Management in Cognitive Radio Networks," IEEE Commun. Mag., vol. 46, no.4, pp.40-48, Apr.2008

[2] I.Akyildiz, W.Lee, M.Vuran, and S.Mohaty, "next generation/Dynamic Spectrum Access/Cognitive Radio Wirelss Networks: A Survey" Computer Networks (Elseiver), vol.50, no. 13, pp.2127-2159, Set, 2006.

[3] M. V. Nguyen, C. S. Hong, S. Lee; "Cross-Layer Optimization for Congestion and Power Control in OFDM-Based Multi-hop Cognitive Radio Networks"; IEEE Transactions on Communications, vol. 60, no. 8, pp. 2101-2112, August 2012.

[4] M. V. Nguyen, C. S. Hong, S. Lee; "Joint Rate Adaption, Power Control, and Spectrum Allocation in OFDMA-Based Multi-hop CRNs"; IEICE Transactions on Communications, vol. E96-B, no. 01, Jan. 2013.

[5] A. Alsharani, X.Shen, and L.Xie, "A cooerative MAC with efficient spectrum sensing algorithm for Distributed opportunistic spectrum networks." JSAC-2009.

[6] Sheldon M.Rosss, "Introduction to probability Models" 10th Edition.