

Adaptive Sensing Scheduling with Hybrid Sensing Model

Chuan Pham, Choong Seon Hong
 Department of Computer Engineering, Kyung Hee University
 E-mail: {pchuan, cshong}@khu.ac.kr

Abstract: Spectrum sensing scheduling is one of key interests in cognitive radio networks. In this paper, our main objective is to find a good sensing scheme which provides more spectrum access opportunities for secondary users without interfering the primary users of the licensed network. More importantly, we have developed a sensing algorithm which can reduce the sensing overhead. As a result, this paper has been focused on the scheduling sensing algorithm which reduces the sensing overhead. This method can improve the transmission time on each channel.

Index terms – Cognitive radio networks, spectrum sensing scheduling, reactive sensing, proactive sensing,

1. Introduction

Cognitive radio networks have attracted considerable amount of attention in recent years [7],[8],[9]. There are many fields of researching in this area such as: scheduling sensing, optimal sensing, spectrum handoff... This paper will focus on a method of scheduling sensing.

On the secondary network (SN) of cognitive radio network (CRN), each secondary user must detect opportunistic spectrum usage to transmit data. Spectrum sensing, an important requirement in cognitive radio network, enables unlicensed users to adapt to the environment by detecting unused spectrum partition without causing interference to the primary network. However, it has been equipped with only one radio interface. It can't sense while transmitting data and otherwise. Detecting opportunities by sensing, it must incur during time transmission. Therefore, there is strong competition between spectrum sensing time to find idle chances of each channel and transmission time. There are several well-known PHY-layer detection methods such as energy detection, matched filter and feature detection [3],[4],[5] have been proposed as candidates for the PHY-layer sensing. On the other hand, the MAC-layer sensing determines which channel must be sensed and how to allocate channel fairly.

The concept of spectrum handoff in cognitive radio networks (CRNs) is a method choosing another channel which collects efficiently spectrum holes. In 2008, H.Kim and K.G.Shin proposed the optimization of the sensing period in each channel [2]. In this study, authors proposed the reactive sensing method and proactive sensing method. Then, they found an optimization method in order to maximize the discovery of spectrum opportunities. In [2], proactive and reactive sensing method were discussed with Queueing Theory to provide a queueing network model of the primary and secondary networks.

In this paper, we review on two methods reactive sensing and proactive sensing scheduling. After that, we find an algorithm to enhance the overhead sensing on each channel.

The rest of the paper is organized as follows: section 2 presents the network model and the assumptions. Section 3 presents advantages and disadvantages of two method reactive sensing and proactive sensing schedule. Then we proposed the hybrid method of sensing scheduling. Section 4, we present the simulation result of the model. Finally, section 5 concludes the paper.

2. Preliminaries

2.1. Network topology

This paper assumes that a group of SUs forms a single-hop wireless SN interfering or cooperating with the transmission range of which there are no other SNs interfering or cooperating with the SN. While an SU is transmitting, other SUs must be silent. In this model, we just focus on status of one SU which is sensing and transmitting on N channels with bandwidth W. we assume that every SU in the SN is equipped with a unique antenna that can be tuned to any combination of N consecutive licensed channels. In addition, this paper also assume that all SUs in an SN should participate in sensing a channel at the same time for each scheduled measurement period to enhance the detection of PU signals even. Sensing information will be collected and coordinated by base station (BS). So that, all cognitive functions are centralized and maintained by BS.

This paper focuses on scheduling sensing of each SU to avoid interference from PUs and get more opportunities transmitting data. In traditional method, SU must periodically sense on each current operating channel. When the current channel conditions are worse or PU appear and reclaim the channel, SUs need to stop transmitting data and find other opportunities on available channels to continuously transmit data

(spectrum handoff) In this paper, we focus on the reactive sensing method and proactive sensing schedule method. Then we propose the better algorithm to get the spectrum holes.

3. Proposed mechanism

In this section, we review two kinds of sensing schemes in the literature including reactive and proactive sensing scheduling. Then, we propose a novel scheme in which we consider about reducing the sensing overhead.

3.1. Reactive sensing scheduling

In [2], logical channel is defined by a pool of available channels which are discovered by sensing. And the home channel [2] is the term which represents a licensed channel which is merged into the logical channel and being utilized by SUs.

In this paper, we assume that when the bandwidth requires on the SN. An SU must sense more than one channel to find more opportunities to transmit data. In the reactive sensing method, each SU transmits on an available channel with transmission time T_s until the channel is reclaimed by PUs. It will sense sequentially another channel to find an available channel. Each sensing on the channel i , it takes T_i^i time. This is the time SU wasting for sensing. This method is also called on-demand sensing.

The advantages of this method are easy for sensing and low cost for sensing time. The logical channel in this method is has only one available channel. An SU can not detect available channels when transmitting data. Therefore, SUs can not seek more bandwidth from just a single home channel. With more home channels in a logical channel, a SU can transmit data with higher data rate. Reactive method also uses the period sensing time T_p if all channels are busy. After T_p time, the sensing will be continued on the first channel. Because the SU is often bound by hardware constraints so that it can only take a fixed number of samples at a time. In this work, the value of T_1 is given as 1ms [6], while the length of T_p can be changed, which reflects variable sensing schedules. Likewise, due to many higher-layer concerns such as coordination and synchronization, often only a set of discrete T_p values are allowed in a practical system. For example, in 802.22 WRAN, T_p value may only take values that are multiples of a MAC frame size 10 ms.

3.2. Proactive sensing scheduling

In [4], the authors prosed the method proactive sensing to discover more idle channels. In this method, each channel we should be sensed periodically with its own sensing period time T_p^i . Although the period sensing is performed on every channel independently, the

concurrent sensing of N channels must be schedule random to not occur. Proactive sensing is performed by periodic sensing and on-demand sensing [2]. Period sensing process will be occurred after T_p^i on channel i . If on an available channel i , the transmission is interrupted by reclaiming of PU, on-demand sensing will be started sequentially another channel to find an available channel. The benefit of proactive sensing is that it can find other available channels when it is transmitting and be faster than reactive sensing. The logical channel will have more available channels at one time. Therefore, SU can transmit packets with higher data rate. However, proactive sensing scheduling has a trade-off between sensing time overhead and opportunities transmission time.

Give T_{OFF}^i is the idle time on channel i , T_t^i is the transmission time. The maximum T_t^{*i} is calculated in (1).

$$T_t^{*i} = T_{OFF}^i - kT_i^i \quad (1)$$

while k is times of sensing in the idle time

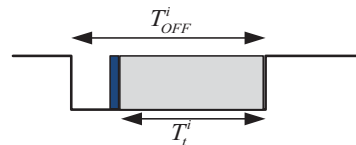


Fig. 1 The illustration of idle time

3.3. Hybrid sensing scheduling

All originality of the proposed mechanism lies in this part of the paper. In proactive sensing, we was taken account to the times of sensing in the idle duration. Because all in the sensing period, SU can't transmit data or interrupt transmit data to sensing. In proactive sensing, the sensing still occurs again and again although channel 1 is idle. It wastes much time for sensing.

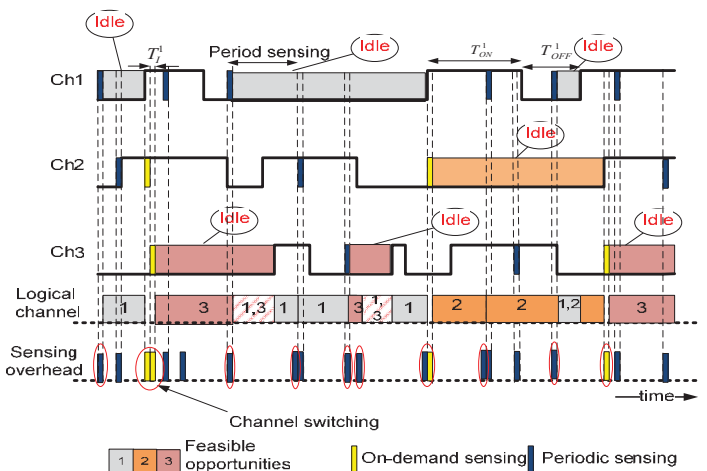


Fig.2 Hybrid sensing scheduling

From (1), we state that when SU discovers idle channel, the transmission will be start and stop sensing demand. This way can be improve the transmission time and not interrupt SU. It is combined from reactive sensing scheduling and proactive sensing scheduling. When the channel is reclaimed by PU, the period sensing will be started again. The period sensing process just demands on each channel when this channel is occupied by PU. The expected transmission time is given by equation (2)

$$T_t^{*i} = T_{OFF}^i - T_i^i \quad (2)$$

4. Simulation and numeric results

For the performance evaluation proposed in this paper, we were implemented in a discrete event simulator. We simulated 3 random channels with three types of sensing scheduling. We assumed that each sensing times takes 3ms and the period sensing on each channel takes 10ms. In this simulation, We summed all the transmitting time in the logical channel. Fig 3 shows that total transmission time in hybrid sensing is better than proactive and reactive sensing (testing time is 100000ms).

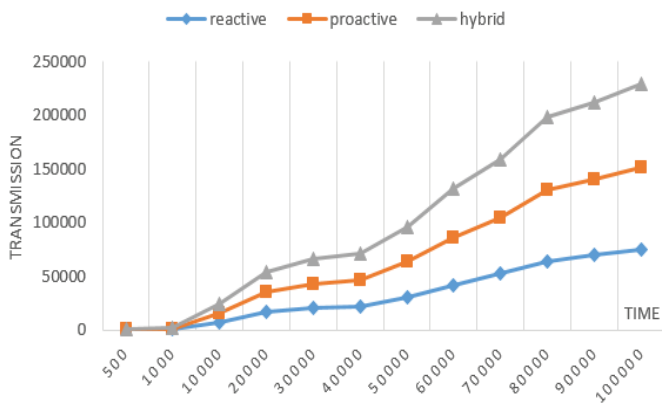


Fig. 3 Transmission time with reactive sensing/proactive sensing/hybrid sensing

5. Conclusions

In this paper, we discussed about sensing scheduling in-band spectrum sensing of IEEE 8.2.22 standard. We propose the hybrid sensing scheduling which combines reactive sensing schedule and proactive sensing schedule. This method minimizes sensing overhead on each channel. However, in this paper we didn't care the optimization period sensing and handoff sensing sequence. These parameters also lead to increase sensing overhead

Acknowledgment

"This research was supported by the MSIP(Ministry of Science, ICT&Future Planning), Korea, under the ITRC(Information Technology Research Center) support

program supervised by the NIPA(National IT Industry Promotion Agency)" (NIPA-2013-(H0301-13-2001). Dr. CS Hong is the corresponding author

6. References

- [1] J. Mitola III, "Cognitive radio: Model-based competence for software radios," Ph.D. dissertation, Dept. of Teleinformatics, KTH, 1999.
- [2] H. Kim and K. G. Shin, "Efficient discovery of spectrum opportunities with MAC-layer sensing in cognitive radio networks," *IEEE Transactions on Mobile Computing*, vol. 7, no. 5, pp. 533-545, May 2008
- [3] D. Cabric, S.M. Mishra, and R.W. Brodersen, "Implementation Issues in Spectrum Sensing for Cognitive Radios," Proc. Asilomar Conf. Signals, Systems, and Computers, pp. 772-776, Nov. 2004.
- [4] H. Tang, "Some Physical Layer Issues of Wide-Band Cognitive Radio Systems," Proc. IEEE Int'l Symp. Dynamic Spectrum Access Networks (DySPAN '05), pp. 151-159, Nov. 2005.
- [5] S. Shankar, C. Cordeiro, and K. Challapali, "Spectrum Agile Radios: Utilization and Sensing Architectures," Proc. IEEE Int'l Symp. Dynamic Spectrum Access Networks (DySPAN '05), pp. 160-169, Nov. 2005.
- [6] H. Kim and K. G. Shin. In-band spectrum sensing in cognitive radio networks: energy detection or feature detection? In Proceedings of the 14th ACM international conference on mobile computing and networking (Mobicom '08), pages 14-25, 2008
- [7]. Mui Van Nguyen, Choong Seon Hong, Sungwon Lee, "Cross-layer optimization for congestion and power control in OFDM-based multi-hop cognitive radio networks," *IEEE Trans. Commun.*, vol. 60, no. 8, pp. 2101-2112, Aug. 2012
- [8]. Mui Van Nguyen, Trung Q. Duong, Choong Seon Hong, Sungwon Lee, Yan Zhang; "Optimal and Sub-Optimal Resource Allocation in Multi-hop Cognitive Radio Networks with Primary User Outage Constraint"; *IET Networks*, vol .1, no. 2, pp. 47-57, June 2012.
- [9]. Mui Van Nguyen, Choong Seon Hong, Sungwon 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.