

STUDY ON SPECTRUM MOBILITY OCCURS IN COGNITIVE RADIO NETWORKS

SAUMYA SRIVASTAVA

Department of ECE, BBD University, LUCKNOW

Abstract- Cognitive radio is one of the technologies which has the possibility to improve the spectrum utilization and network performance. Spectrum Mobility is an critical part in cognitive radio network that not only guarantees favored quality of service of primary users but also grants flexible service for secondary users. Spectrum Mobility occurs when the primary user appears in the licensed band occupied by secondary user and it is used to avoid interference between primary and secondary users. This paper provides a organized current summary of spectrum mobility process, various performance metrics and challenges regarding spectrum mobility are pointed out and finally a number of promising concepts and schemes are briefly presented.

Keywords: Cognitive radio, spectrum holes, spectrum handoff, handoff delay.

1. INTRODUCTION

With the increase in wireless technologies there is no increase in radio spectrum and it has been limited. Every country's government agencies regulate and allocate limited spectrum to avoid interference. From studies it is clear that spectrum is not occupied completely many of the times and much of licensed band remains idle for durations which is a waste of available resource. Studies have proved that there exist unoccupied spaces in the given spectrum and these are considered as spectrum holes as is clearly shown in fig.1

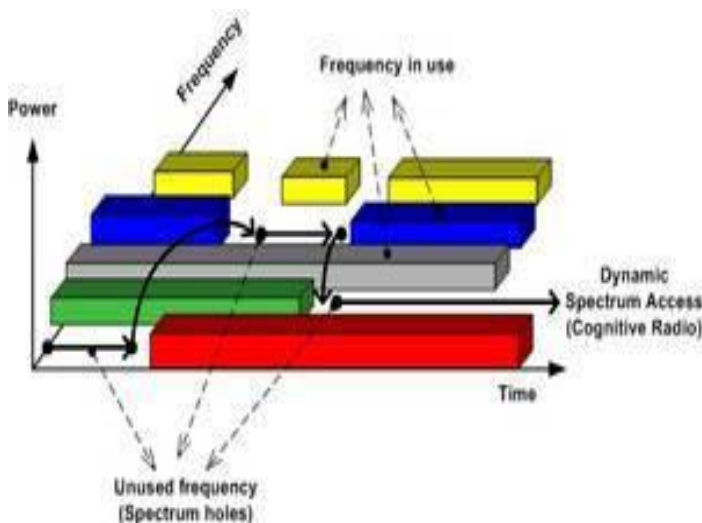


Fig 1: Figure specifying spectrum holes

These existence of spectrum holes inspire researchers to bring cognitive radio as new a field to proficiently utilize radio spectrum .According to studies policy of static spectrum allocation offers inefficient use of radio spectrum. cognitive radio also sets an important position in cognitive radio.

1.1 Cognitive Radio

Cognitive radio Allows the access to spectrum at the time when licensed user. Secondary users or un authorised users use white hole when it is vacant or unused of PU thus maintaining Quality of Service for PU as they are the band owners.[1] The cognitive radio balances between PU and SU, as it is always ready to serve SU at the same time promising acceptable interference level to the PU [1] To achieve so, cognitive radio has to sense spectrum in an optimistic way to sense white holes, vacant bands.

Spectrum sensing performed by cognitive radio must locate the existence or nonexistence of PU. If a PU is found then the SU must instantly vacant the band for maintaining Quality of Service for PU. For spectrum sensing numerous techniques can be used like radio identification base sensing, Matched Filter, Cyclo stationary detection ,energy detection ,sensing with numerous antennas, waveform base sensing and cooperative sensing. Cooperative Spectrum sensing is the most refined and accurate as per its mechanism in merging the results of sensing of many cognitive radio nodes optimizing the perception of surrounding environment to reach to the suitable decision of spectrum exploiting [2].

1.2 Spectrum Management Framework

Spectrum Sensing: Spectrum sensing is a key function of cognitive radio to prevent the injurious obstruction with license users and identify the accessible spectrum for improving the spectrum's utilization. Spectrum sensing aims to resolve spectrum accessibility and the occurrence of the licensed users. Detection performance is often compromised with multipath fading, shadowing and receiver uncertainty issues. To mitigate the force of these issues, cooperative spectrum sensing has been shown to be an effective method.

Spectrum Decision: Based on information of spectrum sensing, a spectrum band is examined and supreme accessible spectrum is selected for transmission. This portion is focused mainly on spectrum availability, rate of communication and eminence of service necessities

Spectrum Sharing: Spectrum sharing is to distribute the spectrum holes moderately among the secondary user bearing in mind usage rate. Spectrum sharing is the simultaneous usage of a specific radio frequency band in a specific geographical area by a number of independent entities, leveraged through mechanisms other than traditional multiple and random-access techniques.

Spectrum Mobility: If the particular segment of the band is needed by a licensed user, the communication needs be continued in another unoccupied portion.

Spectrum Management: Spectrum management is to forecast how long the spectrum holes are likely to remain available for use to the unlicensed users. The CR network (also called the dynamic spectrum access network, secondary network, or unlicensed network) does not have a license to operate in a desired band. Hence, additional functionality is required for CR users to share the licensed spectrum band. CR networks also can be equipped with CR base stations that provide single-hop connection to CR users. Finally, CR networks may include spectrum brokers that play a role in distributing the spectrum resources among different CR networks.

This paper gives us a general idea of cognitive radio systems. Specially, the main focus of conversation in this paper is on spectrum mobility or handoff which is serious and difficult part of cognitive radio networks. Various handoff algorithms are described. This paper will discover the matter of handoff delay caused by spectrum mobility process and how it depends on the handoff schemes involved in handoff process.

2. SPECTRUM MOBILITY

Spectrum mobility allows the secondary users to switch to idle channels. Spectrum mobility occurs when the primary user occurs in the band engaged by secondary user. Since these secondary users has no power over the resource accessibility, thus

secondary system must be planned to sense leftover spectrum as quickly as possible and switch to next idle piece of spectrum as soon as the primary user appears [5]. The most essential and challenging issues in spectrum mobility is the coexistence of secondary users with primary ones, to avoid interference to primary users without any cooperation with primary network and attain a flawless communication .Below the method of spectrum mobility has been discussed.

2.1 Spectrum Mobility Process

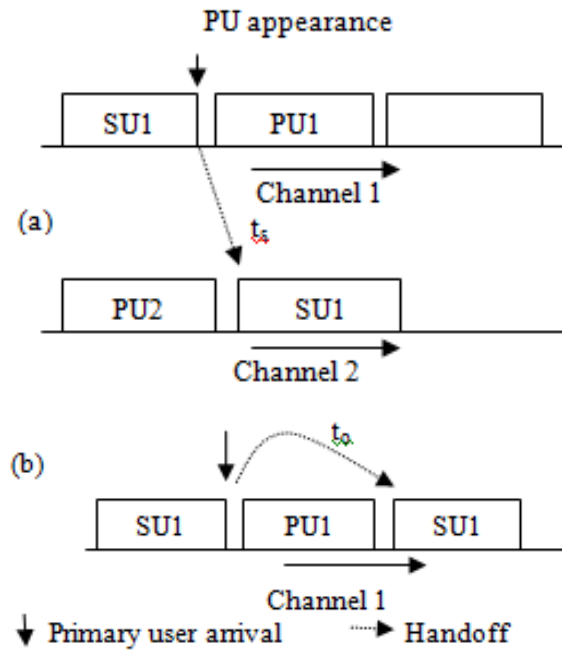


Figure 2: An example of channel selection in spectrum mobility

Here several spectrum handoffs take place during packet transmission. In this figure PU stands for primary user likewise SU stands for secondary user.

- first of all, let the secondary user selects channel 1 and establish transmits its packets. Solid arrow shows disruption due to emergence or arrival of PU on channel 1.
- When a SU is interrupted by PU, there are two probable cases. In the first case (a), when the SU is interrupted by PU, it pause its transmission, modify its operating channel to other channel, like channel 2 and recommence its transmission. A interruption here arises because of switching, and it is referred as handoff delay (denoted by t_s).
- However, at second disruption in channel 2, in other case (b) , SU stays on current channel 2. It wishes to wait until high priority PU of channel 2 finish its transmission; here handoff delay is the busy period that is taken by PU to terminate its transmission, denoted by t_o .

CR user mobility deals with the motion of CR in the network (Lee and Cho, 2013). The mobility is one of the information parameter for the spectrum handoff (Christian et al., 2012).

3. HANDOFF CONCEPT

Spectrum handoff occurs due to two reasons: when the primary users show at its licensed band and when the secondary user needs a improved channel in terms of user demand quality. In both cases secondary users vacate the current operation channel and jump to another appropriate channel in order to resume their unfinished transmission; In general, according to the target channel selection methods, spectrum handoff mechanisms can be classified into various techniques .

A related method will be repeated if SU is interrupted by PU appearance on the selected channel. Note that the appearance of PU is stochastic in nature; it adds more complexity to handoff process and is difficult to achieve fast and smooth spectrum transition limited to performance deprivation of secondary users during handoff .

Thus the method of spectrum handoff can be realized in two phases. How much power is used for transmission. Power control in cognitive radio mitigates unnecessary interference. Further discussion of interference management is absent here to reduce the obscurity as spectrum handoff is the area of discussion.

4. VARIOUS HANDOFF TECHNIQUES

4.1 Reactive and proactive sensing spectrum handoff

In proactive spectrum handoff, secondary users make the target channels for spectrum handoff prepared before its transmission; usually in this process secondary users observe the channel position for long time then based on their inspection and historical statistic make a set of existing channels. In case of spectrum handoff secondary users select one channel in such specified place [7].

In reactive spectrum handoff, the target channel is found on demand; here at the spectrum handoff moment, a spectrum sensing is performed and the best instantaneous results will be used as the target channel. Intuitively, staying in the current function channel and stay until the primary user is done then resuming the awaiting transmission.

4.2 Prediction Based Spectrum Handoff

In order to improve the performance of secondary users, a Markov decision process framework is planned to chose the next channel in case of handoff in [14], [15]; they assumed primary network follows a discrete-time Markov process; provided that secondary users can adaptively select the finest target channel. They resultant the best access strategy using linear programming technique. However, they ignore the result of secondary users' traffic; after a while, the secondary users' actions affects the statistics of channel occupancy. In [6] as the authors mentioned, the Markovian traffic assumption might not sufficiently precise and a more general traffic models are preferred;

PBSM is composed of three processes -spectrum prediction, user mobility prediction, and channel selection.

4.3 Spectrum handoff using Backup channel Solution

In order to cope up with delay sensitive applications and error of prediction, LEE [3] proposes a backup channel solution. Here the secondary users can hold a additional channel for a limited time which can assist in seamless communication rapidly moreover two possibilities are considered. One is full backup solution and the other one is short time backup key In the first scenario, secondary user reserves at least one backup channel all the time however it reduces the spectrum consumption To address this problem, other scenario is considered, where the backup channel is kept for a short interval of time.

4.4 Spectrum Handoff Using Preemptive Resume Priority M/G/1

In CRN channel is allocated on the basis of priority to primary and secondary user, for modeling and analysis

preemptive resume priority (PRP) M/G/1 queue form can be used. One of the most precise models for characterizing the spectrum usage behaviors is the PRP M/G/1 queuing model which is recently received significant attention by researchers. In [1] the secondary users cannot skip to another channel at the moment of primary users arriving; they have to stay at current function channel until the primary user's transmission is finished. Although [7] they allowed the secondary users to change their current operation channel but they did not consider the traffic load of interrupted users which is diverted to other channels; therefore such model cannot reveal the interaction between a model in which consider all mentioned issues in spectrum handoff procedure.

In [1], using PRP M/G/1 model, authors evaluate proactive and reactive scenario based on sensing time, they also showed which one of scenarios are appropriate. In [2], the way of target channel selection was discussed in order to have the least total service time with multiple spectrum handoffs. They proposed a PRP M/G/1 queuing network model to evaluate total service time for various target channel selection channels. Recently in [1], [2] the authors proposed.

5. CLASSIFICATION OF MOBILITY BASED SPECTRUM HANDOFF SCHEMES

This section provides the generic classification of spectrum handoff schemes for CR networks which are shown in Fig. 8 and are explained as follows. This section also provides comparative analysis of different spectrum handoff schemes in terms of their applied domain, complexity, the performance of spectrum handoff scheme and main constraints of it.

Spectrum Mobility based Handoff Techniques	Proactive/Reactive Technique
Intra cell / Intra pool Spectrum Handoff scheme	Reactive type of Spectrum Handoff
Inter cell /Intra pool Spectrum Handoff scheme	Proactive type of Spectrum Handoff
Inter cell / Inter pool Spectrum Handoff scheme	Proactive type of Spectrum Handoff
Intra cell / Intra pool Spectrum Handoff scheme	Reactive type of Spectrum Handoff

Table 1: *classification of Mobility Based Spectrum Handoff Techniques on the basis of Proactive / Reactive technique*

5.1. Intra cell / Intra pool Spectrum Handoff Scheme

In intra cell /intra pool spectrum handoff scheme, CRs handoff in the same spectrum pool with out changing the serving BS. This type of handoff occurs when PUS appear in the network. Hence, this handoff scheme is a reactive type of spectrum handoff scheme.

5.2. Inter cell / Intra pool spectrum handoff scheme

In inter cell /intra pool spectrum handoff scheme, CRs do not change the spectrum pool but change the serving BS. CR uses same type of spectrum band after spectrum handoff. This type of spectrum handoff proactive type of handoff scheme. This type of spectrum handoff scheme uses the same spectrum pool and do not require RF front end reconfiguration.

5.3 Inter cell / Inter pool spectrum handoff scheme

In inter cell/ inter pool spectrum handoff scheme, CRs handoff in different spectrum pool and change the serving BS. Hence, CRs change its original cell to a new target cell This spectrum handoff is proactive type in nature. Spectrum handoff is time consuming process as SUs need to search for the available spectrum and reconfigure their operating frequency at the RF front-ends dynamically and abruptly whenever spectrum availability changes, due to which a significant switching latency also called spectrum handoff delay is introduced. It includes time taken in spectrum sensing, analysis, decision and spectrum switching. Hence it is better to reduce unnecessary spectrum handoffs.

5.4 Intra cell / Intra pool Spectrum Handoff scheme

In intra cell / inter pool spectrum handoff scheme, CRs handoff in the different spectrum pool without change in the serving BS. CRs perform reactive type of spectrum handoff on the appearance of PUs. To reduce the handoff latency a list of backup channel is maintained so that SU can switch to one of the channels among the list quickly whenever handoff took place.

6. CONCLUSION

Cognitive radios provide an enormous unused prospective to wireless systems. In this paper, we have provided a organized general idea on cognitive radio systems. Due to huge explosive research in this field and diversity of existing technical approaches, this paper had a difficulty in covering all the related topics. Instead, the main focus in this paper has been on spectrum mobility in cognitive radio networks which is the most crucial part in cognitive cycle. In this paper we surveyed spectrum handoff in cognitive radio networks which is discussed in smaller amount than other main functionalities in CR networks. Moreover, some works are also mentioned. Due to accuracy and reliability, PRP M/G/1 model have been discussed further than others. We have considered divergent strategies for spectrum handoff. Its key features, performance metrics and challenges engaged are showed in this paper. We expect that this article can assist researchers and it provides a glimpse of technical challenges in spectrum mobility.

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