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A Handoff Using Virtual Channel Scheme for Cognitive Radio Networks

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Abstract- Cognitive radio emerges as an impactful technology that can enhance the radio spectrum utilization and network performance. Spectrum handoff is one of the important feature in cognitive radio network that not only contributes required Qos to primary users but also provide seamless communication for secondary users. Spectrum handoff occurs when the primary user claims the channel occupied by the secondary user, since the secondary users are unlicensed users having no right to access the channel thus secondary user is required to vacate the channel and resume its transmission to the next available idle channel. The process of spectrum handoff however brings it with a notable amount of delay which minimizes the efficiency of network. In this paper we propose a virtual channel approach to optimize the handoff process by reducing the waiting time for secondary user for spectrum handoff and comparing it to existing random channel selection approach. Simulation results claims the validity of our approach, it reduces the waiting time of secondary user and increases the overall capacity of network compared to random channel selection scheme.
Key words: Cognitive Radio, Spectrum Handoff, Virtual Channel, Secondary user waiting time

I. INTRODUCTION

Recently the shortage of spectrum is becoming a critical issue for the new high data rate wireless communication services. The limited available spectrum and underutilization of licensed spectra motivates to expand the availability of spectrum with smarter technology. This also inspired many researchers to pay efforts to cognitive radio technology that can exploit the existing spectrum holes opportunistically [1] [3]. Cognitive radio has four main capabilities as spectrum sensing, spectrum decision, spectrum sharing and spectrum mobility or spectrum handoff [4]. Spectrum handoff is one of the critical and important features of cognitive cycle [2] that provide seamless service in case of primary user appearance in a channel occupied by secondary user; it allows the secondary user to resume its ongoing transmission on another idle channel. For a secondary user, there are two scenarios when the channel occupied by it is claimed by primary or licensed user. In first scenario, it can suspend its transmission on current channel, look up for an idle channel and then switch and resumes its transmission on to this new available channel. Secondly it can opt to stay on current original channel, wait for completion of primary user transmission and resumes its transmission on the same channel as soon as the primary user vacates the channel. In the former scenario, cognitive radio has to sense the spectrum for the availability of channel, prepares and updates the candidate list comprising of available channels at that instant and then selection of one of the one channel as target channel is done for the purpose of spectrum handoff while in later case, the cognitive radio user has to wait for the completion of primary user transmission. In a nutshell, both stay and change scenarios [8] [10] require an extra time for which the secondary user has to wait in order to accomplish its interrupted transmission. This extra time or the waiting time of secondary user decreases the overall capacity of a network therefore impacts the efficiency of network. Thus we are motivated to improve the efficiency of network by reducing the secondary user waiting time and increasing the overall capacity of network. The main contribution of this paper is to propose virtual channel scheme in which virtual channel is formed by the gathering of available free slots in the spectrum without the necessity of sensing performed by the individual cognitive user. This virtual channel scheme is proposed to utilize the concept of both stay and change case simultaneously. The rest of paper is organized as follows. Section II describes the existing handoff schemes. Next section summarizes the concept of virtual channel scheme that can fairly minimize the secondary user waiting time. Simulation results are presented in section V, followed by conclusion in section VI.

II. RELATED WORK

Many researchers are exploring various handoff schemes for the optimized handoff process. Few of these precursor schemes are summarized hereby:

Considering the time instant of target channel selection the author in [5] [9] categorizes the handoff schemes in to reactive sensing spectrum handoff and proactive sensing spectrum handoff. In reactive sensing the target channel is selected after the detection of primary user or at the time of spectrum handoff while in proactive spectrum handoff target channels are selected beforehand. Although in reactive sensing much of the time is wasted on the sensing of channels as sensing is done on-demand while in proactive sensing spectrum handoff there is always probability of erroneous channel selection as target channel since selection is done on the basis of observations. In the study [9], the author suggested a partially observable decision process for spectrum handoff by partially sensing the frequency channels for spectrum handoff in order to reduce the sensing times. To address the collisions between primary and secondary user, a common hopping based spectrum handoff scheme is introduced, simulation results shows the effectiveness of scheme in multiuser environment [11]. A backup channel concept [12] and guard band channel solution is described for delay sensitive applications in study [13] [14]. Backup channel solution however reduces the spectrum utilization as one of the channels is always reserved for backup during the spectrum handoff. Spectrum handoff in opportunistic and negotiated situation is considered in study [6], in opportunistic scenario as soon as the primary user appears; secondary user has to desert the channel while on the other hand in negotiated scenario primary user is allocated to a vacant channel if idle channel is available. If no channel is available for the primary user only then the channel occupied by secondary user is allotted to primary user. Simulations results show the effectiveness of opportunistic scenario as compare to negotiated scenario. In the study [15], a cognitive learning algorithm is introduced in order to determine the channel sensing sequence for the selection of target channel during spectrum handoff. The cognitive radio learns and stores the data of sensing on the basis of idle probability of a channel. This sensing information is utilized to select target channel on the basis of maximum idle probability to accomplish the handoff process.

III. PROPOSED HANDOFF SCHEME

A. *System Model*

In this paper, we assume a slotted system with *N*, number of licensed channels in which user's transmission on a channel is partitioned into slots. The primary user activity is assumed to follow an ON/OFF pattern based on discrete- time, two-state Markov chain [7]. Thus the channel has two occupancy states ON state indicates the presence of primary user that is busy period while OFF state indicates a spectrum opportunity for the secondary user. A centralized approach is utilized for sensing purpose in which a central entity or a base station senses all the channels and all the functions are controlled and managed by this central entity. In order to reduce the sensing overhead at the central entity, a partially observable decision process [10] is used which is based on partially observed information and the observations from the environment. The primary objective is to minimize the waiting time of secondary user, increase the capacity of network and reduces the complexity of handoff process through proposed virtual channel scheme.

B. *Virtual Channel*

A virtual channel is a virtually exist channel in a network which comprises of all the available spectrum holes or free slices of the independent channels of network. Virtual channel access is only provided to secondary user for connection and transmission purpose. As soon as the secondary user is involved in transmission, it needs not to sense the channels for available slice else central entity is there to partially sense the environment and all the information regarding the free slots is used to gather the free slices on to a virtual channel. This virtual channel is supposed to be updated periodically according to the sensing at the central base station or entity. It thus simplifies the complex process of spectrum management in cognitive radio networks.

C. *Communication On Virtual Channel*

Communication on virtual channel is meant for secondary user only. As and when a new secondary user arrives for data transmission, it firstly access the virtual channel, as the virtual channel is formed of free available slices of spectrum thus secondary user establish a link connection on to a virtual channel, this virtual connection is ultimately a connection to concerned channel. Let us assume that a secondary user *S* wants to transmit its data then firstly it need not to sense the entire spectrum band, it only require to access the virtual channel, if the second slot of virtual channel is available at a particular event then secondary user establish a link over this available slot. As discussed in previous section that the virtual channel is actually consist of available slots of licensed

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channels say the slot over which secondary user establish the connection is of channel 1 thus ultimately the connection is established to channel 1. During updating of virtual channel, secondary user stops transmission for a while and again resumes its transmission on to next available slot on virtual channel. Thus the handoff process is minimized to switching from one slot to another on a single virtual channel only.

In this way, the time consuming sensing of entire spectrum and then switching from one channel to another channel of secondary or cognitive radio user is reduced considerably to only a single virtual channel. Moreover as the extra waiting time is reduced for a secondary user thus more and more secondary user can be accommodated in a network that can increase the overall capacity of network.

The process of spectrum handoff using virtual channel can be demonstrated with the help of flow chart as:

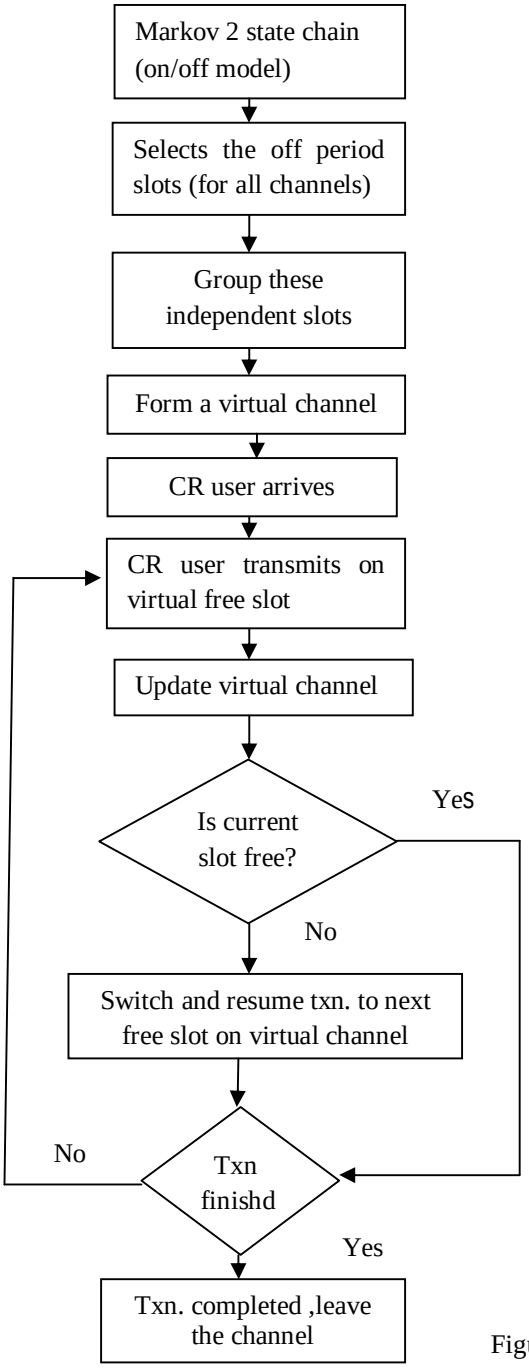

Figure 1.Flow chart for proposed approach

IV. SIMULATION

For simulation purpose MATLAB software is used. Five independent primary channels are simulated as ON/OFF discrete two state Markov chain process. Eight secondary users are involved and number of waiting time slots as per eight secondary users is simulated in figure 2. For comparative analysis random channel selection scheme is used where the target channel is selected randomly. Simulation results show that the waiting time of secondary users notably decreases and in few secondary users it is almost zero in our proposed approach.

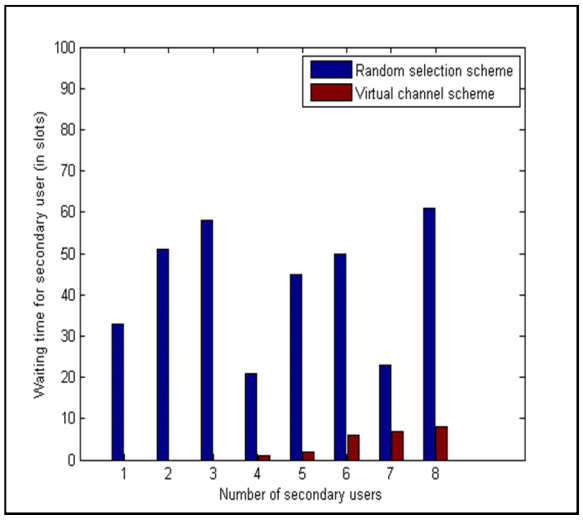

Figure 2 Comparative plot for the waiting time for secondary user

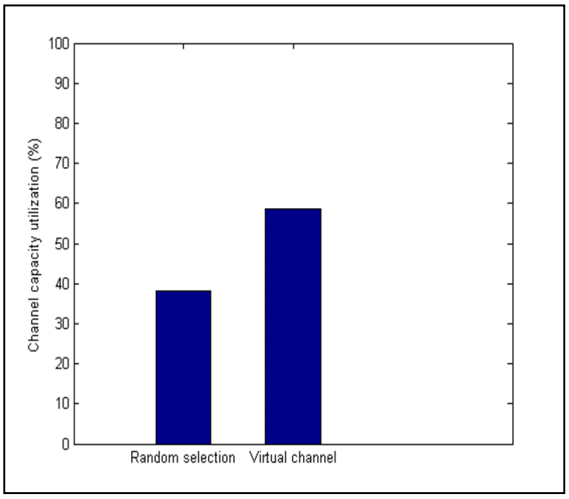

Figure 3.Comparative plot for channel capacity utilization for secondary user

As we have already discussed that as the number of waiting time slots decreases, more and more secondary users can be accommodated in a network thereby increase the overall capacity of network. Figure 3 shows that the capacity of network increases as compare to random channel selection scheme. Both parameters outperforms the existing random selection scheme in a noteworthy way.

V. CONCLUSION

In this paper we have suggested virtual channel selection scheme that decreases the waiting time of secondary user or delay involved in handoff process. A major improvement can be seen in the total overall capacity of network or spectrum utilization, there is almost 20% increase in capacity increase as compare to random channel selection scheme.

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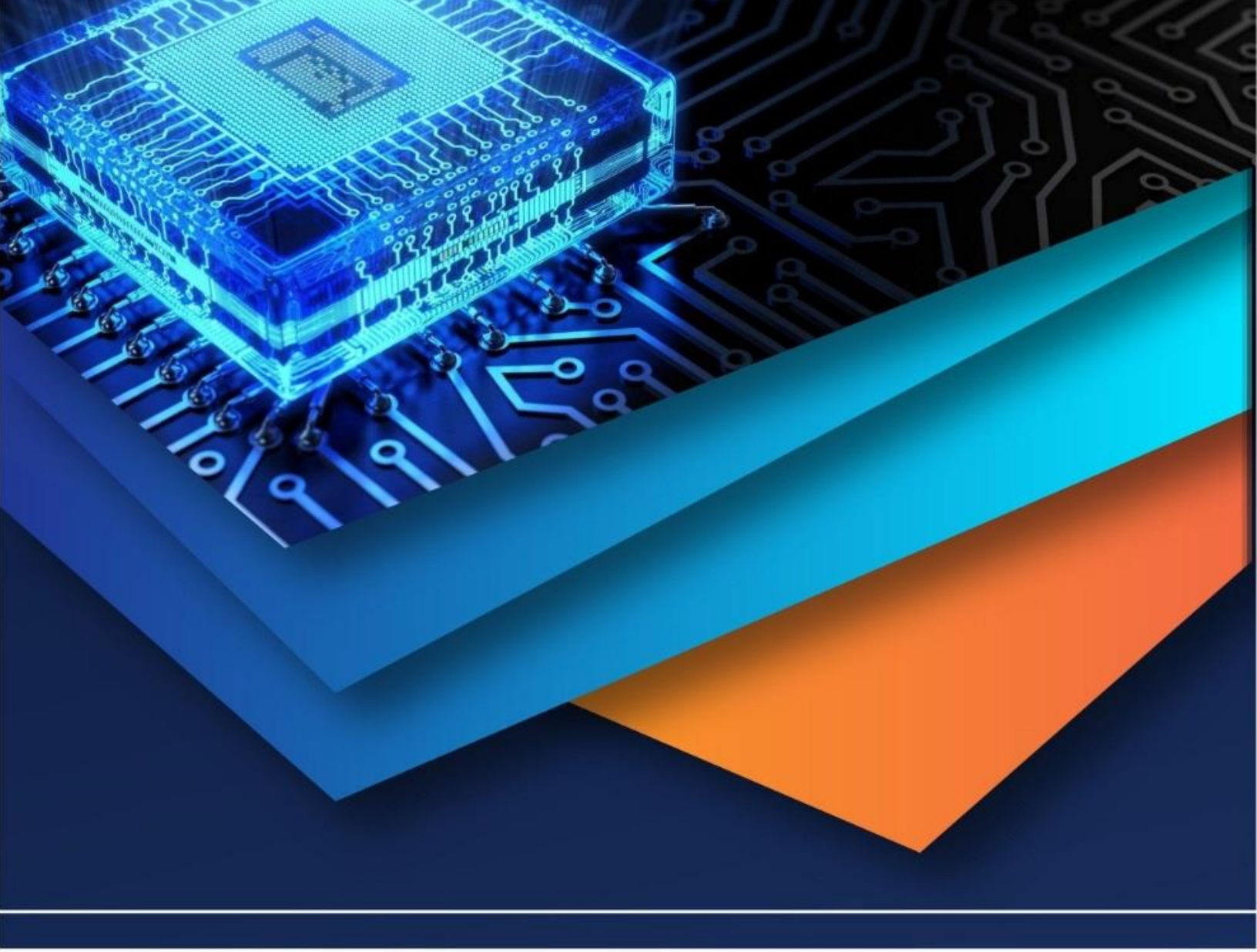

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