Spectrum sensing and Spectrum shifting implementation in a Cognitive Radio based IEEE 802.22 Wireless Regional Area Network

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Abstract

With the technological advancement in wireless applications more effective and efficient utilization of the available spectrum became the urgent requirement. According to the IEEE 802.22 standard the unlicensed secondary devices can operate in the licensed TV band, because this is the high underutilized licensed band, so long they do not interfere the licensed primary users. Therefore the secondary users having cognitive radio features will automatically switch to another channel or mode upon detecting the primary user in its operating band. In this paper we have presented our work based on spectrum sensing using energy detection and spectrum sifting by using a control index generated as result of sensing the spectrum when the primary user is looking for its licensed band. The simulation shows that the proposed spectrum sensing and spectrum shifting using the control index are easier and guarantee better performance. ***Index Terms*** – Cognitive Radio, Primary user, Secondary User, Spectrum sensing, Spectrum shifting.

I. INTRODUCTION

As the TV (54 MHz – 862 MHz) band [1] is highly unutilized, the white spaces in the TV spectrum [15] can be used to provide a wireless broadband multimedia access in the rural areas. Federal Communication Commission [2] in U.S has explored the possibility of utilization of the unutilized TV spectrum by the unlicensed users. In response to a Notice of proposed rulemaking

(NPRM) [3] regarding the television spectrum issued by the U.S. Federal Communications Commission (FCC) in May 2004, The IEEE 802.22 working group on Wireless Regional Area Networks was formed in October 2004 for unlicensed operation on the broadcast TV spectrum. IEEE 802.22 is based on cognitive radio [4,7] to accommodate unlicensed users without interfering with the licensed primary [14] users. The 802.22 standard specifies a fixed point-to-multipoint wireless air interface whereby a base station manages its own cell and all associated Consumer Premise Equipments. The 802.22 system specifies spectral efficiencies in the range of 0.5 bit/ (sec/Hz) up to 5 bit/ (sec/Hz). Another feature of WRAN is the BS coverage range, which can go up to 100 Km if power is not an issue [7].

The remainder of this paper is organized as follows: Section II discusses the necessary background for the work done. In Section III we presented the simulation models and the associated results. Finally, we make a conclusion in section IV.

II. BACKGROUND

This section introduces the necessary background information of Cognitive Radio based WRAN system. A cognitive radio can operate at any unused frequency in the licensed TV band, regardless of whether the frequency is assigned to licensed services or not. Cognitive radios continuously perform spectrum sensing, dynamically identify unused (“white”) [6] spectrum and operate in this spectrum band when it is not used by incumbent radio systems i.e. the primary users of this band and automatically switches to another band when primary users are detected. A cognitive radio observes its environment and adapts its transmission characteristics accordingly. The cognitive radio concept was first introduced in the software defined radio research community [5]. Spectrum sensing [12, 16] has been considered as a key functionality to satisfy the requirement of avoiding interference to potential primary users. Recently three major methods for IEEE 802.22 WRAN spectrum sensing implementation has proposed, which includes matched filter, energy detector [10] and feature detector [8, 9]. Other approaches are cyclostationary detection properties of a signal [11, 13]. One more challenge in CR based WRAN is to enable reliable Primary User detection and continuous Secondary User operation at the same time. The suggested solution is Dynamic Frequency hopping (DFH) [17, 18].

III. SIMULATION AND RESULTS

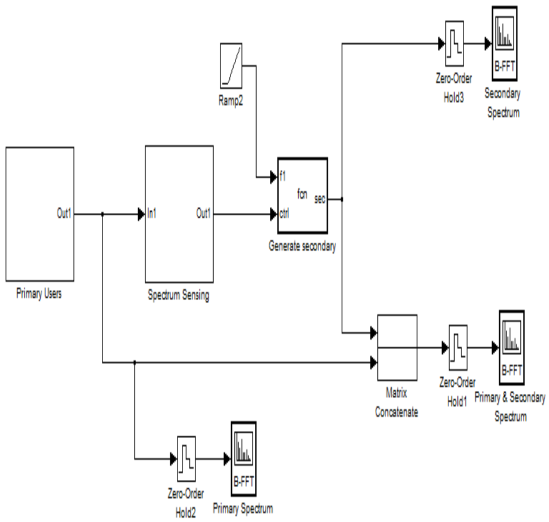

Fig1: Model for Spectrum Sensing and Spectrum Shifting

The above figure shows a Simulink Model for Spectrum Sensing and Spectrum Shifting required for WRAN. It uses energy detection technique for sensing of Primary users and indices for shifting the secondary users. It consists of the following blocks:- Primary Users: Generates Random Primary Signals in a particular range of frequency. Spectrum Sensing: Senses the Energy level of each carrier, determines the Energy possessed by the carrier and returns the index of the carrier which is not present in the spectrum. Generate Secondary: Receives the index of the absent carrier from the spectrum sensing block and generates the secondary signal at that particular carrier frequency that is not present. Scopes and Display: Displays the spectrum of the primary and secondary users.

A. Primary Users–

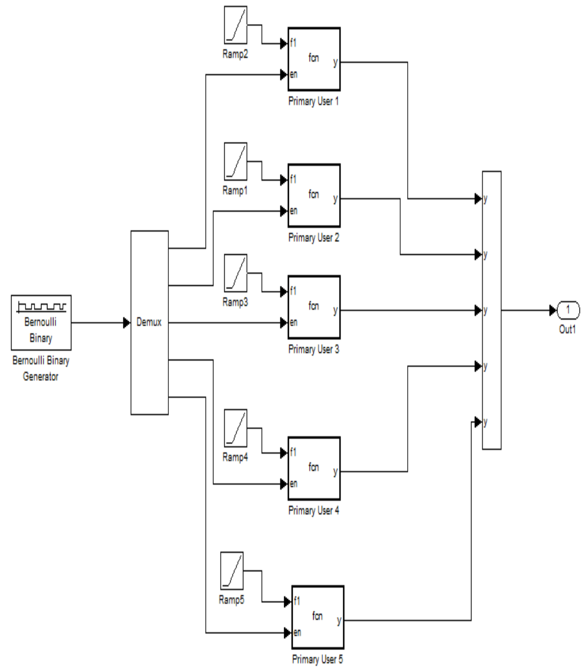

Fig2: Primary user

Code Algorithm to generate the primary user signal is given below,

1. If en=1 then transmit primary i.e y=Amplitude*sine(freq)
2. Else don't transmit i.e y=0.

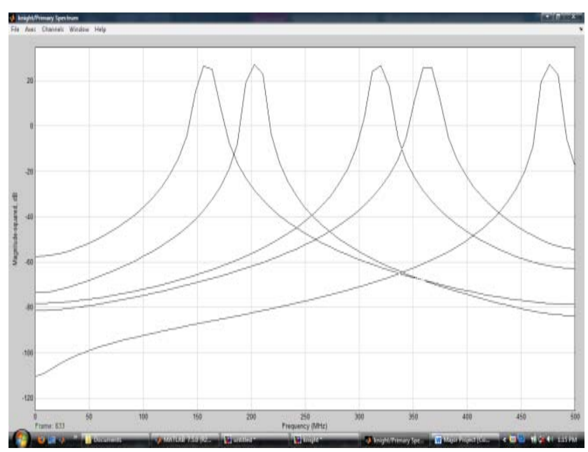

Fig3: figure shows the five primary signals generated

B. Spectrum sensing block –

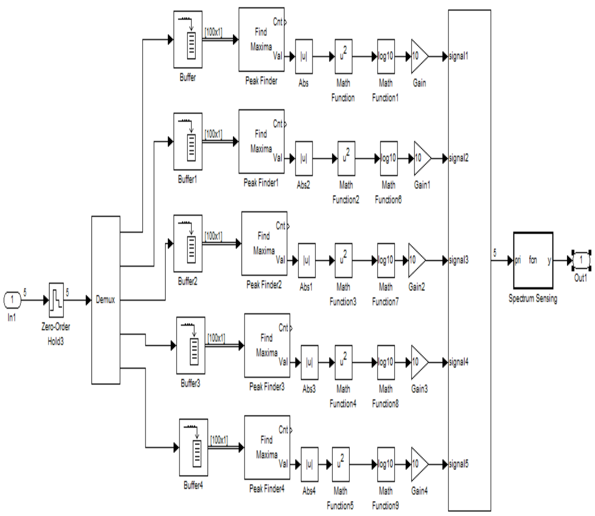

Fig 4: Figure shows the Spectrum sensing block.

This block mainly senses the channel for presence of a particular carrier frequency. It uses energy based sensing to sense the spectrum .The energy is then calculated in the dB. These calculated energies are then processed to determine the index of the absent carrier. The Generate Secondary block takes the control index from the spectrum sensing block and accordingly generates the secondary spectrum at a particular carrier frequency defined by the control index.

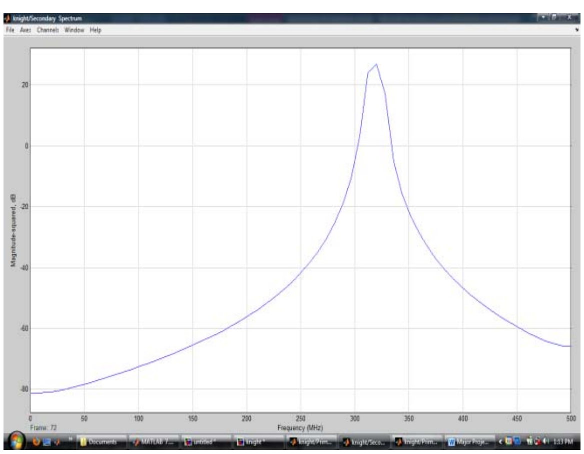

Fig5: Generated Secondary Spectrum

C. Flow chart –

The flowchart below depicts the ongoing process of our model

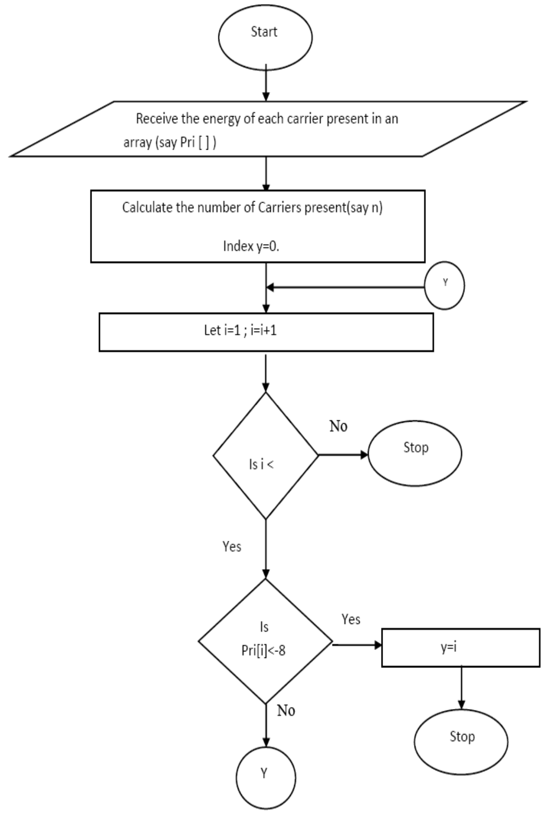

Fig 6: flow chart of the working of the model.

Figures given below depict the above mentioned process.

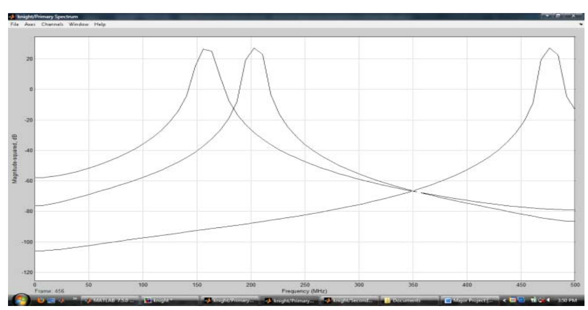

Fig7: White Space Between250MHz to 450MHz

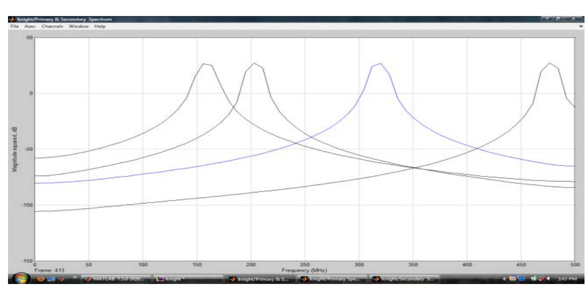

Fig8: Secondary Spectrum between 250 MHz to 450 MHz

Again, when the primary user comes back to its space(as shown in the figure above) the spectrum sensing device senses this and searches for another empty band(i.e. between 400 to 500MHz).

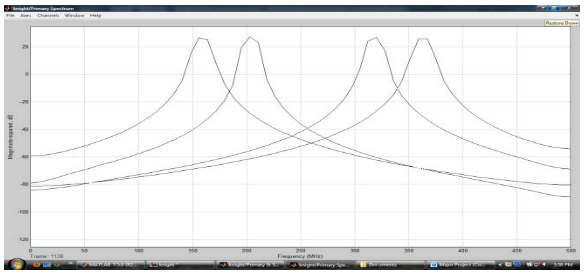

Fig 9: Primary Signal Occupying 250MHz to 450MHz band

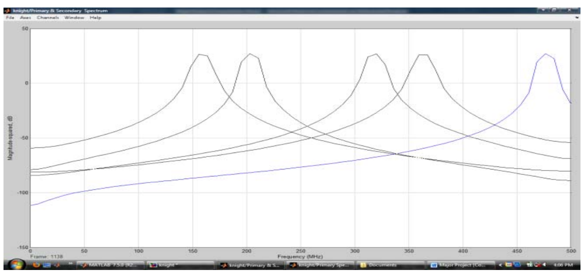

Fig 10: Secondary Signal Shifting another band (i.e. between 400 to 500MHz)

So, the secondary spectrum is shifted to this new available vacant band.

IV. CONCLUSION

By using the MATLAB/ Simulink we are successfully able to sense the available spectrum, which is unutilized and dynamically allocate the unlicensed user to that band and whenever the licensed primary user is looking for its allocated band the secondary user shifts its band to some other available bands. However the online Spectrum sensing and shifting has yet not been implemented in hardware platform. We are working for implementation by a Software Defined Radio (SDR).

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