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Practical Implementation of Cognitive Radio Using Energy Detection Technique

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Abstract: ***Due to the growing demand of wireless spectrum the Cognitive Radio (CR) is used for the spectrum utilization purpose. Basically the Licensed users use the licensed bands but with the help of CR technology, the licensed bands can also be provided to see users. The main aim of cognitive radio is to sense the spectrum continuously. In this paper, we provide theproposal that how the capacity of the system can be increased by reuse the unused licensed band by simulating a Cognitive radio system. The secondary users can occupy free space (spectrum holes) and also licensed bands by continuously monitoring the spectrum.***

Index Terms— Cognitive Radio, Spectrum Sensing, Spectrum Holes, Primary Users, Secondary Users.

I. INTRODUCTION

The demand for spectrum resources is increasing day by day due to the continuousgrowth in Wireless communication system but there is a point to be noted that the Radio spectrum is band limited. The radio spectrum can be represented by two kinds of bands, i.e. licensed band and unlicensed band. The users lie in licensed band is called Primary users (PU) and the users lie in unlicensed band is called Secondary users (SU). The licensed band is allocated to users having license to use radio spectrum. When the licensed band is idle, i.e., none of primary user is using the allocated spectrum, then this band is commonly said to be idle band or spectrum holes. This idle band can be used by secondary users (unlicensed users). The IEEE 802.22 group has been formed to make the interference of the air in the T.V. broadcasting. [1]

The spectrum holes (SH's) are of two types:-

1. Temporal spectrum holes.
2. Spatial spectrum holes.

1. *Temporal spectrum hole:* - Temporal spectrum hole is said to be that spectrum band which is allocated to primary user but the primary user is not using for transmission, so this spectrum band can be used by the secondary user.
2. *Spatial spectrum holes:*- Spatial spectrum hole is that when Primary user transmission is within a particular area and the outside area can be used by the secondary user. [1]

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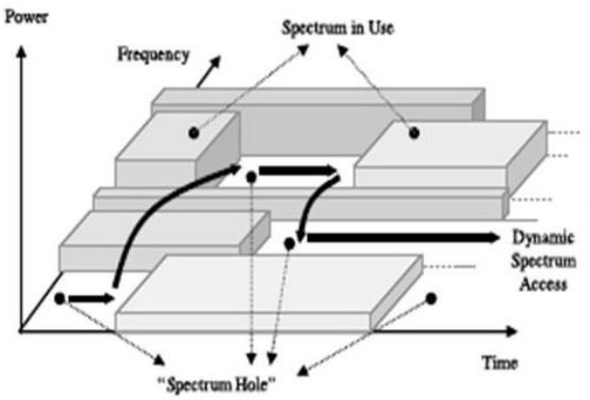

Figure1: Spectrum Access [3].

II. LITERATURE SURVEY

In 2008, Amir Ghasemi has described the requirements, challenges and design trade-offs for Spectrum Sensing in Cognitive Radio network. In 2010,Jose Marinho, Edmundo Monteiro have suggested the techniques and future research directions for cognitive radio. In 2011, Mansi Subhedar and Gajanan Birajdar have proposed the different techniques which are used for the spectrum sensing. In the same year, Wassim El-Hajj, HaidarSafa, Mohsen Guizani, have described security issues for Cognitive Radio Networks. In the same year,Danda B Rawat and Gongjun Yan have described how the signal can be shared among various users and to sense the environment whether the licensed band is used or not by the primary user. In 2012, Lu Lu, XiangweiZhou,Onunkwo and Geoffrey Ye Li, have proposed the spectrum sensing techniques and how to allocate the spectrum to the primary and secondary users. In2013,Eeru R. Lavudiya, Dr. K. D. Kulat and Jagdish D. Kene have described how to enhance the detection probability by using the different spectrum detection techniques in the cognitive radio system.

III. FUNCTIONS OF COGNITIVE RADIO

There are different functions of the cognitive radio which are used in the spread spectrum. The functions are as follows:-

A. Spectrum sensing

In the spectrum sensing the unlicensed or secondary users continuously monitors the activities of the primary or licensed user band. If there is having spectral holes then those spectral holes are used by the secondary user. The secondary users can use those spectrum holes without primary user interference.

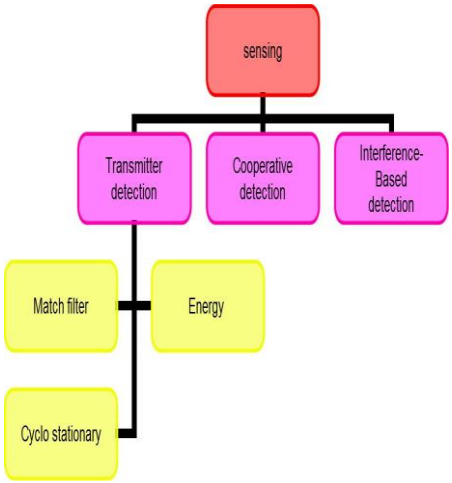

Figure2: Spectrum Sensing

B. Spectrum sharing

When the licensed band is not used by the primary users so the property of providing those spectrum holes to the secondary users in the cognitive radio is called spectrum sharing.

C. Spectrum Management

The primary (licensed) user use the licensed band, but actually the whole licensed spectrum band is not used by the primary user. So there is having spectrum holes or white spaces in the spectrum band. The property of founding and select the white spaces by the cognitive radio is called spectrum management.

D. Spectrum Mobility

Cognitive radio leaves channel when primary user comes. This property of cognitive radio is called as the spectrum mobility [2].

IV. TECHNIQUES OF COGNITIVE RADIO SPREAD SPECTRUM

There are different techniques which are used to check that the primary user is present in the band or not, in other words these techniques are used to determine the PU transmission.

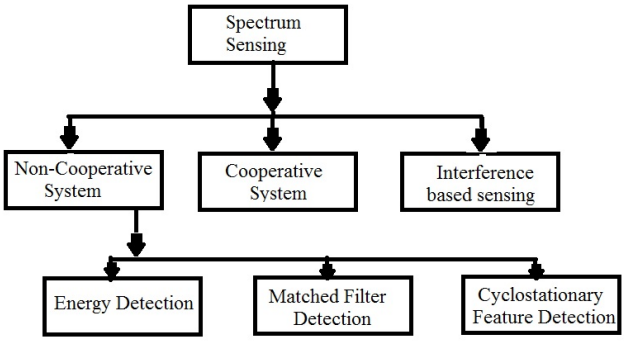

Figure3: Different techniques in Cognitive Radio

The different techniques are:-

- Matched Filter detection technique.
- Cyclostationary Feature detection technique.
- Energy detection technique.

A. Matched Filter detection technique

In this technique all the information related to the PU is known by the SU, it also checks the presence or absence of the primary user. The signal to noise ratio is maximized in the matched filter detection. The performance of the matched filter is better as compare to other techniques. The sensing time for this technique is very less. [1] This technique refers to coherent detection. If the PU transmission is known by the SU then this is the better technique than other techniques [2] .Sometimes the PU transmitted signal but SU not known about that problem this technique is less applicable [1].

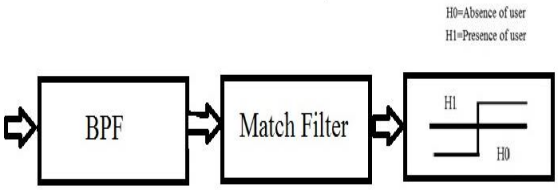

Figure4: Block diagram of matched filter [4]

The operation of the matched filter is equivalent to the correlation. The unknown signal is passing through the filter whose impulse response is mirror and the signal is time shifted version of the reference signal. The expression for the operation of matched filter is:

$$Y[n]=\sum_{K=-\infty}^{\infty}h[n-k]x[k]$$

Here x is unknown signal which is convolved with 'h'. For maximizing the SNR the impulse response of matched filter is matched with reference signal.

The advantage of Matched filter is that they are having less detection time.

The disadvantage is that they require earlier knowledge of the every primary signal [3].

B. Cyclostationary Feature detection technique

The cyclostationary detection will detect the signal for the spectrum sensing, so it is also called the Feature detection technique. If the signal is having periodic autocorrelation and signal mean then that signal is called cyclostationary. The signal is separated from the noise in the cyclostationary, there are having difficulties in the calculations that is the main problem of this technique. The cyclostationary feature detection checks or determine the different waveforms for the calculations thatare the main advantage of this technique over the energy detection [2].

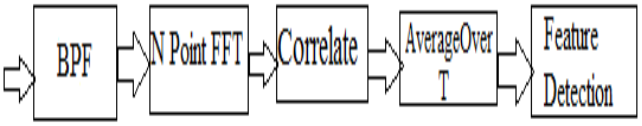

Figure5: cyclostationary feature detection [4]

C. Energy detection technique

The detection of the average energy of the samples is called energy detection.

$$Z=\frac{1}{N}\sum_{t=1}^{N}|x(t)|^2$$

Here the threshold γ and Z is compared and the decision is taken by the SU is that the PU is present or not present. By increasing the sensing duration there is not sure that there is better detection [1].

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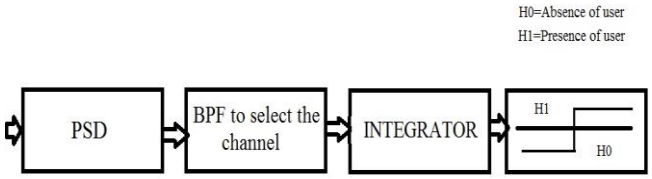


Figure6: Energy detection block diagram [4]

$$y(k) = n(k).....H0$$

$$y(k) = h * s(k) + n(k).....H1$$

The y (k) is the sample to be analyzed at each instant k and n (k) is noise of variance.

Suppose the y (k) is the received samples sequence kε [1, 2, 3…..N], which is at signal detector. The decision rule can be written as:

$$H0.....if\varepsilon < v$$

$$H1.....if\varepsilon > v$$

The estimated energy of received signal is $\varepsilon = E|y(k)|^2$, v is chosen to be the noise variance [4].

The signal is not separated from the noise in the energy detection technique.[1] The energy detection technique requires that how much power of noise in the signal, according to that power the detection threshold is selected.[2]

The primary user earlier information is not required in this technique as compare to the other matched and cyclostationary detection techniques.

V. SIMULATION RESULTS

The paper presents cognitive radio system using MATLAB R2013 We have used the FFT for the digital implementation. Assume that there are five primary users which are present in the spectrum at same time or at different time slots. In the cognitive Radio the Secondary users continuously monitors the spectrum holes. The energy detection method is used to allocate the spectrum holes to the unlicensed users immediately. [5]

The Carrier frequencies used for five signals are 2000Hz, 4000Hz, 6000Hz, 8000Hz, 10000Hz and sampling frequency is 20000Hz. For finding the presence of primary users the power spectrum density is compared with threshold value.

Assume that 1st, 3rd, 5thprimary users are present and 2nd, 4th primary users are not present.

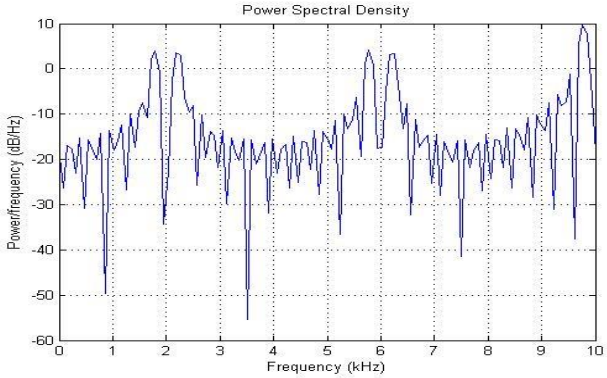


Figure (a): when 2nd, 4th primary users are not present.

In this figure the second and fourth peaks are not present because they are not present in spectrum band.

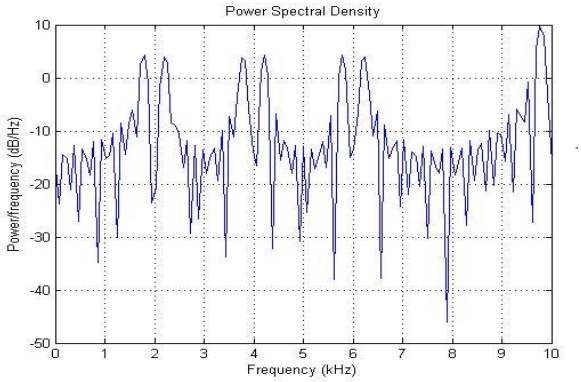
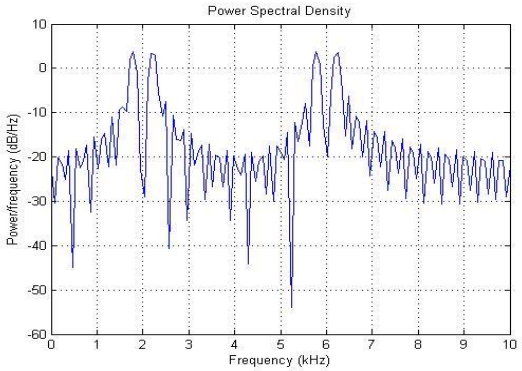


Figure (b): when 2nd slot is used by secondary user.

In this figure the second slot is used by secondary user so the second peak goes high.



Figure(c): when 5th primary user leaves the slot.

In this figure the 5th primary user leaves the slot so there is decrease in amplitude the 5th peak.

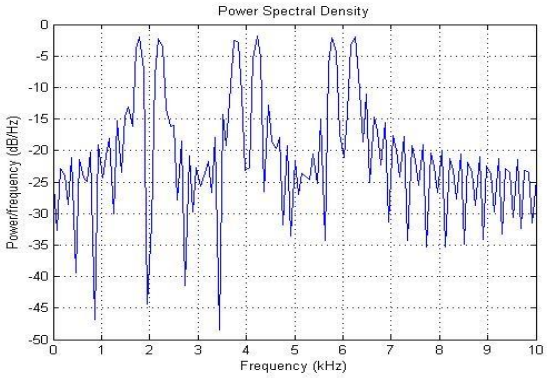
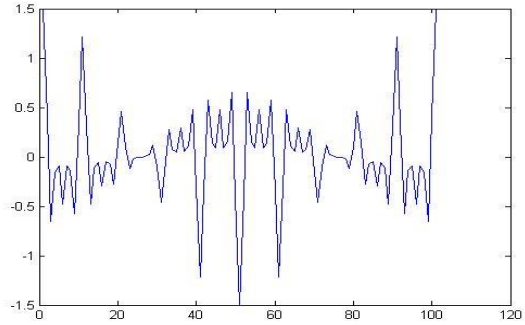


Figure (d): SNR is taken as-5dB.



Figure(e): SignalAttenuation in percent is 50%.

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VI. CONCLUSION

Cognitive Radio is the best technology to increase the spectrum utilization. The cognitive users always monitor the licensed spectrum bands. When there is spectrum holes in the band those spectrum holes are provided to the secondary cognitive users. In this paper we are showing spectrum allocation by using the energy detection method by using FFT. Thegraphical representation shows how the spectrum signal varies if there is presence of primary user and there is absence of licensed primary user. Here the SNR is taken as -5dB and the 50% signal attenuation.

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