ISSN: 2277-3754
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 1, Issue 2, February 2012

Different spectrum sensing techniques used in non cooperative system

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Abstract- The new era of communication includes Software Defined Radio (SDR). A SDR is a radio that includes a transmitter in which the operating parameters including the frequency range, modulation type or maximum radiated or conducted output power can be altered by making a change in software without making any hardware changes. In this paper we have implemented the various transmitter detection techniques in SDR in mat lab. The Implementation are based on BPSK and QPSK modulation scheme and the SNR values are verified over varying frequency range.

Index Terms— **SDR, BPSK, QPSK, CR, Spectrum Sensing, Match Filter, Energy Detection.**

I. INTRODUCTION

The new era of communication includes Software Defined Radio (SDR). A SDR is a radio that includes a transmitter in which the operating parameters including the frequency range, modulation type or maximum radiated or conducted output power can be altered by making a change in software without making any hardware changes [1]. SDR is used to minimize hardware requirements; it gives user a cheaper and reliable solution. But it will not take into account spectrum availability Cognitive Radio (CR) is newer version of SDR in which all the transmitter parameters change like SDR but it will also change the parameters according to the spectrum availability. In [4] the authors measure the power spectral density (PSD) of the received 6 GHz wide signal. Figure 1.1 shows very low utilization of spectrum from 3-6 GHz.

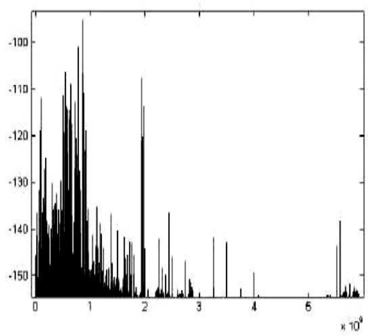

Figure 1.1 Measurement of 0-6 GHz spectrum utilization at BWRC [4]

In order to improve spectrum efficiency dynamic spectrum access technique is imperative. Dynamic spectrum access techniques allow the cognitive radio to operate in the best available channel. More specifically the cognitive radio technology will enable the user to determine which portion of the spectrum is available, detect the presence of primary user (spectrum sensing), select the best available channel (spectrum management), coordinates the access to the channel with other users (spectrum sharing) and migrate to some other channel whenever the primary user is detected (spectrum mobility)[2].

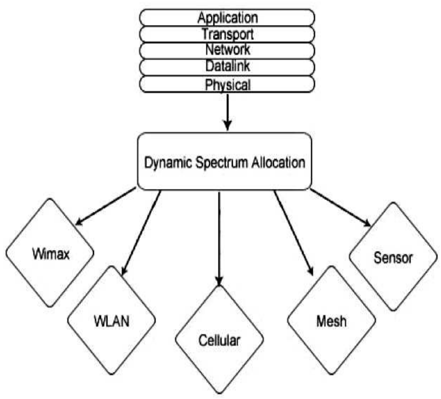

Figure 1.2 Dynamic changes in all Layers

The ultimate objective of the cognitive radio is to obtain the best available spectrum through Cognitive Capability and Reconfigurability as described above. Since there is already a shortage of spectrum, the most important challenge is to share the licensed spectrum without interfering with the transmission of other licensed users as illustrated in Figure 1.2. The cognitive radio enables the usage of temporally unused spectrum, which is referred to as spectrum hole or white space [16]. If this band is further used by a licensed user, the cognitive radio moves to another spectrum hole or stays in the same band, altering its transmission power level or modulation scheme to avoid interference.

The cognitive capability of a cognitive radio enables real time interaction with its environment to determine appropriate communication parameters and adapt to the dynamic radio environment. The tasks required for adaptive operation in open spectrum are shown in Figure 1.3 [16], which is referred to as the cognitive cycle. The three main steps of the cognitive cycle, shown in Figure 1.3, are as follows:

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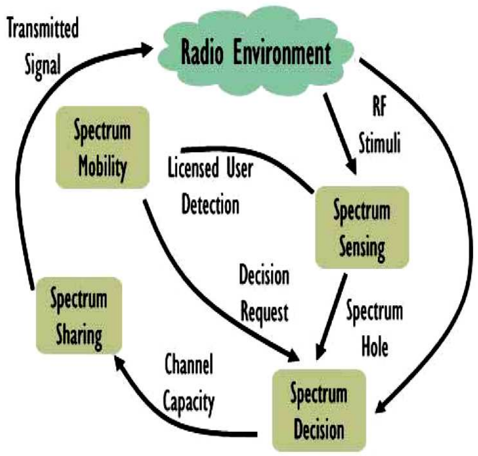

Fig1.3 cognitive cycle

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A. The Cognitive Radio Architecture

Existing wireless network architectures employ heterogeneity in terms of both spectrum policies and communication technologies [17]. Moreover, some portion of the radio spectrum is licensed for different technologies and some bands remain unlicensed (called Industrial Scientific Medical (ISM) band). A clear description of Cognitive Radio Network architecture is essential for the development of communication protocols.

B. Classification of Techniques

The main challenge to the Cognitive radios is the spectrum sensing. In spectrum sensing there is a need to find spectrum holes in the radio environment for CR users. However it is difficult for CR to have a direct measurement of channel between primary transmitter and receiver [2].CR can not transmit and detect the radio environment simultaneously, thus, we need such spectrum sensing techniques that take less time for sensing the radio environment. In literature the spectrum sensing techniques have been classified in the following three categories [2].

II. IMPLEMENTATION OF TRANSMITTER DETECTION

A. Primary user transmitter:

Step 1: The system parameters are set in this step. The parameters are: (i) the operating frequency, 'freq'; (ii) the sampling frequency, 'Fs'; (iii) number of samples per symbol period, 'L'; (iv) the sampling period, 'Ts'; (v) roll-off factor for the (square-root) raised cosine filters, 'alpha'; (vi) N+1 is the length of the square-root raised cosine filter, 'N'; (vii) signal to noise ratio, 'snr'; (viii) channel impulse response, 'h'.

Step 2: This is any piece of information (a text file, a sampled speech signal, a coded image …) that is converted to sequence of bits. Here are two options either take input from the user to transmit or use default data sequence.

Step 3: This a square-root raised-cosine filters with roll-off factor α. Here, α is set equal to 0.5. In the real world, the transmit signal is continuous time. Since in computer simulation, we can only have sampled signals, we approximate continuous-time signals by a dense grid of samples. Here, we have L = 100 samples per symbol period. The function 'sr_cos p' generates a square-root raised-cosine pulse, for the transmit filter, pT (t). The output of this step is Y.

Step 4: Modulation is done to generate an RF (radio frequency) signal for transmission through channel. Here two modulation techniques BPSK (Binary Phase Shift Keying) and QPSK (Quadrature Phase Shift Keying) are available. It depends on type of primary transmitter that whether to use BPSK or QPSK.

Step 5: This is characterized by an impulse response c(t) and an additive noise. Here, we have chosen $c(t) = \delta(t)$ which in the discrete domain becomes c = 1. If the channel is multipath, e.g., with the impulse response $c(t) = a0\delta(t - t0) + a1\delta(t - t1)$, it has the equivalent discrete domain c = [zeros(N0,1); a0; zeros(N1,1); a1], where N0 and N1 are t0 and t1 in unit of Ts

Step 6: The channel noise is assumed to be Additive White Gaussian with signal strength 2dB. In MATLAB 'awgn' function is used for this purpose.

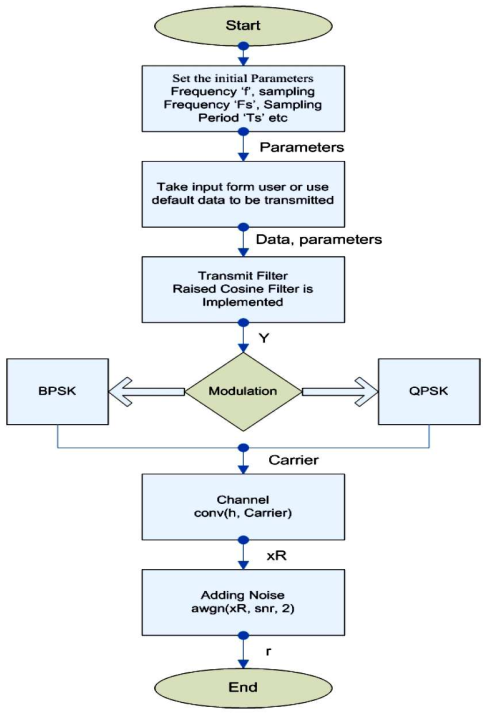

Fig.1.4. primary user detection

ISSN: 2277-3754
International Journal of Engineering and Innovative Technology (IJEIT)
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B. Energy Detection

The simplest detection technique for spectrum sensing is Energy Detection. As discussed in Chapter 2 energy detector measures the energy received from primary user during the observation interval. If energy is less then certain threshold value then it declares it as spectrum hole. Let r(t) is the received signal which we have to pass from energy detector. The procedure of the Energy Detector is as follows

Step 1: First estimate Power Spectral Density (PSD) by using periodogram function in MATLAB.

Pxx = Periodogram(r)

Step 2: The power spectral density (PSD) is intended for continuous spectra. The integral of the PSD over a given frequency band computes the average power in the signal over that frequency band.

Hpsd=Dspdata.psd (Pxx)

Step 3: Now one frequency component takes almost 20 points in MATLAB. So for each frequency there points are summed and get the result.

Step 4: On experimental basis when results at low and high SNR are compared then threshold λ is set to be 5000.

Step 5: Finally the output of the integrator, Y is compared with a threshold value λ to decide whether primary user is present or not.

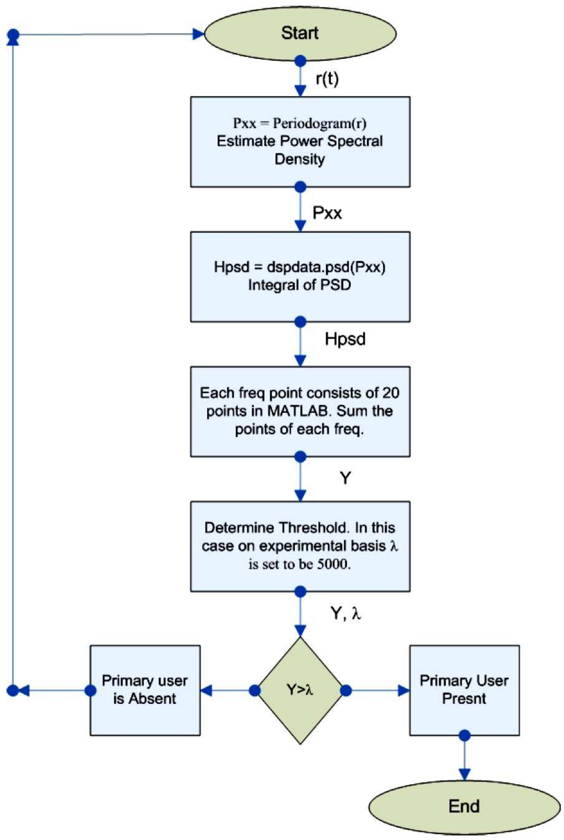

Fig.1.5. Energy Detection

Flow chart for the implementation of Energy Detector is shown in Figure 4.2. The MATLAB script 'energy detector', presented in Annex I, simulates the Energy Detector for Spectrum Sensing in Cognitive Radio Networks. The code is self explanatory. Figure 4.3 shows the output of energy detector when there is a primary user at 200 Hz using BPSK is present with very good SNR. It's very clear in the figure that there is peak at exactly 200 Hz. So energy detector compared this peak with threshold value, in this case its greater then threshold. Hence, energy detector said that primary user is present at 200 Hz.

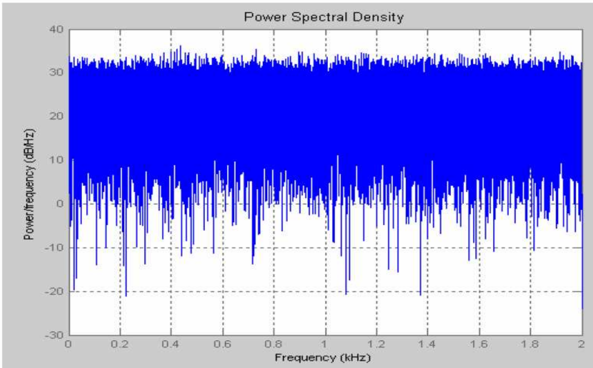

Fig.1.6. Energy Detector Output at SNR -30dB for BPSK when primary user is present at 200Hz

C. Matched Filter

Another technique for spectrum sensing is Matched Filter as discussed in Chapter 2. Matched filter requires prior knowledge about primary user's waveform. Hence, it requires less sensing time for detection. Flow chart of Matched Filter is shown in Figure 4.7. Let r (t) is the received signal which we have to pass from matched filter. The procedure of the matched filter is as follows.

Step 1: For the matched filter prior knowledge of primary user waveform is required. Therefore a local carrier is generated using local oscillator.

Step 2: xcorr estimates the cross-correlation sequence of a random process. Autocorrelation is handled as a special case.

Step 3: On experimental basis when results at low and high SNR are compared then threshold λ is set to be ±35.

Step 4: Finally the output of the integrator, Y is compared with a threshold value λ to decide whether primary user is present or not.

The MATLAB script 'matched filter', presented in Annex I, simulates the Matched Filter for Spectrum Sensing in Cognitive Radio Networks. The code is self-explanatory. For the case of BPSK in which the two pulses are p(t) and –p(t). The correlation coefficient c of these pulses is -1. Under good SNR conditions the receiver computes the correlation between p (t) and received pulse. If correlation is 1 we decide p (t) is received as in Figure 4.5, otherwise we will decide that –p (t) is received. When SNR conditions are not good then correlation coefficient is no longer +1 or -1, but has smaller

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magnitude, thus reducing the distingushability. Figure 4.8 shows the correlation of received signal with signal generated at cognitive radio under good SNR conditions.

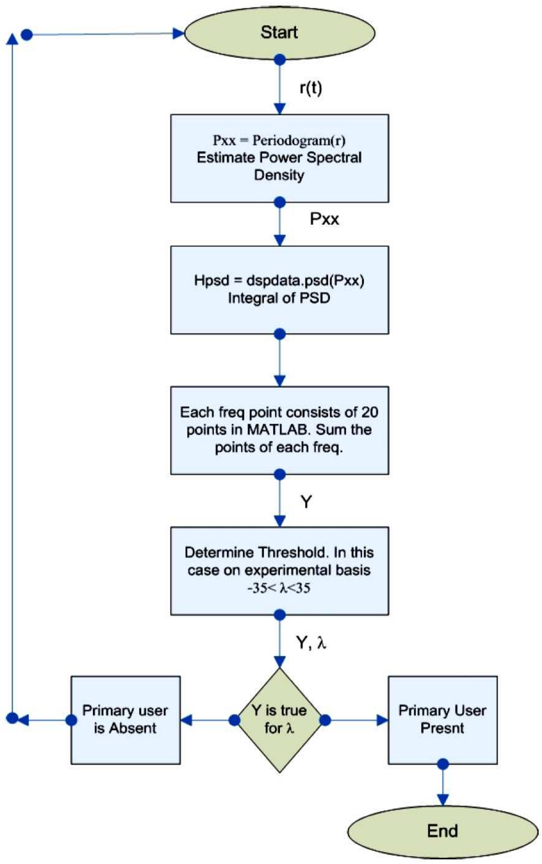

Fig1.8 Matched Filter

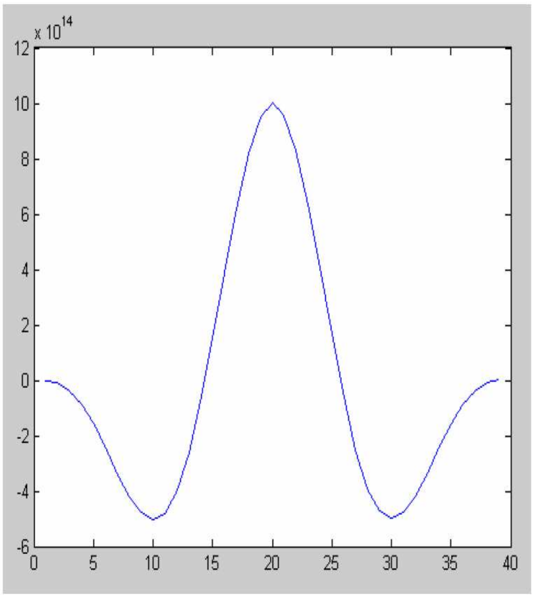

Fig1.9 Matched Filter Output at SNR 30dB for BPSK

III. CONCLUSION

As the demand of radio spectrum increases in past few years and licensed bands are used inefficiently, improvement in the existing spectrum access policy is expected. Dynamic spectrum access is imagine to resolve the spectrum shortage by allowing unlicensed users to dynamically utilize spectrum holes across the licensed spectrum on noninterfering basis. This paper research work was aimed towards the detection and classification of primary user's waveform in cognitive radio networks. The primary requirement of a spectrum sensing system is its real time processing and decision making. The proposed methodology has been implemented on a desktop PC and requires MATLAB support for simulation.

First all the transmitter detection techniques are compared on the basis of three metrics: Sensing Time, Detection Sensitivity and ease of implementation. By comparing these techniques it is concluded that cyclostationary feature detection gives best results but take long computation time compared to other techniques. In this paper main issues associated with spectrum sensing techniques are highlighted. Performance of these spectrum sensing techniques limits due to uncertainty in the noise level.

IV. FUTURE WORK

Most of the research on spectrum sensing is mainly focused on reliable sensing to meet the regulatory requirements. One of the important areas for the research is to focus on user level cooperation among cognitive radios and system level cooperation among different cognitive radio networks to overcome the noise level uncertainties. In this work, the noise level uncertainties are catered by a proper combination of spectrum sensing techniques. Another area for research is cross layer communication in which spectrum sensing and higher layer functionalities can help in improving quality of service (QoS).

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