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SVSS: Selective Variant Intelligent Spectrum Sensing for Cognitive Radio

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Abstract: In recent past the growth of wireless devices and multimedia applications has resulted in increased usage of spectrum causing spectral congestion problem. In order to access the electromagnetic spectrum in an opportunistic way Cognitive radio (CR) provides tempting solution by making best use of the frequency band which is not heavily occupied by licensed users i.e. primary user(PU), hence improving the spectrum utilization and quality of service (QoS) of a secondary user (SU). In this paper, a new hybrid spectrum sensing technique is proposed for transmitter based spectrum sensing which can reduce the computational power consumption and sensing time of frequency band. The proposed technique helps in detecting the inactive spectrum bands opportunistically with better utilization of the spectrum with increase in the overall spectrum efficiency. The Strategy is being described in the following sections. Where two parameters of comparison are taken, with which the results are formulated which are probability of detection and probability of misdetection. In both the considered parameters the Selective Variant Intelligent Spectrum Sensing (SVSS) performs better than Intelligent Spectrum sensing scheme (I3S).

Keywords: cognitive radio, spectrum hole, spectrum sensing, opportunistic spectrum access, Primary User, Secondary User.

I. INTRODUCTION

The major challenges in the design of wireless network are the use of frequency spectrum. With the drastic increase in communication applications in various countries, almost all of the spectrum has been fully allocated resulting in the spectrum congestion problem. From the recent report of Federal Communication Commission (FCC) about 15 to 85% of spectrum is not utilized [1].

Utilization of the frequency band can be improved by introducing Secondary User (SU) which will continuously detect the presence of PU called **spectrum sensing, and** utilize licensed band when Primary User (PU) is absent. Secondary User (SU) will transmit their information without disrupting licensed user (PU), such an opportunity is called **spectrum hole** and the device that detect these holes are called **Cognitive Radio** (CR) [2].

CR is widely as one of the promising technology for future wireless communication. CR senses the spectral environment over a wide range of frequency bands and exploits the temporally unoccupied bands for opportunistic wireless transmissions [3][2][5]. According to Federal Communication Commission (FCC) "Cognitive radio :A radio or system that senses its operational electromagnetic environment and can dynamically and autonomously adjust its radio operating parameters to modify system operation, as maximize throughput, mitigate interference facilitate interoperability, access secondary markets."[12] As discussed above, spectrum sensing is a essential component in a CR. However there are several factors which make the sensing problem difficult to solve. First, the signal-to-noise ratio (SNR) of the PU received at the secondary receivers may be very low. Secondly, time dispersion and fading of the wireless channel can complicate the sensing problem. In particular, fading causes the received signal power to fluctuate dramatically, while unknown time dispersed channel causes coherent detection unreliable Thirdly, the noise/interference level changes with time resulting in noise uncertainty.

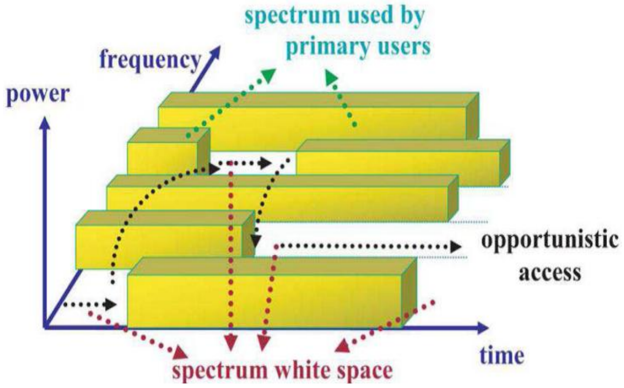

Fig 1: Spectrum utilization

For the anterior challenges, several methods for accurate signal detection have been proposed, including matched filter detection[7]–[13],[6], energy detection, [7][9][6][17], and cyclostationary feature detection [18] [19][20][16], each of the detection having different operational requirements, advantages and disadvantages. To combat the negative effect caused by fading to the

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transmitter detection accuracy, a new detection method based on CR user cooperation is proposed in [21] and [22]. Matched filter detection provides desirable detection but it requires full previous knowledge about the waveforms and channels of the primary user signal hence is not a very good solution for Cognitive Radio. Energy detection is the most commonly used detection method as it does not require any knowledge of the input signal and is also less complex than other techniques. However, performance of energy detection is not robust to noise, fading and interference and is known to be poor at low SNRs whereas Cyclostationary detection provides superior detection accuracy but is more complex in computation and needs longer sensing time. However, all these techniques are not efficient in extreme noisy conditions.

In this paper, a hybrid model for transmitter based spectrum sensing is investigated, where various aspects of spectrum sensing problems are analysed. The approach presented here helps in detecting the inactive spectrum bands opportunistically with better utilization of the spectrum under non cooperative sensing with increase in the overall spectrum efficiency.

II. SPCETRUM SENSING

Spectrum sensing or PU detection is an important function for cognitive radio. It can be defined as process of finding spectrum holes by sensing radio spectrum around cognitive radio receiver.

Temporary usage of unused frequency bands by CR is commonly known as spectrum holes. Spectrum holes are of two types, temporal spectrum holes and spatial spectral holes.

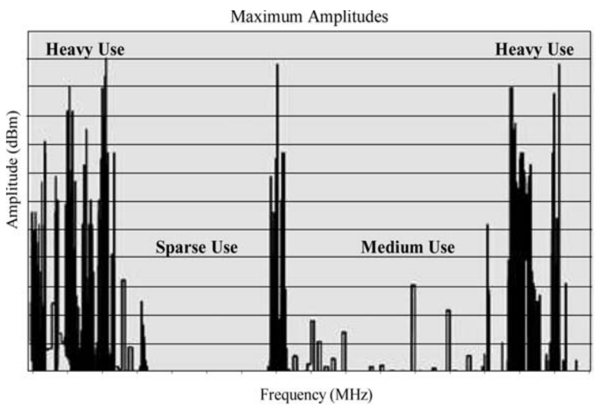

Fig 2: Spectrum usage

A spectrum hole which is not occupied by the PU during the time of sensing is temporal spectrum hole, hence can be used by SU at that time slot. Band which is unoccupied by PU at some spatial areas is spatial spectrum hole, therefore it can be occupied by SU as well as outside this area. CR hops to another spectrum holes if the band is used more by PU. Fig. 2 here shows use of the spectrum frequencies.

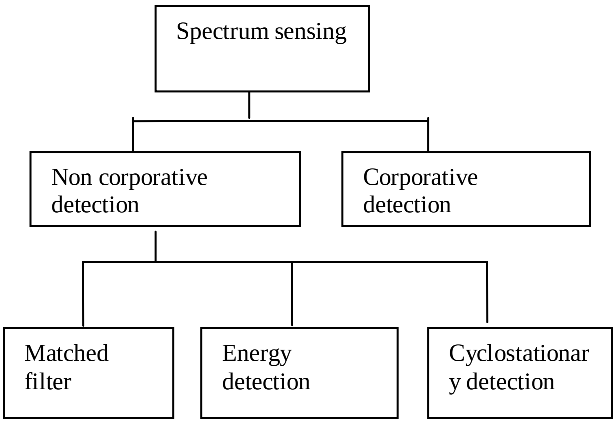

Fig-3: Spectrum sensing

To enhance the detection probability diverse spectrum sensing techniques can be used as shown in Fig.3

A. Corporative Spectrum Sensing (CSS)
Depending on single secondary user will not give sufficient sensing results during short sensing time because of many problems faced such as, Signal-to-Noise Ratio (SNR), shadowing, fading, etc. Therefore many ways of Corporative spectrum sensing have been proposed to obtain better results than single secondary user sensing.

In CSS scheme trust factor of each user is considered to enhance the global sensing performance of CRN. It is based on decision fusion, where all of the collaborative SUs perform local sensing and make binary local decision individually and transmit their local binary decision to the Fusion Centre (FC) where data fusion rule will be performed to make global decision on presence and absence of licensed users (PU) activities. Simulations result show that the proposed technique can obtain better detection performance than the traditional decision fusion ways and does not need any prior information of PU‘s signal and noise.

B. Non corporative detection technique
In Non corporative detection technique individual radios works locally and independently to carry out their own detection of unused frequency band and occupancy of spectrum [10]. Three methods have been discussed in the following subsections under non cooperative detection.Z

1) Matched filter detection: Matched filter is one of the favourable methods for detection of licensed user (PU) and is used when the transmitted signal is known. It requires accurate information of the PU signalling features which are operating frequency, bandwidth, pulse shaping, order and modulation type [17] so that CR can demodulate transmitted signal. Advantage of matched filter are; it requires less sensing time to achieve good detection performance due to coherent detection and can also work with very low SNR. This technique is not applicable in case where transmit signal by PU‘s are unknown to SU‘s [18].

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2) Energy detection: Energy detection is a mechanism to detect signal using an energy detector (also known as radiometer) to specify the absence or presence of signal in the band. Energy detector based method is common way of sensing the spectrum because of its low computational time and implementation complexities [17]. It is very simple and practical method as receiver does not need any information about PU‘s signal to be detected, so it is widely adopted. The signal is recognized by comparing the threshold which depends on the noise floor with the output of energy detector [19] However there are some limitations of this technique which includes inability to differentiate interference between signal from a user signal and noise, it is also not effective for those signals whose signal power has been scattered over a wideband.

3) Cyclostationary based sensing: Cyclostationary detector utilizes the cyclostationary feature of the signals for spectrum sensing. If mean and autocorrelation of cyclostationary are a periodic function then a signal is said to be cyclostationary. [20]. Feature detection refers to sunder out the features from the received signal and perform detection based on the extracted feature [21], [22]. Cyclostationary detection is better option than energy detector in case where energy detection is not so effective. It performs better than energy detector because of its noise rejection ability as noise is totally random and does not show any periodic behaviour.

Cyclostationary detector can differentiate noise from licensed user (PU) signal and can also be used for detecting weak signal at a very low signal-to-noise ratio region. Cyclostationary detection technique is best used when we have no prior knowledge about licensed user signal. The disadvantage of this method is the complexity of calculation and long sensing time.

III. RELATED WORK

An overview of different existing techniques, their approaches, advantages and disadvantages used in cognitive radio is provided in the table given below.

TABLE 1 RELATED WORK

Name of the author/year	Paper title	Approach	Remarks /Advantage /Disadvantage
(Jo, et al, 2013)	Selfish Attacks and Detection in Cognitive Radio Ad-Hoc Networks	COOPON (cooperative neighbouring cognitive radio nodes)	• An easy and efficient selfish CR attack detection technique. • Drawback, COOPON may be less reliable for detection when there is more than one neighbouring selfish node
Tawk et al, 2014	Cognitive-Radio and Antenna Functionalities: A Tutorial	Cognitive engine	• Channel sensing in observe part , • Spectrum analysis/decision in decide part • Hardware reconfigurability in act part • Learning algorithm in learn part cognitive engine is responsible for integrating and managing above four functions into a single cognitive-radio device.
Farag & Ehab, (2014)	An Efficient Dynamic Thresholds Energy Detection Technique for Cognitive Radio Spectrum Sensing	Energy detection method	• Spectrum sensing in CR • Simplicity in computation • Is based upon predicting the PU present activity • Improved the sensing performance by about 3.5 times. • Increase in computational complexity.
Hung et al, 2015	Performance Analysis of a Cognitive Radio Network With a Buffered Relay	Secondary relay (SR).	• Link reliability and Coverage range of CRN can be increase through help of SR.
Shen & Alsusa, 2013	An Efficient Multiple Lags Selection Method for Cyclostationary Feature Based Spectrum-Sensing	Cyclostationary Feature Based detection	• Author present a new scheme for lag set selection • Multiple lags are used to detect cyclostationary feature detection. • Shown that the proposed method, compared to other existing methods, can lead to superior detection performance in the low SNR region.
Bagwari & Singh, 2012	Comparative performance evaluation of Spectrum Sensing Techniques for Cognitive Radio Networks	Comparative analysis of the three techniques	• Cyclostationary feature detection outperforms other two techniques at low signal to noise ratio (SNR), • Disadvantages; has long observation time and implementation is complex.

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IV. PROPOSED WORK DONE

All the detections techniques discussed above are being used for the detection of spectrum holes, as discussed all of them have its own advantages and disadvantages such as matched filter requires accurate information of the PU signalling features which are operating frequency, bandwidth, pulse shaping, order and modulation type [11] so that CR can demodulate transmitted signal, This technique is not applicable in case where transmit signal by PU‘s are unknown to SU‘s [9]. Energy detection technique is the most commonly used detection method asit does not require any knowledge of the input signal and this technique is also less complex than others.

However, its performance is poor at low SNR Lead to false detection is not robust to noise. Cyclostationary detection technique is best used when we have no prior knowledge about licensed user signal. The disadvantage of this method is the complexity of calculation and long sensing time. To overcome the flaws of these detection techniques, a new Hybrid spectrum sensing Technique is proposed for transmitter based spectrum sensing which can reduce the computational time power consumption and sensing time of frequency band.

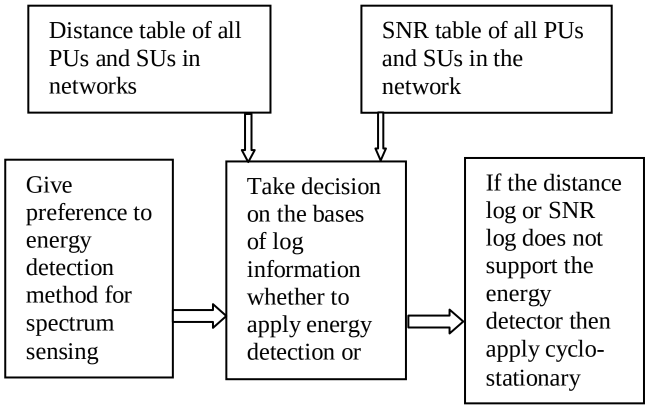

Fig: 3 Proposed work block diagram

This model is a fusion of two techniques i.e. energy detection and cyclostationary detection. From our literature survey we conclude that out of the various techniques available for spectrum sensing in cognitive radio, the most important ones are Energy Based and Cyclostationary based methods based methods. So in our proposed work we are going to combine the advantages of above mentioned methods. This approach will help in detecting the inactive spectrum bands opportunistically with better utilization of the spectrum with increase in the overall spectrum efficiency under non cooperative sensing.

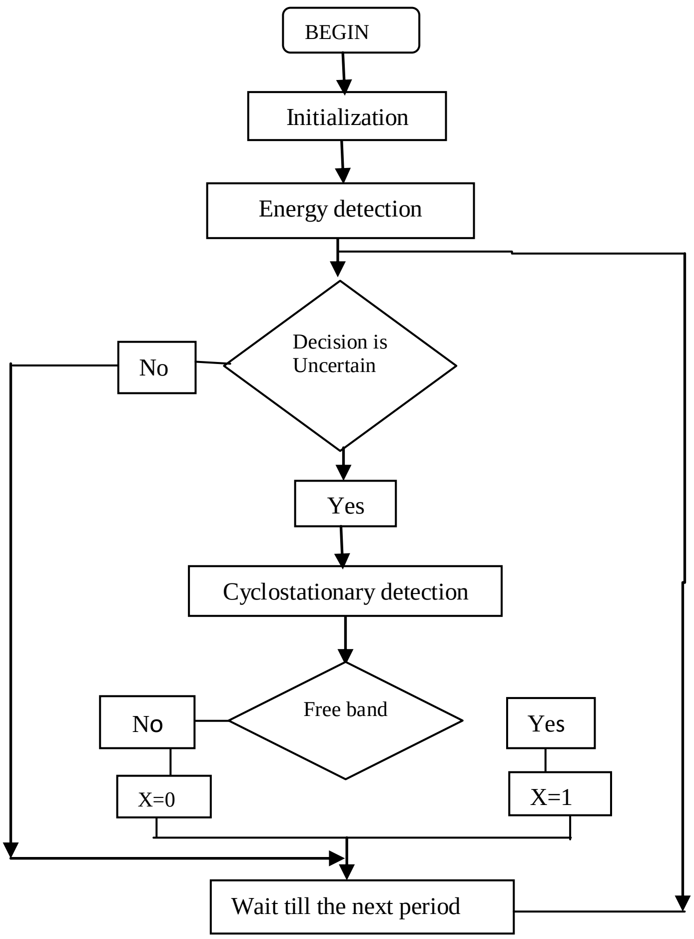

Fig.4: Flowchart of proposed work

The Fig.3 shows the combination of energy detection and cyclostationary detection techniques. The first task here is to determine whether a primary user exists in that particular area or not. Then to first use energy detection for detection of spectrum holes, if that does not work or give us false alarm or miss detection. The next job is to then use cyclostationary detection technique for the detection of idle spectrum bands.

- Initialization of overall frequency band available for the communication.
- Declaring and updating the information of private and public bands.
- Running request sequences randomly to test the environment.
- Checking for the gap in private bands using energy detection.
- If the decision is uncertain then allow the cyclostationary detection to work.
- Otherwise wait till the next period of shift data.
- Also implement a feedback loop to continuously monitor the performance of the detection scheme.
- In between all this maintain the accuracy by dividing the gap opportunities as two separate categories.
- Category 1 is for short distance shift of data.
- Category 2 for long distance shift of data.

V. RESULTS

Graphs shown represents the IS3 and SVSS techniques used for comparisons on bases of two parameters which are probability of false detection and probability of correct detection.

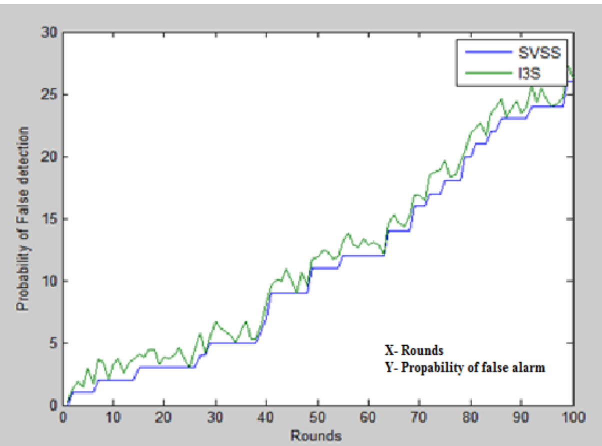

Fig.5: Probability of False Detection in I3S and SVSS

This Fig.5 shows the plot between SVSS and I3S (Intelligent Spectrum sensing) in the bases of Probability of False Detection. In this graph we can clearly see the curve of SVSS is much below the I3S which proves the robustness of the system in terms of false alarm detection. In detection of false alarm the SVSS system performs better than the I3S. Also the stability in the curve, although for short periods is better in case of SVSS because of the clear action being taken right at the beginning of the detection process.

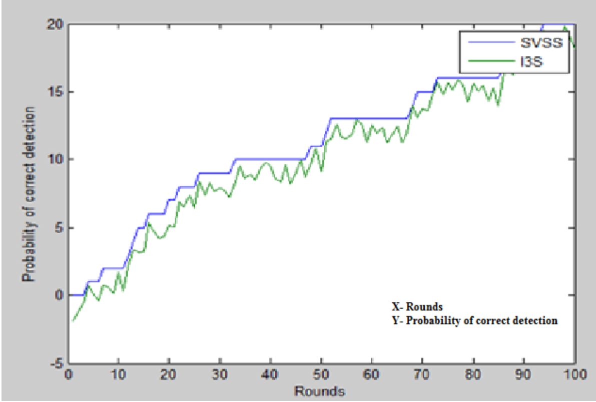

Fig.6: Probability of correct Detection in I3S and SVSS

This Fig.6 shows the plot bet SVSS (Selective Variant Intelligent Spectrum Sensing.) and I3S (Intelligent Spectrum sensing) in the bases of Probability of correct Detection. In this graph we can clearly see the curve of SVSS is above the I3S which proves the robustness of the system in terms of correct detection. While detecting the correct slots the SVSS system performs better than the I3S. Also if we look at the stability in the curve, although for short periods is better in case of SVSS because of the clear action being taken right at the beginning of the detection process.

VI. CONCLUSION

In this paper, cognitive radio network related to spectrum sensing technique is proposed. A number of different methods are proposed for accurate signal detection in different research papers including Energy detection, matched filter detection and cyclostationary detection techniques which are being used most efficient in terms of computational, power consumption and sensing time, is Energy based methods. But in Energy based method the accuracy of correct detection is less due to increased distances between PUs and SUs, also the decreased SNR causes a lot of problem in Energy based methods. So in our proposed work we have tried to use some strategy which can reduce the computational power consumption and sensing time.

From these observations a new hybrid model for transmitter based spectrum sensing is proposed, where various aspects of spectrum sensing problems are analysed. The approach presented here helps in detecting the inactive spectrum bands opportunistically with better utilization of the spectrum under non cooperative sensing with increase in the overall spectrum efficiency. The Strategy is being described in the following sections. We have taken two parameters of comparison with which we have formulated the results which are probability of detection and probability of misdetection. In both the considered parameters the SVSS performs better than I3S.

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VI. FUTURE SCOPE

Though this system is considered to be efficient but few limitations are also present such as load is greater due to regular check for the vacant spectrum, this scenario can be considered to be fulfilled in future. Future scope of this work can very advantageous if can apply it on the mechanism of SVSS. We propose that the history logs of the conditions that give out false and correct detection are stored and are used to mine the accuracy of the system in certain scenarios for futuristic predictions**.**

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