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A Survey of Spectrum Sensing Procedures in Cognitive Radio Network

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ABSTRACT: In recent years, cognitive radio acts as a better technology for future generation networks because of its efficient capability intelligent system which can be used to sense, learn and optimized. Cognitive radio grants unlicensed users to adopt to the licensed frequency bands by way of dynamic spectrum access in order to reduce spectrum deficiency. This craves intelligent spectrum sensing techniques like co-operative sensing which generates use of information from number of users. The main defiance in any cognitive radio system is to improvise secondary user's throughput while limiting objection foisted on licensed users. In wireless communication system, CR is the most challenging and promising concept for an efficient usage of the radio spectrum.Spectrum sensing is one of the most critical aspects of the cognitive radio as it offers the awareness of the spectrum holes in the networking environment.Deciding the optimal sensing, transmission timing strategies and accurate sensing techniques are of tremendous emphasized in a cognitive radio network. Spectrum sensing is significant enough to make real time decisions about which it bands to sense, when and for how long to hold the spectrum using the sensed spectrum information. In this paper, the cognitive radio concepts and the review of different spectrum sensing techniques are discussed in a broader sense.

KEYWORDS*:* Cognitive Radio (CR), Additive WhiteGaussian Noise (AWGN), Dynamic Spectrum Allocation (DSA), Primary User (PU), Secondary User (SU).

I. INTRODUCTION

In wireless communication systems, the requisite to admit the spectrum is broadly defined by frequency, transmission power, spectrum owner (i.e., licensee), nature of use, and the duration of license. Usually, a license is assigned to one licensee, and the use of spectrum by this licensee must be conciled to the specification in the license. Earlier in the spectrum licensing schemes, the license cannot alter the nature of utility or relocate the right to other licensees. Besides, the radio spectrum is licensed for larger regions and generally in larger lumps chunks. All these elements in the prevailing model for spectrum allocation and assignment restraint the use and result in low utilization of the frequency spectrum. Since the available, booming wireless applications and services are exhausting for high transmission capacity and more data transmission Therefore, the utilization of the radio spectrum needs to be enhanced.

To score better the efficiency and utilization of the radio spectrum, the mentioned constraints should be revised by customizing the spectrum licensing scheme and endorsing a dynamic spectrum management model. The basic perception is to make spectrum access more extensile by admitting the unlicensed users to access the radio spectrumunder certain conditions and restrictions.

Because the traditional wireless systems were devised to operate on a dedicated frequency band, they are unable to use the improved flexibility provided by this spectrum licensing scheme. Hence, the concept of cognitive radio (CR) evolved, the prime objective is to provide adaptability to wireless transmission over dynamic spectrum access (DSA) so that the utilization of the frequency spectrum can be improvised without losing the benefits blended with the static spectrum allocation.

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II. COGNITIVE RADIO NETWORKS-FEATURES

The universal definition for Cognitive Radio is given as "Cognitive Radio is a radio system for wireless communication in which a network system or a wireless node alters its transmission or reception attributedepending on the interaction with the environment to communicate perfectly without interfacing with the licensed users."The term was coined to portray the intelligent radios

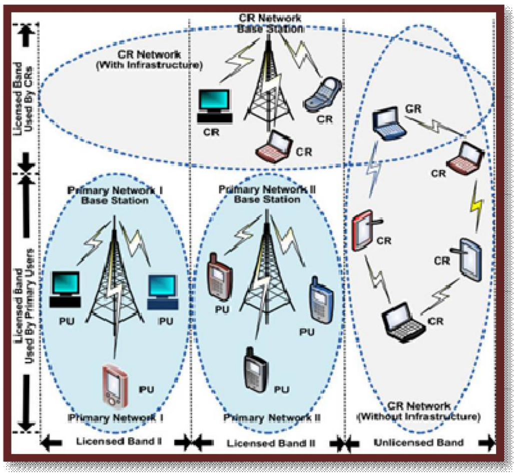

Fig1. Cognitive radio architecture

that can independently make decisions by applying the gathered information about the RF environment via the model-based reasoning, and can also learn and plan according to their past experience.The main important characteristics of cognitive radio are

Cognitive capability: Cognitive Capability clarifiesthe capability to seize or sense the information from its radio environment of the radio technology. Joseph Mitola first coined the cognitive capability in term of the cognitive cycle "a cognitive radio continuouslymonitors the environment, orients itself, creates plans, decides, and then acts"

Reconfigurability: Reconfigurability refers to radio capability to alter the functionalities which makes the cognitive radio to be programmed productively based onthe radio environment (frequency, transmission power, modulation scheme, communication protocol).

The CR is a "smarter radio" in the sense that it can identifies the channels which comprises the signals from aenormous class of heterogeneous devices, networks, and services. Upon this sensing, the radio will implement sophisticated algorithms to share the limited- bandwidth channel with remaining users so that to accomplish the efficient wireless communication. By this way, the CR concept discovers the concept of multiple access incorporating devices in a single homogeneous system to multiple access among devices in different radio spectrums using differentradio transmission techniques and thus different systems (i.e., inter-system multiple access as opposed to the more traditional intra-system multiple access), which have different priorities in accessing the spectrum.

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III. SPECTRUM MANAGEMENT PROCESS

The various spectrum management functions of the cognitive radio network are depicted and explained as follows:

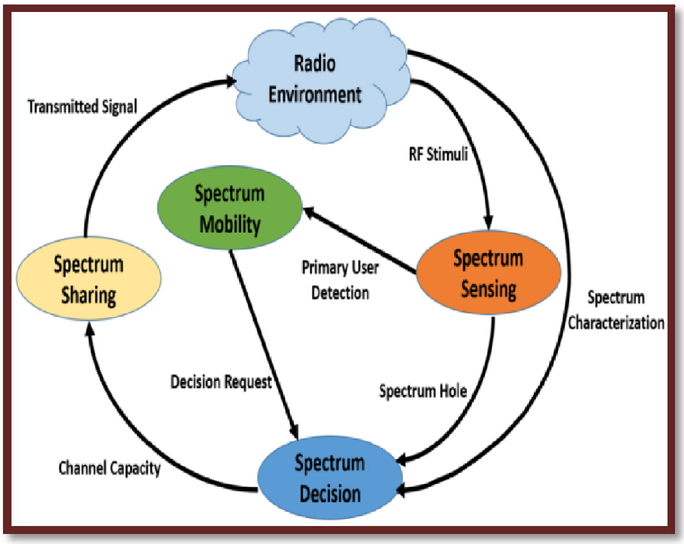

Fig 2 Cognitive radio cycle

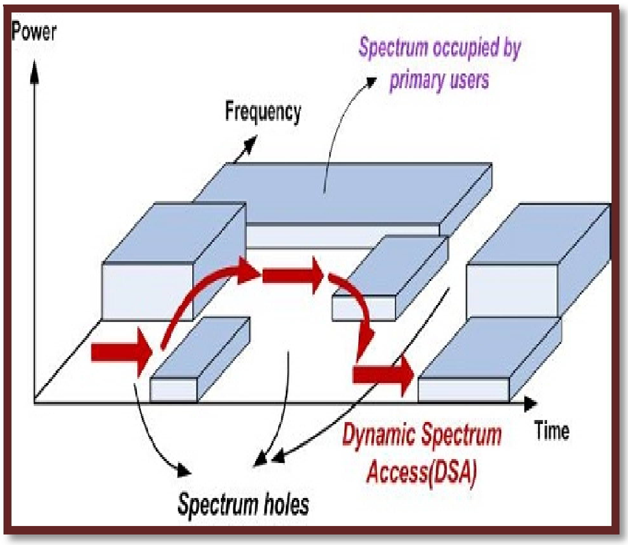

Fig 3.Spectrum space

A.Spectrum sensing - Spectrum sensing invokes to the detection of available PU spectrum usage of a stipulated time in a particular geographical area. It also helps to detect the available spectrum hole as well to make it profitable for SUs. The SU must have to be familiar about the channel structure of the spectrum using by PU's.In particular, a CR transceiver detects an unused spectrum or spectrum hole (i.e., band, location, and time) and also finds the method of accessing it (i.e., transmission power and access duration) without interfering the transmission of the licensed user.

B.Spectrum decision **–**Once getting the information from spectrum sensing, the major goal of CR is to send and receive information as far as possible with betterquality of service [QoS]. CR might utilize the database for improve its operational performance.

C. Spectrum sharing**–**Sincethere are multiple CR users trying to utilize the spectrum, CR network access [14] should be coordinated to prevent multiple users colliding in overlapping portions of the spectrum. After the decision is made on spectrum access, on the basis of spectrum analysis, the spectrum holes (also called spectrum opportunities) are accessed by the unlicensed users. It gives a balance between cognitive and non-cognitive users for transferring information, CR share the available resources.

D. Spectrum mobility - required by a primary user, the communication must be prolonged in another vacant portion of the spectrum. Spectrum mobility is a function associated to the change of operating frequency band of CR users. When a licensed user initiates accessing a radio channel which is currently being used by an unlicensed user, the unlicensed user can switch to the idle spectrum band.

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IV. SPECTRUM SENSING FOR SPECTRUM OPPORTUNITIES

The various spectrum sensing techniques are depicted in Fig 4 and being explained as follows

A.Primary transmitter detection/signal processing techniques: In this category, the detection of primary users is accomplishedbased on the received signal at CR users. This approach incorporates

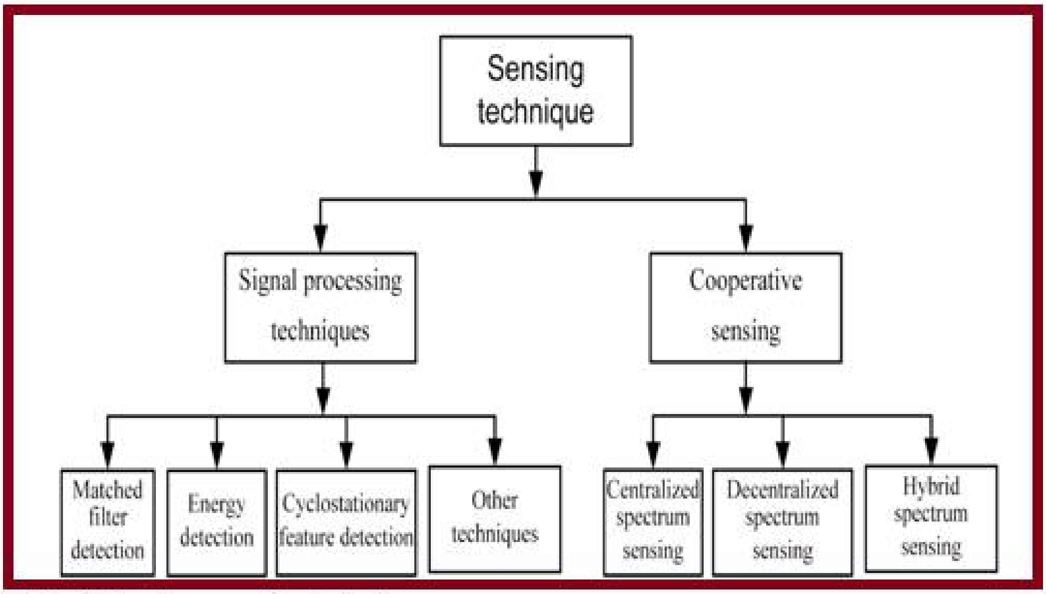

Fig 4- Spectrum sensing techniques

[i].Matched filter (MF) based detection

The matched filter is the optimal linear filter for maximizing the signal to noise ratio (SNR) in the event of additive stochastic noise. Matched filters are generally utilized in radar, where a known signal is sent out, and the reflected signal is examined for common elements of the out-going signal. In matched filtering technique, the user uses prior knowledge of PU. primary user's waveform in order to determine whether the spectrum is in use. A matched filter (MF) is a linear filter designed to improvise the output signal to noise ratio for a given input signal. When secondary user has a priori knowledge of primary user signal, matched filter detection is utilized.

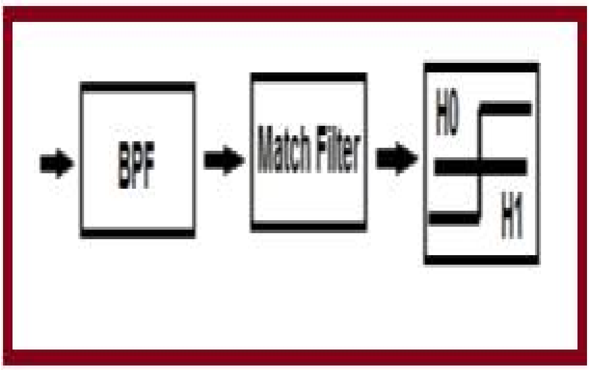

Fig 5.Matched filter

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Matched filter operation is correspondent to correlation in which the exotic signal is convolved with the filter whose impulse response is the mirror and time shifted version of a reference signal. The operation of matched filter detection is expressed as:

$$y[n] = \sum_{k=-\infty}^{\infty} h[n-k]x[k] \qquad [i]$$

Where 'x' is the unknown signal and is being convolved with the 'h', the impulse response of matched filter which is matched to the reference signal for improvising the SNR. Detection by using matched filter is better only in cases where the information from the primary users is aware to the cognitive users.

Advantages: Needs less detection time slot since it needs only O (1/SNR) samples to achieve a given probability of detection constraint. When the information of the primary user signal is aware to the cognitive radio user, matched filter detection is the suitable detection in stationary Gaussian noise.

Disadvantages: Needs a precedentinformation of every initial signal. If the information is not correct, MF performs poorly. Also the most significant disadvantage of MF is that a CR would need a mostdedicated receiver for each and every type of primary user

[ii]Energy Based Detection

It is a non-coherentrevelation method that exposes the primary signal based on the sensed energy. Owed to its simplicity and no requirement on a priori knowledge of primary user signal, energy detection (ED) is the most attractive sensing technique in cooperative sensing.

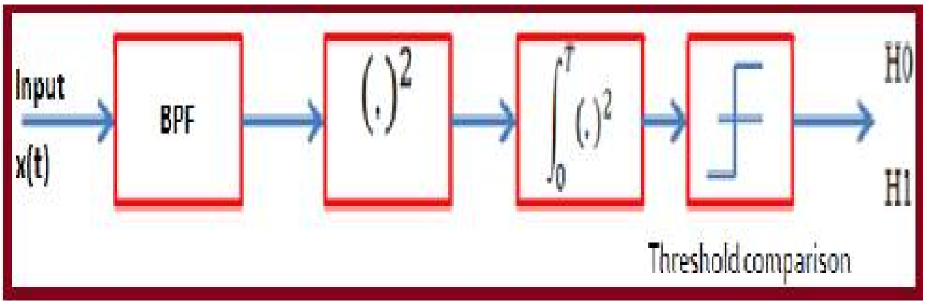

Fig 6.Energy Based Spectrum Sensing

In this method, signal is passed through band pass filter of the bandwidth W and is integrated over time interval. The output from the integrator block is then compared to a predefined threshold. This comparison is used to discover the existence of absence of the primary user. The threshold value can set to be fixed or variable based on the channel conditions. The ED is said to be the blind signal detector because it ignores the structure of the signal. It measures the existene of the signal by comparing the energy received with a known threshold H derived from the statistics of the noise.

$$y_i(k) = s_i(k) + w_i(k) \qquad (ii)$$

Where, $y_i(k)$ is the k-th sample of received signal at i-th SU $s_i(k)$, with mean zero and variance σ_s^2represents the signal transmitted by the PU, $w_{i(k)}$is Additive White GaussianNoise (AWGN) with mean zero and varianceσ_w^2at i-th SUand k=1,2,3,4 … …N is the number of samples of receivedsignal.The energy detector decision metric can be written as

$$M_i = \frac{1}{N}\sum_{K=1}^{N} |y_i\,(k)|^2 \quad (iii)$$

Where, N= Observation vector size. To choice of occupancy band can be obtain by the matching the decision metric M opposite to fixed threshold λ_E. Presence or absence of PU scan be distinguished from the two hypotheses as follows:

$$y_i(k) = w_i(k) \qquad : H_0 \quad (iv)$$
$$y_i(k) = w_i(k) + s_i(k) \qquad : H_1 \quad (v)$$

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Where,H_0 means frequency is ideal, there is no PU signal and H_1 means frequency is occupied, there is PU signal.Even though the energy detector offers a better filtering it's accompanied by a number of disadvantages

- sensing time taken to achieve a given probability of detection may be high.
- detection performance is subject to the uncertainty of noise power.
- ED cannot be used to distinguish primary signals from the CR user signals. As a result CR users need to be tightly synchronized and refrained from the transmissions during an interval called Quiet Period in cooperative sensing.
- ED cannot be used to detect spread spectrum signals.

[iii]Cyclostationary Based Detection

It denotes the detection of PU transmissions by exploiting the built-in periodicity of the received signals. For sensing the availability of signal in the spectrum this method used cyclic correlation function instead of power spectral density (PSD).

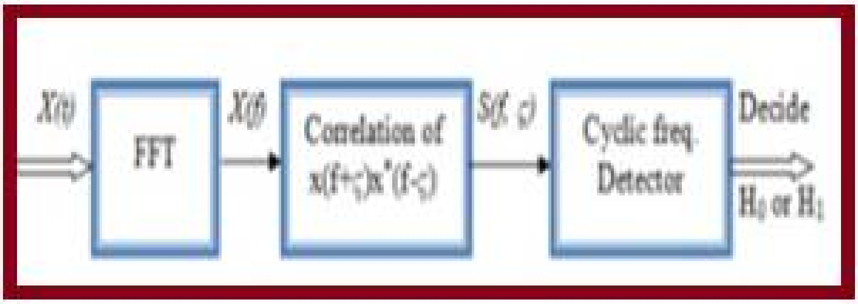

Fig 7.Cyclostationary based detection

This algorithm differentiated PU signals from noise. Cyclostationarity based method is used for distinguishing the difference of transmissions among PUs. Due to the periodicity, these cyclostationary signals manipulate the features of periodic statistics and spectral correlation, which is not found in stationary noise and interference. Thus, cyclostationary feature detection is robust to noise uncertainties and performs better than energy detection in low SNR regions. Although it desires a priori knowledge of the signal characteristics, cyclostationary feature detection is proficient of distinguishing the CR transmissions from the different types of PU signals. This eliminates the integration requirement of energy detection in cooperative sensing. Moreover, CR users may not be prescribed to keep silent during cooperative sensing and thus improving the overall CR throughput. This method has its own limitations owing to its high computational complexity and long sensing time. Due to these issues, this detection method is less familiar than energy detection in cooperative sensing accuracy

B.Cooperative and Collaborative Detection

In this approach, the primary signals for spectrum opportunities are detected loyally by interacting or cooperating with other users, and the method can be invoked as either centralized access to spectrum associated by a spectrum server or distributed method assigned by the spectrum load smoothing algorithm/ external detection. Cooperative spectrum sensing (CSS), CR system contributes its own sensing information with other sensing nodes and utilizes the sensing outcomes of others to give a decision. CSS hasrobust to sensing errors due to hidden node or fading channelsalso itreduces the probabilities of false alarm as well as profanities of misdetection.

Additionally, hidden PU problems and long detection time can be resolved by cooperation of detection data. Complexity and efficient information sharing problems are still issues to examined for this type of sensing technique.Conventional cooperative sensing is of three steps procedure: local sensing, reporting, and data fusion. Added to these steps, there are other preliminary components that are decisive for cooperative sensing. We call these basic and yet imperative components as the elements of cooperative sensing. Cooperation models consider the modeling of how CR users cooperate to perform sensing. We examine the most attractive parallel fusion network models.

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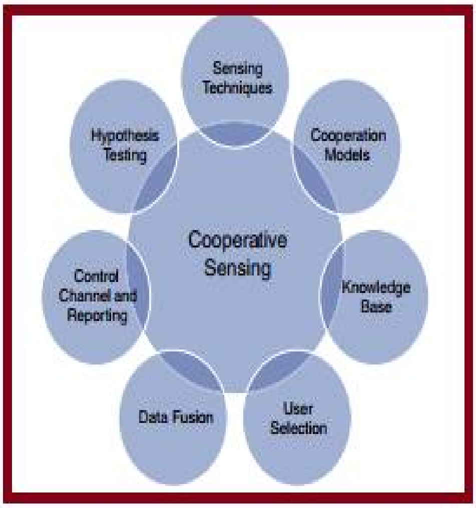

Fig 8. Elements of spectrum sensing methods

. • *Sensing techniques* are used to identify the RF environment, considering observation samples, and adapting signal processing techniques for detecting the PU signal or the available spectrum. The elite of the sensing technique has the effect on how CR users cooperate with each other.

• *Hypothesis testing* is a statistical test to determine the presence or absence of a PU. This test can be performed individually by each cooperating user for local decisions or performed by the fusion center for cooperative decision.

• *Control channel and reporting* concerns about how the sensing results obtained by cooperating CR users can be efficiently and reliably reported to the fusion center or shared with other CR users via the bandwidth-limited and fading-susceptible control channel.

• *Data fusion* is the process of combining the reported or shared sensing results for making the cooperative decision. Based on their data type, the sensing results can be combined by signal combining techniques or decision fusion rules.

• *User selection* deals with how to optimally select the cooperating CR users and determine the proper cooperation footprint/range to maximize the cooperative gain and minimize the cooperation overhead.

• *Knowledge base* stores the information and facilitates the cooperative sensing process to improve the detection performance. The information in the knowledge base is either a priori knowledge or the knowledge accumulated through the experience. The knowledge may include PU and CR user locations, PU activity models, and received signal strength (RSS) profiles. Cooperation can be implemented in three ways:

[i]. Centralized Sensing

In centralized sensing a central manager (BS or AP) compiles all CR sensing data and makes a decision on channel state, i.e. idle or busy. The intention isto reduce the fading effects of the channel and improve the detection performance.

[ii] Distributed Sensing

In distributed sensing, CR detecting nodes access information among each other but each CR makes decisions on its own. It's better than centralized sensing because there is no requirement of any backbone infrastructure that's why it is reduced cost.

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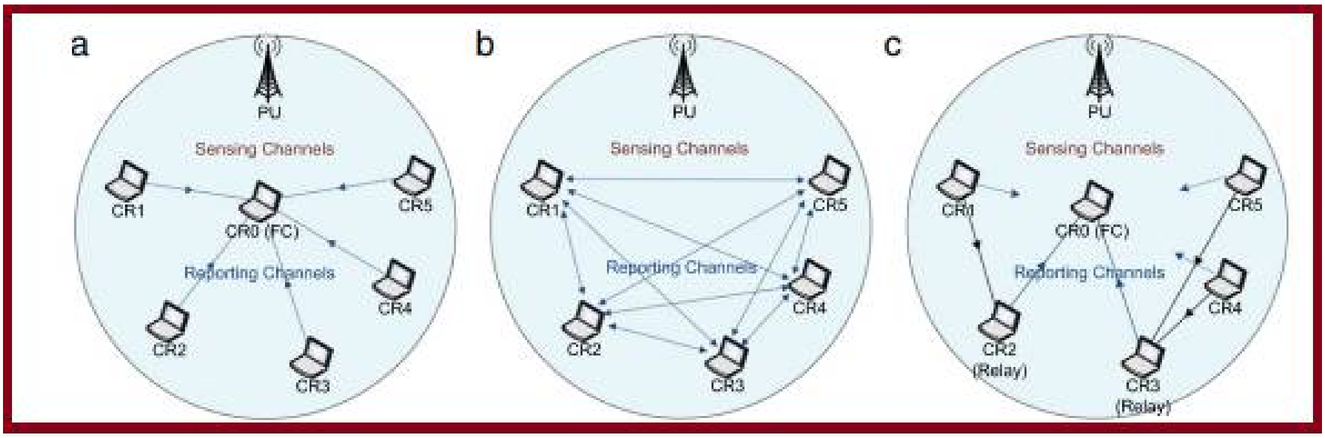

Fig 9: Classification of cooperative sensing methods (a) Centralized (b) Distributed (c) Cluster

[iii] Cluster Based Sensing

In clustering method all CRs are segmented into cluster, where one CR act as cluster head (CH) and remaining CRs will act as cluster members. In CR all CRs delivers their own information such as current location, current energy level and SNR of reporting channel to the Fusion center (FC). Firstly FC sorts all CRs in ascending order based on the SNR value of the reporting channel and then calculates the average energy level and makes CH for current round, whose energy level is higher than average level.

V.CHALLENGES AND COMPARISON OF VARIOUS SENSING TECHNIQUES

Latterlyrefined wireless standards have initiated to incorporate the cognitive features. Even though it istedious to expect a wireless standard that is based on wideband spectrum sensing and opportunistic exploitation of the spectrum, the trend is in this direction.

A.Challenges

[i]Hardware Requirements: High sampling rate (HSR) with large dynamic ranges is obligatory for spectrum sensing in a CR system. High speed signal processing is also major issue for decreasing the sensing time. Noise variation estimation technique may be a solution for this issue for optimal receiving node design for increasing the handoff and channel estimation

[ii]Hidden PUs Problem: Multipath fading or shadowing noticed by the SUs at the time of sensing is the main example of this issue.

[iii]Detecting Spread Spectrum PUs: Detection of spread spectrum signaling is the main issue for SU nodes for detecting the presence of PUs. In this case,

PU utilizes a larger bandwidth even through the actual bandwidth is much narrower.

[iv]Security Issues: Security is always a challenging part for all methodologies. CR has some malicious or selfish users; which can change its air interface to PUs. Due to these reasons, the spectrum sensing result is not enough. Between cooperation and non-cooperation approaches, the centralized and distributed architectures, cooperation approach are more susceptible to attacks.

B.Comparison

In energy detector based sensing, there is no need of any detail of PU's signal that's why its design is complex free. It also used in wide band spectrum sensing. The drawback is this type of sensing is to select threshold efficiently. If the SNR is very low, this method is inefficient enough to avoid interference with PUs. Cyclostationary detection gives good performance than energy detection but it's more computational complexity and takes lasting Observation time. The main advantage of matched filter detection is its better detection performance and minimum time to

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accampalish the processing gain. The disadvantages of matched filter detection method is it needs proper prior knowledge of the PUs signaling features such as bandwidth, operating frequency, modulation type and order, pulse shaping and frame format. It is avastpower consumption method.

VI. CONCLUSION

In this paper, the spectrum sensing and concepts considering various dimensions including simulated and implemented techniques were discussed.The advantages and disadvantages of several sensing methodsalso discussed. High speed communication with low cost and dynamic spectrum access is the future goal of CR.

Spectrum is a very relevant resource in wireless communication systems and it has been a predominant research topic from the recent several decades. The improvement of the cognitive radio network requires the involvement and interaction of many recent techniques, including distributed spectrum sensing, interference management, cognitive radio reconfiguration management, and cooperative communications. Furthermore, in order to fully realize the CR system in wireless communications for efficient utilization of scarce RF spectrum, the method used in recognizing the interference and/or spectrum sensing should be steady and prompt so that the primary user will not get affected from the CR system to utilize their licensed spectrum. Infuture, the analysis of energy detection based channel detection method and a threshold determination method which is functional and able to detect PUs even in low SNR may be carried out.

REFERENCES

[1].Mahfuzulhoq Chowdhury, Asaduzzaman, MdFazlul Kader, Performance Analysis of Local and Cooperative Spectrum Sensing in Cognitive Radio Networks, International Journal of Signal Processing, Image Processing and Pattern Recognition, 2013.

[2]Meghana Joshi, Mrs. Borde SD, Comprehensive Analysis of various Energy Detection parameters in Spectrum Sensing for Cognitive Radio systems, 2014 International Conference on Advances in Communication and Computing Technologies.

[3].Ian.F.Akyildiz, Won-Yeol Lee, and Kaushik R. Chowdhury, Georgia Institute of Technology, “Spectrum Management in Cognitive Radio Ad Hoc Networks”,August 2009

[4]Z. Quan, S. Cui, H. Poor, A. Sayed, Collaborative wideband sensing for cognitive radios, IEEE Signal Processing Magazine 25 (2008)60–73.

[5] C. Sun, W. Zhang, K. Ben, Cluster-based ooperative spectrum sensing in cognitive radio systems, in: Proc. of IEEE ICC 2007.

[6].C. Wu, C. He, L. Jiang, Y. Chen, and Q. Shi, “Optimal Channel Sensing Sequence Design for Spectrum Handoff”, IEEE Wireless Communications Letters, vol. 4, no. 4, 2015.

[7]. Won-Yeol Lee, Student Member IEEE, and Ian F. Akyildiz, Fellow, IEEE, “Spectrum Aware Mobility Management In Cognitive Radio Cellular Networks”, IEEE Transactions On Mobile Computing, Vol-11, No.4, Apr 2012.

[8]. Hano Wang, Gosan Noh, Dongkyu Kim, Sungtae Kim, and Daesik Hong, “Advanced Sensing Techniques of Energy Detection In Cognitive Radios”, Journal Of Communications and Networks, Vol. 12, No. 1, February 2010

[9]. Zhuan Ye1, GokhanMemik, John Grosspietsch “Energy Detection Using Estimated Noise Variance For Spectrum Sensing In Cognitive Radio Networks”, IEEE Communications Society, WCNC 2008 Proceedings

[10]. Li-Chun Wang, Chung-Wei Wang, Chung-Jun Chang. "Optimal targetchannel sequence design for multiple spectrum handoffs in cognitiveradio networks," iEEE Transactions on Communications, ol.60, no.9,2012.

[11]. N. Baldo, B. R. Tamma, B. S. Manoj, R. Rao, and M. Zorzi, “A neural network based cognitive controller for dynamic channel selection”, in Proc. of IEEE International Conference on ommunications (ICC'09), pp. 1-5, Dresden Germany, 2009.

[12].R. Kaniezhil, Dr. C. Chandrasekar, “Comparing Spectrum Utilization using Fuzzy Logic System for Heterogeneous Wireless Networks via Cognitive Radio”, International Journal of Scientific & Engineering Research, Volume 3, Issue 7,July 2012, pp.1 - 10.