Cognitive Radio Networks and its Related Issues

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***Abstract* -** The need for a flexible and robust wireless communication is becoming more evident in recent times. The future of wireless networks is thought of as a union of mobile communication systems and internet technologies to offer a wide variety of services to the users. One promising solution to such problems is the Cognitive Radio (CR). And to serve this purpose the initial goal considered in CR is spectrum sensing. The prime focus in this paper for sensing the spectrum is cyclostationary technique since it gives desirable output even in low signal-to–noise ratio (SNR). Also an overview of the security threats faced by the CR is discussed in this paper.

Keywords *- Spectrum; cognitive radio network (CRN); signal to noise ratio (SNR); primary users (PU);secondary users(SU).*

I. INTRODUCTION

The last decade is witnessing an increasing demand for wireless radio spectrum with the rapid deployment of new applications and wireless devices. Since the maximum portion of licensed spectrum is severely under-utilized, the fixed spectrum assignment policy is becoming a bottleneck for more efficient utilization of spectrum [1].

II. COGNITIVE RADIO NETWORK

Cognitive radio is an adaptive technology that allows the unlicensed user to use the frequency bands of the licensed users by monitoring the spectrum continuously in order to avoid any interference to the primary users. CR basically learns from its surrounding and then performs the required functions to serve best to its users.

The minimal features of the CR are:

i. To handle diversity in QOS, the cognitive network architecture is equipped with unified cross layer.

ii. To continuously monitor the presence of multi-carriers in CR network, it needs efficient spectrum sensing techniques.

iii. To adapt to the fluctuating nature of CR network and allocation of bandwidth, dynamic spectrum access methods are needed.

iv. To have minimal interference to PU that has occupied the adjacent bands, adaptive spectrum sculpting at the transmitter end is needed [2].

A. Trainable Adaptive Radio System

The applications of the cognitive network has been explained in this paper with the radio system which is trainable adaptive to enable intelligent connections among the various nodes. The wireless communication demands the use of cognitive networks & for communication to be free of any interference, efficient communication is desirable between the nodes that change its parameters of sensing as well as transmission. Based on the active monitoring, the parameters are changed in the radio environment, whether internal or external. The two-layer architecture explains the working of cognitive radio where the signals on the frequency are transmitted on the second layer which is assigned to the first layer after the radio frequency band was sensed. In case of the cognitive radio, the context & the content are being focused rather than the management & the configuration of the networks [3].

B. Challenges Faced by CRN

To accomplish the task of spectrum sensing, one must be aware of the challenges associated with it. Some of the challenges are explained below:

- Hardware Requirements**:** To the high rate of sampling, analogue to digital converters with high resolution and large dynamic range, and high speed signal processors adds to the cost of spectrum sensing for various applications in CR. To capture and analyse relatively larger band so that CR can use the spectrum opportunistically.
- Hidden Primary User Problem: Hidden node problem in CSMD can be considered as hidden primary user problem. Severe multipath fading, shadowing are factors that cause this problem. One of the remedy for this problem can be cooperative sensing.

There are other challenges like detecting spread spectrum primary users, sensing durations and frequency which must be kept in mind while selecting the spectrum sensing technique [4].

III. COMPARISON OF DIFFERENT ALGORITHMS

To enhance the primary user detection, variety of techniques have been proposed, which include detection with pilot signal, cyclostationary feature detection etc. Furthermore the tradeoff between probability of primary user being not detected & the other parameters has to be investigated. Hence the parameters are:-

- For the detection, the computational overhead needed.
- The dissipation of power.
- The transmission time/ bandwidth wasted for detection.

- The area of hardware and
- The cost needed per unit [5].

A. Reliable Detection of Primary User Signal

The prime importance of detecting the PU reliably is:

a) To avoid the interference with PU.
b) Providing permission to SU of their spectrum by CR.
c) For the capacity increase of cognitive, the spectrum opportunities are created.

B. Primary User Signal Detectors

When the signal is received reliably & sampling of wideband signal is done, DSP (digital signal processing) technique are used to so that sensitivity of radio is increased by processing gain & the primary users can be identified on the basis of knowledge of the signal characteristics. Matched filter, energy detection & cyclostationary feature detection are the techniques considered.

(i) MATCHED FILTER

- Optimal detection
- Demodulate signals due to signal processing.
- Processing gain proportional to number of samples.

DISADVANTAGE

- Implementation complexity large
- Separate matched filter based receiver in CR for every PV system.

(ii) ENERGY DETECTION

- Sub optimal detection.
- Non signal processing.
- Integrates squared samples.
- By comparing output of energy detector with threshold, the signal is detected depending on the estimated noise power.
- Implementation simplicity makes it favourable candidate.

DISADVANTAGE

- A small estimation error in noise power causes significant performance loss of energy detection.
- Energy detection completely fails in the detection of weak signals at low SNR's.
- Requirement to estimate the noise power of actual RF transceiver within a fraction of Db would be difficult to achieve.

(iii) CYCLOSTATIONARY FEATURE DETECTION

- Ability to extract distinct features of a modulated signal such as sine wave carrier, modulation type.
- By analysing spectral correlation function i.e. two dimensions transform; these features are detected in contrast with power spectrum density being one dimension transform.
- The discrimination of noise energy from modulated signal energy is major advantage of spectral correlation function which is the resultant of the fact that noise is basically a wide sense stationary signal without correlation, while modulated signals are cyclostationary with spectral correlation due to redundancy embedded of periodicity in signals.

Cyclostationary feature detection hence is better than energy detector when discriminating against noise due to its robustness to unknown noise variance.

DISADVANTAGE

- Implementation complexity increases by N complex multiplicands to compute cross-correlation of N point FFT outputs. While energy detection complexity is of N point FFT [6].

Hence in the scenario of the network of cognitive radio, users are mostly mobile & topology of network varies with time, moreover there is lack of fast & cost system is low for the literature being reviewed. The proposed technique in this paper is the Ant Colony System (ACS) technique which is based on the graph coloring problem (GCP) for the allocation of the spectrum in the network for cognitive radio. The investigation of the performance of this method compared to the particle swarm optimization (PSO) is a proposed approach for the various numbers of the users both primary & secondary as well as the channels that are available. Moreover, the algorithm proposed performs much better than the initially studied algorithm with a little more time to run is albeit [7].

C. Why to Choose Cyclostationary Feature Detection

While studying the previous work, the 4 distinct & novel contributions made are:-

i. For embedding cyclostationary signatures in OFDM-based waveform, a flexible, low- complexity technique is introduced.
ii. For the detection & analysis of signatures, a robust approach is presented.
iii. For the sake of signal detection, identification of cognitive network & frequency rendezvous, the use of cyclostationary signature is discussed & hence using the simulation result, its performance is examined.
iv. An OFDM based transceiver that is implemented & analyzed using cyclostationary signatures on a real CR test platform are presented [8].

As statistical periodicity is exhibited by most of the communication signals, defined as cyclostationary, CFD is the proposed technique for spectrum sensing and in turn detect the PU's existence. The advantage of CFD is its high signal sensitivity which is the effect of distinctive cyclic spectrum. The assistance of the licensed system provides complete knowledge of cyclic spectrum of tested signals, for high sensitivity [9].

To sense the radio spectrum, cognitive radio is being used to discover unused frequency band so that they can be used in a cyclic manner. The primary users transmission are detected even in the presence of low signal to noise ratio (SNR) reliably also including fading & shadowing. Cyclostationary is generally exhibited by the communication signals & statistical periodically is related to factors like guard period, modulation schemes, coding etc. These properties favours in designing detection so that the primary& secondary signals can be distinguished. A generalized likelihood ratio test (GLRT) is being used to detect the cyclostationary presence with multiple cyclic frequencies. By combining the statistics of local tests from the multiple secondary users, distributed decision is employed. To mitigate the effect of shadowing, the user cooperation is allowed, providing a larger footprint supporting the system of cognitive radio [10].

D. Cyclostationary Deatection in Single Antenna & Multiple Antenna CR Reaceivers

The cyclostationary detection is a technique used to detect the presence of the PU signal. The cyclic statistics of the signal have to be gain from the oversampled signal in this technique but with respect to the rate of symbol or else it can be done through multiple receivers by receiving the signal.

To use the multiple antennas is a recent surge in the interest for both the transmitter as well as the receiver to increase the capacity of the wireless channels. The performance of the detection for the cyclostationary detector to sense the spectrum in scenario of multiple antennas for cognitive radio needs to be determined [11].

IV. COLLOBARATIVE DETECTION WITH CENSORING

When the results of spectrum sensing are transmitted in a scheme of collaborative spectrum sensing by the secondary users to other secondary users or to FC, substantial traffic is generated in ad-hoc scenario. By the transmission of only the relevant or the statistics of the informative test to the FC or the other users, there is significant reduction in the amount of the data transmitted. This is termed as censoring. Since only fewer terminals are transmitted at the given time, the energy consumption is hence reduced of the secondary user terminals. Hence the censoring strategy proposed is based on the communication rate constraints for cyclostationary spectrum sensing [12].

V. SECURITY CONCERNS INVOLVED IN CRN

The performance of the system for cooperative sensing is significantly affected by the presence of the nodes which are malicious. Due to the malfunctioning of the device or some selfish reason, the node act maliciously. For example if the absence of signal is detected by the node but it might generate false positive, & the wrong decision is taken by the access point considering the presence of the primary signal & hence the malicious node can transmit its own signal selfishly over the free channel available [13].

To combat the attacks against the cognitive radio networks, this paper highlighted the importance to design an appropriate intrusion detection system. Hence to implement in any secondary use, a lightweight IDS has been proposed. In future, one must further focus on the investigation on enhancing the sensitivity of detection of the intrusion detection system (IDS) [14].

TABLE I. REVIEW OF RESULTS

Sr.no.	Overview	Terminology	Result
[1]	The fundamentals of CRN have been discussed in this paper.	CR characteristics. CR function. Network Architecture and application. Spectrum sensing and analysis.	The important uses in dynamic spectrum allocation and sharing.
[2]	The purpose and the minimal features of CRN are entertained.	Spectrum holes. Primary signal detection.	CR basically learns from its surrounding and performs the required functions.
[3]	Power spectral density (PDS) is estimated by the CR to determine the frequencies used & unused.	Estimation of the power spectral density.	CR operates autonomously accessing the spectrum dependency on the receivers which are sensitive & device learning.
[4]	To accomplish the task of spectrum sensing, one must be aware of the challenges associated with it.	Challenges faced by CRN like hardware requirements, hidden primary user problem, sensing duration etc.	A deep survey of the various methodologies of the CR is presented.
[5]	The 3 major aspects for the detection of the primary user are: time until primary user is detected, the reliable detection of primary user, the time taken to clear the spectrum.	Concerns of existing primary users. The way Forward: Test bed and Test Cases. Metrics and requirements For Experimental Evaluation.	The test bed to experiment in CR at physical & link layer. The emulation of primary & secondary users and the evaluation of the sensing schemes performance.
[6]	Focus on the issues related to designs in an implementation that is limiting their performance or even make them unfeasible.	Unique Physical layer functions. Reliable detection of primary user signals. Primary user signal detectors. Wideband Transmissions.	The signal processing techniques are compared dictating that the best is cyclostationary feature detection.

[7]	The graph coloring problem (GCP) & the Ant colony system (ACS) are the approaches addressed as a solution to the challenge in the CR networks.	Ant Colony System. Problem graph depiction. Ant distribution initializing. Ant probability distribution rule.	For channel flexibility cost evaluation is increased so that impact rate for parameter is controlled in channel selection probability.
[8]	Using cyclostationary signatures with minimal complexity the existing transmitter architectures can be adapted easily.	Cyclostationary Signal Analysis. Signature Generation. Signature Detection and Analysis.	Signal is transmitted at a range of power level estimation at the receiver, & detection is performed over a range of observation times.
[9]	As statistical periodicity is exhibited by communication signals, defined as cyclostationary, CFD is the proposed technique for spectrum sensing and in turn detect the PU's existence	CFD (cyclostationary feature detection) technique.	The optimal and sub-optimal methods is used to select multiple lags and compared to sub-optimal methods giving superior performance of detection low SNR region.
[10]	The generalized likelihood ratio test to enable transmission detection for primary users with multiple cyclic frequencies & the test statistics for the distribution.	A generalized likelihood ratio test (GLRT).	Reliable performance of detector in low SNR regime is demonstrated through the simulation and gains obtained via decision making are collaboratively done.
[11]	Cyclostationary detector based on maximal ratio combining is used to detect the primary user.	Cyclostationary Detection in Single And Multiple Antenna CR Receiver.	The MIMO CR is enjoying advantage of 6dB SNR over single antenna for probability of detection.
[12]	The multi-cycle CFAR detectors for single user have been proposed with the extension to accommodate the user collaboration.	Single user detection using multiple cyclic frequencies. Collaborative detection with censoring.	Energy efficiency in sensing spectrum in CR by combining cyclostationary detection and user collaboration with censoring.
[13]	Identifying malicious users and their harmful effects are mitigated which harms the performance of the system for cooperative sensing.	Methods to detect malicious users • Pre-filtering of the sensing data. • Trust factors. • Quantization.	To identify and nullify the effect of the nodes which are malicious where sensing devices use energy detector. The decision process is simplified.
[14]	To combat CRNS against threats; intrusion detection system is used. The description of CRN based on IEEE wireless regional area network and some of the security threats are given.	Existing CRN Architecture and Attacks. Major security threats against CRN • PUE attacks. • Objective function attacks. • Jamming attack.	To combat attacks against CRN and to implement in any secondary use, a lightweight IDS has been proposed.

VI. CONCUSION

This paper emphasizes not on the evolution on the CRN but also takes into consideration the very initial function of CR that is spectrum sensing. It determines the various spectrum sensing techniques that can be used. One can go through the overview of the functionalities of each technique. At the same time the various disadvantages mentioned provides easy way of judgment. Moreover the security issues involved in cognitive radio has also been enlightened.

VII. REFERENCES

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