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Cognitive Radio Networks: A Dynamic Investigation

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Abstract:
The increase in demand of the wireless and cellular applications has put lot of restraints on the usage of convenient radio spectrum which is a limited and expensive resource. Further-more, the fixed-spectrum is allowed to lead under-utilization of the spectrum as a great part of licensed spectrum is not efficiently utilized. CRN is a predominant-technology which assigns unique way to improve utilization effectiveness of the accessible radio frequency spectrum. The spectrum sensing mechanism helps to sense the white spaces or spectrum-holes specifying high spectral-resolution ability. In this specific paper, the effective investigation of the spectrum sensing approaches is specified. The issues and challenges involved in performance of the RF spectrum sensing approaches are conferred in detail by opting the distinct methodologies.

Keywords:
Cognitive Radio (CR), Primary User (PU), Secondary User (SU), Dynamic Spectrum Access (DSA), Software Defined Radio (SDR), Spectrum sensing.

Introduction:

The electromagnetic radio spectrum is rarely found and is getting utilized day to day. It is also found in the allocated spectrum which is underutilized because of its static allocation and it is conventional approach of spectrum management. It is very inflexible to operate in a certain frequency band. The most of the useful radio spectrum is already allocated. It is very difficult to find vacant bands to either deploy new services or to enhance existing ones.

To overcome this situation, we need to come up with a improved utilization of the spectrum creating opportunities i.e.; Dynamic spectrum access [3]. By using Cognitive Radio (CR) technology the issue of spectrum underutilization in wireless communication can be solved in a better way. CRs are designed in order to contribute highly reliable communication for each users of the network, whenever and wherever needed and to facilitate efficient utilization of the radio spectrum [1]. Cognitive radio: CR is a radio that can change its transmitter parameters based on interaction with environment in which it operates. CR includes spectrum sensing, spectrum management and spectrum mobility and spectrum sharing.

- **Spectrum Sensing:**
  It can detect unused spectrum and shares the Spectrum with other users without any harmful interference.
- **Spectrum Management:**
  It captures the available spectrum to meet user communication requirements.
- **Spectrum Mobility:**
  It maintains the seamless communication requirements during the transition to better spectrum.
- **Spectrum Sharing:**
  Among all the co-existing the fair spectrum scheduling method is also provided.

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Cognitive Radios:

CR is the latest term in wireless communication technology. Which communicates with real time environment to alter dynamically, operating parameters are transmit power, carrier frequency, modulate itself with the environment when there is a large change in incoming RF with the own purpose to take utility of the available spectrum without the interference of primary users. CR includes intelligent detection by a receiver, with which it verifies. The communication systems are in use which takes an immediate decision of shifting to vacant channels while stopping stored ones. This reduces the usage of available RF (Radio-Frequency) spectrum while minimizing the interference to remaining users. The most prior form, CR is a hybrid technology involving SDR (Software Defined Radio). It performs the allocating, identifying and authorizing of it own user and adjusts output power so that its modulation properties are to be noted that Software Defined Radio, cannot reconstruct by itself, whereas Cognitive Radio can perform reconstruction process.

The FCC (Federal Communications Commission) is ruled in November '2008. The unused portions of the Radio Frequency spectrum (known as white spaces)may be made to make available for public use .White space devices (RFS) must include technologies to protect interference, such as relocation capabilities and spectrum sensing.[5]. The idea for Cognitive Radio was developed by "Joseph mitola-III" at the Defense Advanced Research Projects Agency (DARPA) in the United States. This CR is sometimes known as "Mitola radio". The CR is viewed as the key enabling technology for future mobile wireless services everywhere, anytime and with any device or any system. [8]

III. SPECTRUM SENSING MECHANISM

Energy Detection Approach:

It is a non coherent detection method. In this technique the primary signal based on the sensed energy is detected. It is easy to implement. While using energy detection we don't require the antecedent knowledge of first signal. Energy Detection (ED) technique is one of the most popular sensing technique, In this process, the signal is passed through BPF of the bandwidth and is racially balanced over time interval. The output of the integrator block is then compared with a predefined threshold. The comparison of input signal and threshold signal is used to know the existence or non existence of the basic user. The threshold value can be set to non variable or variable based on the conditions of the Energy detection technique, because it doesn't agree the structure of the signal and pre-estimates the presence of signal by verifying the energy received with a known threshold. While verifying we will decrease the signal detection to a simple problem as a hypothesis test,

$$y(k) = n(k)\ldots\ldots\ldots\ldots\ldots\ldots H_0$$
$$y(k) = h*s(k) + n(k)\ldots\ldots\ldots H_1$$

Whereas

y (k) is the sample to be analyzed at each instant k

n (k) is the noise of variance σ^2

y (k) is a sequence of received samples k E {1, 2….N} at the signal detector, then a decision rule can be stated as

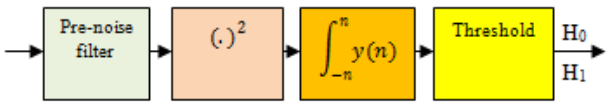

Fig.1: System model of Energy detection

H_0 ……if ϵ < Threshold (Absence of PUs)

H_1 ……..if ϵ > Threshold (Presence of PUs)

Whereas; $\epsilon = E|y(k)|^2$ the estimated energy of the received signal and v is chosen to be the noise variance σ^2

Matched filter Approach

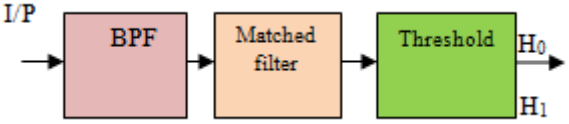

Fig 2: System model of Matched Filter

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A matched-filter (MF) is a linear filter designed to maximize the output signal to noise ratio for a given input signal, in matched-filter detection the secondary user has a prior knowledge of primary user signal is needed Matched filter operation is equivalent to correlation in which the unknown 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:

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

Where 'x' is the unknown signal (vector) and is convolved with to the reference signal for maximizing the SNR. is known to the cognitive users and interference of matched filter that is matched

Utilities:

- Robust to noise performs better than energy detection in low SNR regions.
- In pattern of matched-filter, though we need antecedent knowledge of the signal characteristics however it is capable of distinguishing the CR transmissions from various types of PU signals.
- Synchronization requirement of energy detection in collaborative sensing is eliminated using this process.
- Improves the overall Cognitive radio throughput.

Characteristics of dynamic cognitive Radio

Features that CRs can be used to enable a more effective and flexible spectrum usage.

- Frequency Agility: The CR can change its operating frequency for the adaptation of the environment.
- Dynamic Frequency Selection: The CR senses the signals from nearby transmitters to work from the chosen optimal environment.
- Adaptive Modulation: The wave forms and transmission characteristics can be reconfigured by all the opportunities for the usage of spectrum in an effective way.
- Transmit Power Control: The transmission power will be adapted to full power limits when ever it is necessary on the one hand. The lower levels on the other hand will allow greater sharing of spectrum.

Cooperative Techniques:

If multiple CR users collaborate in sensing the channel then we require high sensitivity requirements. Various topologies are currently used and are broadly classified into three regimes according to their level of cooperation.

Cooperative sensing techniques:

- Centralized Coordinated
- Decentralized Coordinated
- Decentralized Uncoordinated

Requirements of Cooperation in CR:

Dive sensitivity requirements: Channel impairments like building penetration losses, shadowing and multipath fading impose high sensitivity requirements innately limited by cost and power requirements. Employment cooperation between nodes is drastically reducing the sensitivity requirements up to -25 decibels/meter. By using cooperation scheme we can obtain reduction in sensitivity.

Primary Receiver Detection

In general, primary receiver radiates the local oscillator (LO) leakage power from its RF front end while receiving the data from primary transmitter. It has been proposed as a method to detect primary user by mounting a low cost sensor node close to a primary user's receiver in order to detect the local oscillator (LO) leakage power radiated by the RF front end of the primary user's receiver which are within the communication range of CR system users. The local sensor then indicates the sensed information to the CR users so that they can easily analyze the spectrum occupancy status.

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Other Approaches:

Multi -Taper Spectrum Sensing and Estimation

Multi Taper spectrum estimation (MTSE) has proposed by Thomson (1982) before the CR concept was introduced. The last N received samples are collected in the form of vector and are represented as a set of slepian base vectors. The main idea of this method is that the Fourier transforms of Slepian vectors have the maximal energy concentration in the bandwidth fc-W to fc +W under finite sample size constraints. By exploiting this feature, CR user can easily analyze the spectrum opportunities in given band. As MTSE uses multiple prototype filters and is better for small sample spaces since the computational complication increases with large number of samples.

Filter Bank Based Spectrum Sensing

Filter bank based spectrum estimation (FBSE) is considered as the simplified version of MTSE which uses only one prototype filter for each and every band. It has been proposed for multi-carrier modulations based Cognitive Radio systems by using a pair of matched Nyquist-filter. The same concept of maximal energy concentration in the bandwidth fc -W to fc +W is used by FBSE. By exploiting this information, CR user analyzes the spectrum opportunities and spectrum tenancy. Where, MTSE is better for small number of samples whereas FBSE is better for large number of samples [7].

Wavelet Based Detection

This technique is widely used in image processing for edge detection applications. This approach is proposed by Tain and Giannakos (2006) in spectrum sensing where wavelets are used to detect edges in power spectral density (PSD) of a wideband channel. In power spectral density the edges are the boundary between spectrum holes and occupied bands and hence it helps to find vacant bands. Based on this information CR can identify the spectrum opportunities.

Random Hough transform based detection

It is also widely used to detect the pattern (such as lines, circles) in image processing applications. Rappaport (2002) have proposed to perform Random Hough transform of received signal r(n) to analyze the existence of radar pulses in the operating channels of IEEE 802.11 wireless systems.

Radio Identification Based Detection

These techniques are used in the context of European Transparent Ubiquitous Terminal (TRUST) project which is based on certain elicit features such as transmission spectrum, modulation technique, transmission recurrence, etc. If the features are elicit from the received signal, CR users can exploit those features and select suitable transmission parameters for them. [13].

IV. SIMULATION OUTPUT

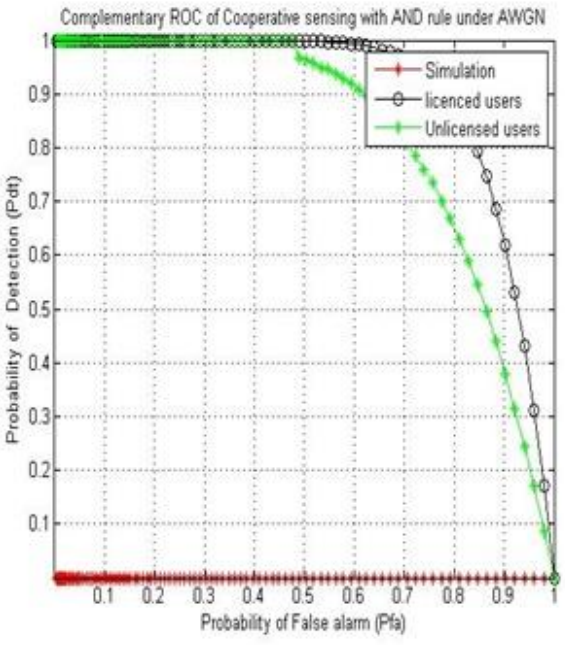

Fig 3: Analysis of P_d and P_f

The above diagram has compiled in MATLAB version, it is determination of detection possibility and false alarm probability to analyze the cognitive primary user and secondary user.

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if the detection probability is above the threshold; in case of absence of primary user and if threshold is below; case is absence. This specific simulation gives clarity on mechanism of matched filter for efficient utilization of spectrum; the channel utilized to transmit is AWGN channel, Furthermore the detection possibility(P_d) is 1 db and P_f is of same as 1db, to improve and enhance the spectrum efficiency.

V. CONCLUSION AND FUTURE SCOPE:

The Spectrum is very important resource in wireless communication system. It has been a main research topic from last many decades. CR is a rising technology which enables spaces. Considering the threat raised by cognitive radios the crucial need to achieve results in terms of adequate use of available spectrum and limited interference with licensed primary users using spectrum sensing method. As characterized in this paper, the expansion of the cognitive radio network needs the crises and communication of advanced techniques, along with cognitive radio reconfiguration management, interference management, distributed spectrum sensing and cooperative communications. Therefore, in order to realize the Cognitive Radio system in wireless communications completely for effective utilization of rare Radio Frequency spectrum. The method used in recognizing the interference.

The spectrum sensing should be reliable, So that the foremost user will not agonize from CR system to use the licensed spectrum. We furnished few non identical signal processing techniques by assembling them into 3 basic categories and their details successively. We also handover the pros and cons of various spectrum sensing methods. The comparison in terms of accuracies, Implementations, operation and complexities is also shown. Considering the relevance the energy detection procedure is preferred as it is widely used common way of detection because of its low implementation and computational complexities. In energy detection approach, the users do not require any knowledge on the basic signals as in matched filters and other proposals.

In this techniques, the signal detection is executed by comparing the output of energy detector with a threshold value which is given.

REFERENCES:

[1] Ning Han, Sung Hwan Shon, Jae Hak Chung,Jae Moung Kim,"Spectral correlation based signal dection method for spectrum sensing in IEEE 802.22 WRAN Systems",ICACT 2006,The 8th International Conf.advanced communication Technology,pp.1764-1770,2006.

[2] D.B.Rawat, G.Yan, C.Bajracharya,"Signal Processing Techniques for spectrum sensing in CRN.",International Journal of Ultra WideBand Communications and systems, Vol,No.x/x, pp. 1-10, 2010.

[3] Ian F.Akyildiz,Brandon F.Lo, Ravikumar (2011), "Cooperative spectrum sensing in CRN : A survey.

[4] "Radio Applications", In proceeding of IEEE Dynamic Spectrum Access Networks, Dy SPAN 2005, November 2005,pp. 124-130.

[5] Tevfik Yucek, Huseyin Arslan, "A Survey of spectrum Sensing Algorithems for CR applications,"IEEE Communication Surveys & Tutorials, vol 11, No.1, 2009.

[6] Z.Tizn, G.B.Giannakis, "A Wavelet Approach to Wide band spectrum sensing for cognitive radios," In proc. IEEE Int.Conf.

[7] Anant Sahai,Niels Hoven,Shridhar Mubaraq Mishra,Rahul Tandra, "Fundamental tradeoffs in robust spectrum sensing for oppurtunistis frequency reuse",IEEE J.Selected areas Communications, 2006.

[8] B.Farhang-Boroujeny,R.Kempter,"Multicarrier Communication Techniques for Spectrum Sensing and Communications Congnitive Radio", IEEE Communtion Magazine, Vol 48, No. 4, Apr.2008

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

[9] "Performance and Analysis of Energy Spotting Method for Cognitive radio using AWGN Condition" , in Proc international Journal & Magazine of Engineering. Technology, Management and Research, volume 2 (2015).Issue no:11,257-261.

[10] Danijiela Cabric, Artem Tkachenko, Robert W.Brodersen, "Spectrum Sensing Measurements of Pilot, Energy, and Col-laborative Detection", Military Communication Conference

[11] Zhi Tian, Georgios B.Giannakis,A" wavelet approach to wideband spectrum sensing for cognitive radios",proc. 1st Int. Conf. on Cognitive Radio Oriented Wireless Networks & Coms.(CROWNCOM),Mykonos,2006.

[12] Weifang Wang, "Spectrum Sensing for Cognitive Radio", Thrid International Symposium on International Symposium on Intelligent Information Technology Application Workshop,pp:410-412,2009.

[13] Amir Ghasemi, Elvino S,Sousa, "Spectrum Sensing in Cognitive Radio Network: Requirements, Challenges and Design Trade-offs Cognitive Radio Communication and networks", IEEE Communication Magazine, pp. 32-39,2008.

[14] K. Challapali, S.Mangold, Z. Zhong, "Spectrum Agile Radio:Detecting Spectrum Opportunities", In proc. Int. Symposium on Advanced Radio Technologies, Boulder, Co, Mar.2004.

[15] "Cooperative Spectrum Sensing in Cognitive Radio, Part II: Multiuser Networks", IEEE Transactions on Wireless Communication, Vol. 6, No,6, pp. 2214-2222, Jun.2007.

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