International Journal For Technological Research In Engineering
Volume 5, Issue 10, June-2018 *ISSN (Online): 2347 - 4718*

A REVIEW ON COGNITIVE RADIO BASED SPECTRUM SENSING TECHNIQUES

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Abstract: Due to underutilization of radio spectrum allocated to primary users and ever increasing demand of spectrum, Cognitive Radio has emerged as a well-known dynamic spectrum utilization technique. Spectrum sensing is an essential part of Cognitive radio which enable the user to sense the white and grey spaces in RF environment. This paper enlightens the method of spectrum sensing, the recent advancements and the problems associated with the efficient use of it.
Keywords: Cognitive Radio, Spectrum Sensing techniques.

I. INTRODUCTION

Cognitive Radio(CR) is a dynamicadaptive, intelligent radio network technology that can automatically detect white spaces in the available radio spectrum and change transmission parameters enabling more communications to run concurrently and also improve radio operating behavior. The term 'white spaces' here means the unoccupied channels or bandwidths not in use at that particular time interval which has been allocated to the licensed user known as primary user. To enable the use of these white spaces the CR Network make use of the technique known as Spectrum Sensing. It may be defined as the technique through which Cognitive Radio get enabled to search for vacant channels in the electromagnetic spectrum space.

From this definition we can deduce three primarycognitive radio tasks:

1) Spectrum Sensing (senses its operational electromagnetic environment)
2) Channel Identification (to maximize throughput)
3) Transmit power control & Dynamic spectrum management (dynamically and autonomously adjust its radio operating parameters to modify system operation, mitigate interference, facilitate interoperability)

This definition also suggests that Cognitive Radio are self-configurable radios that sense the spectral environment, autonomously & dynamically detect and interpret the changes occurring and facilitate coherent, reliable wireless communication without causing interference with existing licensed users. Exploitation of spectrum needs efficient spectrummanagement that comprises of both static and dynamic processes. Static allocation technique is fixed by regulatory mechanisms (i.e. static in temporal and spatial dimensions) while newer approach works with dynamic spectrum management for dynamic allocation in wireless communication system. Basic methodology of cognitive radio based on dynamic spectrum management, for accessing the spectrum opportunistically is divided into fourphases:-

Spectrum Sensing involves "spectrum hole" detection for efficient usage of dynamic allocation technique. Spectrum Hole is the potential opportunity to use the spectrum by a secondary user without interfering with licensed user. However, definition of "Spectrum Hole" in time and frequency domain may be more nuanced [3]. Spectrum allocation follows spectrum sensing and refers to interpreting the frequency band to use. In case of multiple users, sharing of spectrum can occurs. In spectrum allocation, bandwidth sensing is necessary to distinguish between the margins of bandwidth for proper detection of signals.

SpectrumConfiguration is adaption and estimation of the parameter required for transmission. Cognitive Radio may potentially reconfigure itself according to required modulation scheme, carrier frequency, transmit power etc. and this reconfiguration must occur very quickly.

Spectrum transmission is the phase where system identifies the transmission of other units with primary user. It must be able to detect any interference accurately to minimize the number of false detections. After reliable identification of the available spectrum holes, the cognitive radio system needs to estimate the transmission parameters such as spectrum bandwidth, power levels, Power control, bit rate control, etc.

Prime advantages offered by Cognitive Radio are

1) Improved efficiency by allowing unlicensed users to exploit spectrum whenever it will not cause interference to licensed users.
2) Highly Reliable communication as and when required.

Accurate Spectrum sensing is one of the major challenges in Cognitive Radios. We reviewCognitive Radio basic model in Section 1 & 2.

The rest of the paper is organized as follows: We review various spectrum sensing methodologies and their strengths and shortcomings in Section 3. Section 4 discusses challenges/issues in cognitive radio systems. Section 5 provide small introduction of dynamic spectrum management (DSM). Finally, Section 6 concludes the paper and outlines potential future research areas.

II. COGNITIVE RADIO – BASIC MODEL

Both licensed and unlicensed frequency bands are available for opportunistic exploitation by Cognitive Radios. However, in the licensed band, detection of existing legacy users - also known as primary users - is of prime importance to avoid interference with cognitive radio transmission, by continuously hopping to next vacant frequency band [4]. From cognitive radio perspective, primary users are generally defined as the users who have license to use a given frequency spectrum in a given time window. Similarly, Secondary Users (SUs), are unlicensed users having no legacy rights to the spectrum and thus having low priority as compared to PUs. To establish reliable communication, SUs need to opportunistically exploit this spectrum without causing interference to primary users [5,6,7].

III. SPECTRUM SENSING TECHNIQUES

3.1. Spectrum Sensing – An Overview

Accurate spectrum sensing has remained the fundamental problem in Cognitive Radio. It is so important because reliability of transmission without any interference to PUs depends squarely on accurately detecting the presence of any PUs. Presence or absence of PUs will facilitate identification of spectrum holes which can be exploited by SUs.

In cognitive radio, process of sensing of spectrum has three main objectives:

- Continuous radio channel monitoring to sense the temporal spectrum occupancy by a PU at a given time without interference.
- Continuous sensing for spectrum holes to dynamically allocate spectrum as and when needed.
- Estimation of transmission parameters like power levels, interference temperature, and conditions required for dynamic spectrum management.

A number of solutions have been proposed over the years to facilitate accurate spectrum sensing [12].

From implementation point of view, Spectrum sensing can be classified on the basis of hardware architecture which makes use of various spectrum sensing methodologies [13, 14, 15]. There are two architectures under consideration: Single Radio architecture where a single cognitive radio is used for both spectrum sensing and transmission. It is simple and low cost but less accurate. Dual Radio architecture utilizes two radios making it complex and costly as compared to Single Radio Architecture but is more accurate [5].

IV. CHALLENGES AND ISSUES IN COGNITIVE RADIO

Despite progress in research on Cognitive radio techniques, issues remain in implementation of available theoretical methods due to several limitations [31]. Some of these limitations are discussed below.

1. Hidden terminal problem

This problem is characterized by missing detection of primary user due to location of transmitter w.r.t the primary receiver. This causes interference with primary user transmission. Cooperative sensing addresses this problem to some extent by information sharing but other techniques still require better solutions [32].

2. Hardware requirements

Most of the detectors are based on Energy Detection techniques because of simplicity of implementation. However, these energy detectors suffer from some drawbacks. Also, presence of several identically distributed spectrally superimposed signals will confuse most energy detection schemes, preventing the interceptor from determining anything more than the knowledge that signals are present in the environment. Another significant drawback is that energy detection cannot distinguish among different types of transmissions or interference from signals. More computationally extensive techniques still lack in hardware implementation because of various logistical, design and financial limitations [5].

3. Scanning a very wide spectrum range

A cognitive radio needs to continuously scan a verywide range of frequency bands in order to sense andidentify spectrum holes. To sense a very largefrequency band, a sufficiently large sampling rate will be needed. Simple hardware implementation of such a wideband cognitive system is still a challenge.

4. Security

In cognitive radio, security concerns remain a concern and security standards need to be developed. Some common scenarios have been explored. For e.g. a malicious user can impersonate a primary user and compromise the cognitive network. It has been named as primary user emulation (PUE) attack [33]. A primary user authentication scheme is proposed in [34]. Primary user identification using a public key encryption system is discussed in [35] as a mitigation exercise to repair a compromised network.

V. DYNAMIC SPECTRUM MANAGEMENT

Dynamic spectrum management (DSM) efficiently solves problem of spectrum scarcity and spectrum under-utilization in wireless communication. This technology covers frequency assignment with dynamic channel/spectrum allocation (DSA) and contains information about spectrum sensing for both primary and secondary users. Cognitive radio has been one of the most vital applications of dynamic spectrummanagement.DSM manually allocates un-used spectrum, after link adaption as it combines unused channel on basis of pre cancellation of estimated interference for multiple user (i.e. both primary and secondary users). DSM is a promising tool for many radio technologies in wireless communication, as it provides broad bandwidth for spectrum sensing.

VI. CONCLUSION & FUTURE WORK

In this paper, Cognitive Radio and various spectrum sensing techniques have been reviewed. Performance and accuracy of individual spectrum sensing techniques have been investigated with attention to newer approaches to detection problem. Challenges have been discussed. More research is needed to simplify cognitive radio implementation models, associated security aspects and accuracy of spectrum sensing techniques. In particular, the efficacy of spectrum sensing algorithms in noisy and fading environments needs attention.

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