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Overview on Cognitive Radio Network Review

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Abstract

Cognitive Radio (CR) it refers to detect the unused spectrum and sharing it without harmful interference with other users. an its intelligent wireless communication system and considered to be promising technology of the next generation communication networks that is aware of its surrounding bandwidth availability and adapt, it can capture the best available spectrum to meet user communication requirements (spectrum management) by sharing unused spectrum depending on parameters like signal strength, dimension, node speed and availability of unused spectrum. And it can change transmitter parameters based on interaction with the environment in which it operates. In this paper we presented general overview on cognitive radio (CR) and we gave a brief note about history of CR and architecture concept, and then pointed out some key research challenges. Finally we gave comparative study of various methodologies.

Keywords: *CRN, PUs, SUs, Spectrum Sensing, Spectrum Management.*

1. Introduction

First presented to concept of cognitive radio (CR) was by Joseph Mitola 1999. He described the CR approach as devices and networks that are “sufficiently computationally intelligent about radio resources and related computer-to-computer communications to find user communications needs as a function of use context, and to provide radio resources and wireless services most appropriate to those needs.” A CR continuously perceive, control itself, creates a plan, makes decisions based on the plan and directing, and then moved based on those decisions. After Haykin published his seminal paper (Haykin 2005), the term CR changed to mean at most dynamic spectrum access oriented operation. According to Haykin there is two key functions of a CR are: (1) A radio scene analyzer at the receiver to identify spectrum holes or white spaces, and (2) Dynamic spectrum manager and transmit-power controller at the transmitter to allocate the spectrum holes among multiple CR users [1].

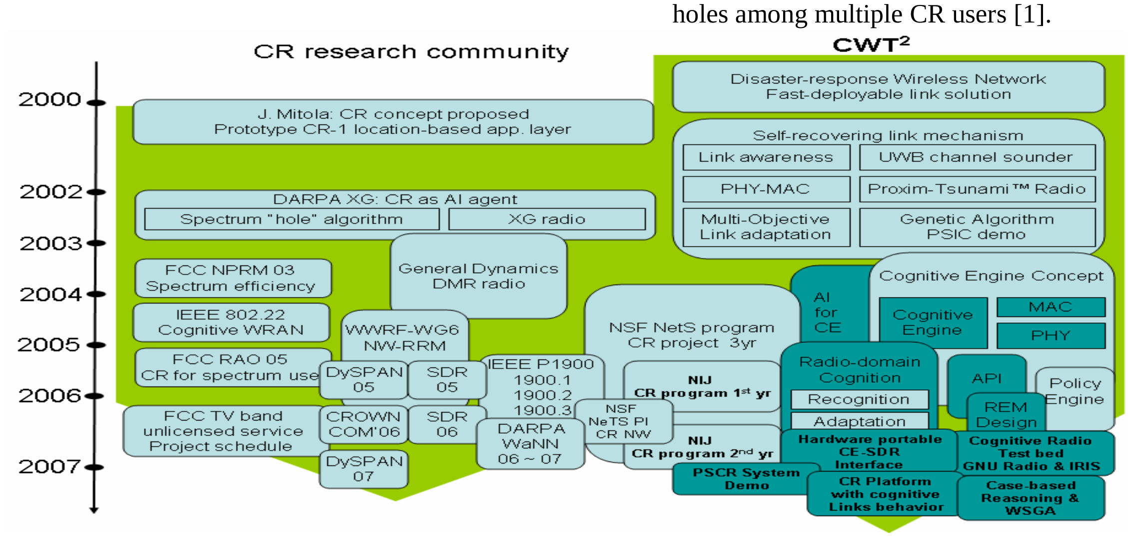

Figure 1: CR Research History and Wireless Telecommunications (CWT) Road Map [2]

Cognitive Radio knows of their environment and it's able to dynamically tune the spectrum usage based on (location, nearby radios, time of day), Also Spectrum is a very valuable resource in wireless communication systems and it has been a major research topic from last several decades.

CR enables spectrum sensing for opportunistic spectrum usage by providing a means for the use of white spaces that means achieving better utilization of the frequency spectrum. In CRN the secondary users (SUs) are allowed to utilize the frequency bands of primary users (PUs) when these bands are not currently being used. Unlimited access to internet, Ensures connectivity and spectrum mobility, increased scalability and improved reliability, lower prices and reduced power consumption [3].

A spectrum hole or white space is an area with discontinuous lines represent time periods when the respective frequency bands at the specific geographic locations are vacant and can be utilized for CR communication by CR users [4]. Spectrum hole concept can be further generalized as transmission opportunity in radio spectrum space. Radio spectrum space is a theoretical hyperspace occupied by radio signals which has dimensions of location, angle of arrival, frequency, time, energy and possibly others. A radio build on cognitive radio concept have the ability to sense and understand its local radio spectrum environment, to identify spectrum holes in radio spectrum space, to make autonomous decisions about how it accesses spectrum and to adapt its transmissions accordingly. Such cognitive radio using dynamic spectrum access has the potential to significantly improve spectrum efficiency utilization resulting in easier and flexible spectrum access for current or future wireless services.

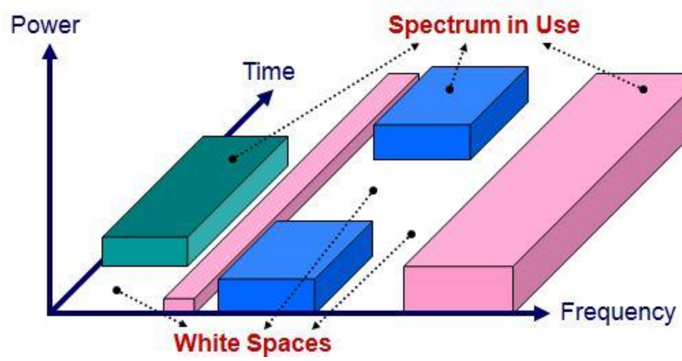

Figure 2: Spectrum Holes or White Space [5]

According to transmit and received parameters, there are two main types of cognitive radio: Full Cognitive Radio (or Mitola radio): In which every possible parameter observable by a wireless node (or network) is considered, And Spectrum-Sensing Cognitive Radio: In which only the radio-frequency spectrum is considered [6].

2. The Main Functions of Cognitive Radio Systems

Spectrum Sensing

Spectrum sensing techniques are utilized to identify primary user's spectrum occupancy status and should be carried out and transmit data successfully through secondary users (SUs) without causing considerable interference with the primary users (PUs) and increases data transfer speed.

Spectrum sensing techniques can be classified into three categories:

- Transmitter detection: Cognitive radios (CR) must have the capability to determine if a signal from a primary transmitter is locally present in a certain spectrum, there are several approaches proposed :
    - matched filter detection
    - Energy detection
- Cooperative detection: It refers to spectrum sensing methods where information from multiple Cognitive radio users are incorporated for primary user detection.
- Interference based detection.

Spectrum Management

It is the task of capturing the best available spectrum to meet user communication requirements and to avoid collisions with other (CRSs) .After sensing and probing a channel, the CR needs to make a decision on whether to terminate the scan and use the underlying channel or to skip it and scan the next one, therefore spectrum management functions are required for Cognitive radios, these management functions can be classified as:

- spectrum analysis
- spectrum decision

Spectrum Mobility

It is defined as the process when a cognitive radio user exchanges its frequency of operation. Cognitive radios system (CRS) should decide on the best spectrum band to meet the Quality of Service requirements (QoS) by allowing the radio terminals to operate in the best available frequency band, maintaining seamless communication requirements during the transition to better spectrum.

Spectrum Sharing

It consider one of the major challenges in open spectrum usage is the spectrum sharing and it refers to providing the fair spectrum scheduling method .by using Cognitive Radio Technique the secondary users (SUs) can sharing the free spectrum bands which are licensed originally to the primary users (PUs) without causing interference to (PUs) and achieve the maximum throughput. With these functions it will be able to utilize radio spectrum efficiently [7].

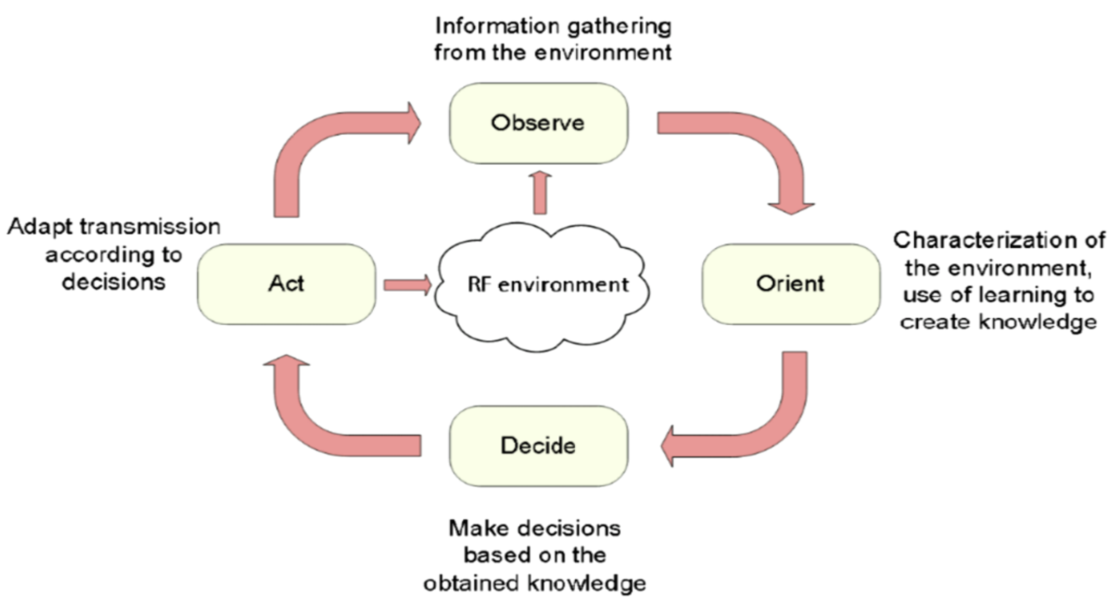

Figure 3: Cognitive Cycle as an Observer, Orient, Decide, and act" (OODA) Loop [1]

3. Cognitive Radio Concept Architecture

There are two major subsystems in a cognitive radio; a cognitive unit that makes decisions based on various inputs and a flexible SDR unit whose operating software provides a range of possible operating modes. A separate spectrum sensing subsystem is also often included in the architectural a cognitive radio to measure the signal environment to determine the presence of other services or users. It is important to note that these subsystems do not necessarily define a single piece of equipment, but may instead incorporate components that are spread across an entire network. As a result, cognitive radio is often referred to as a cognitive radio system or a cognitive network. The cognitive unit is further separated into two parts as shown in the block diagram below in figure (4). The first labeled the "cognitive engine" tries to find a solution or optimize a performance goal based on inputs received defining the radio's current internal state and operating environment. The second engine is the "policy engine" and is used to ensure that the solution provided by the "cognitive engine" is in compliance with regulatory rules and other policies external to the radio [8].

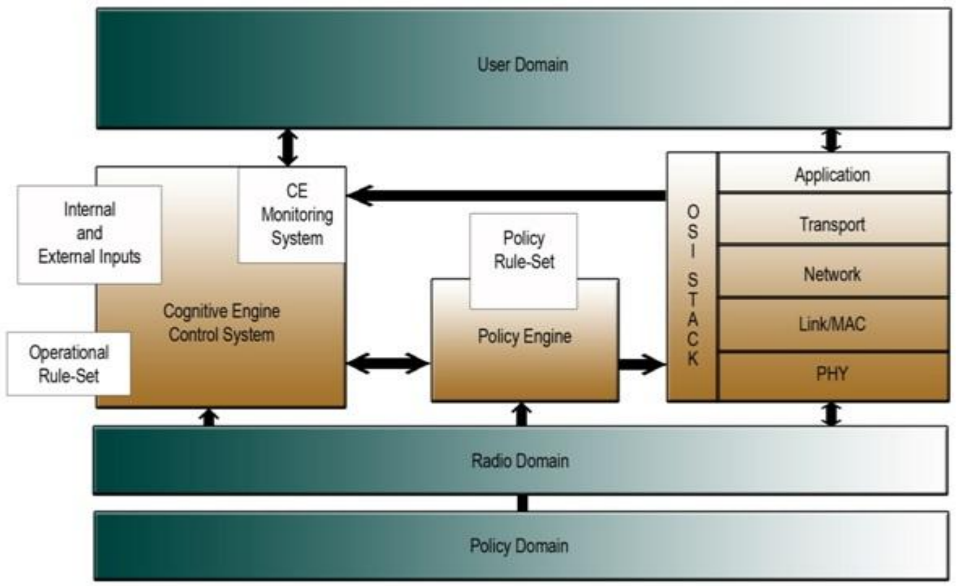

Figure 4: Cognitive Radio Concept Architecture [8]

4. Channel Selection for Cognitive Radio Systems

Channel selection is a very important task to perform in order to fulfill the needs of CRS users. The aim of selecting channel is to meet the extreme appropriate spectrum bands and channels for requesting services and applications. As discussed in Masonta 2013) and (Lee & Akyildiz 2011), the CRS system needs to characterize the bands and channels by Taking into account the existing radio situation and the PU activity to find the best transmission opportunities. By selecting the best channels for own transmission, the CRS is able to, for example, decrease delays of own transmission. And increase throughput, and decrease collision with the primary users. Intelligent selection can be seen as a multi-phase process that is described in Figure6. In the first phase, the data are classified. The basic reason for this is the estimation process in the second phase. Estimation is done with models which creates a need for classification, i.e., the estimation model is selected based on the classification. Classification can be performed, for example, to automatically recognize attributes of incoming signal such as type of jammers, carrier frequency, or modulation type (Dostert 1983, Hamkins & Simon 2006). Finally, the third phase is decision, which is made based on the estimation, for example, to select the center frequency for the receiver. [1]

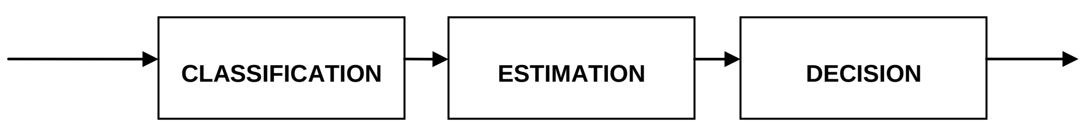

Figure 5: Intelligent Selection Process [1]

5. Research Challenges in CRSs

There are many ceases in applying available technologies for CR development. The challenges security, spectrum mobility, intelligence distribution and implementation, and sensing.

Decision Making

Decision making drives CRS, the first pertinent research challenge is where I make a decision and how. Number one is directly related to whether the CR process should be performing. This aspect is more critical not only for cognitive networks, where intelligence is more likely to be distributed, but also for cognitive radios, as decision making could be influenced by collaboration between them and also with other devices. The issue number tow is the choice of the decision algorithms.

Learning Process

One of the significant sides of the learning mechanisms is the learning performed is overseen or un overseen. The first challenge of learning is to make correct choices and avoid the wrong before give a decision, especially in independent or unsupervised learning process. The second issue is to concretely define learning process in the context of CRS, its objectives and contributions. In qualifications of implementation and algorithm design, the cognitive functionalities, which are related to enabling devices or networks to learn from previous decisions to get better their behavior, are too much complex. The design of the learning algorithm perform by itself a defiance, and measurements which should be used by learning open new issues related to which measurements to use and how to perform them.

Security

The open and dynamic nature of cognitive radio challenges the conventional wireless security paradigms e.g., cryptography and authentication, which derives researchers and scientists to seek new means to complement the traditional security methods and improve the cognitive radio security. The first issue is on equipment authorization, especially on evaluation criteria and security certification. Also by putting artificial intelligence (AI) engines in charge of our wireless devices, we need to be aware that these engines can be provided false sensory input by adversaries, and this false input affects its beliefs and behavior. It becomes even more problematic with the employment of self-learning mechanisms. Software and hardware certification will not provide sufficient assurances that the device conforms to the operational envelopes. Software certification and the security of the software are also challenging area, especially when software provides the control of dynamic systems. The security of that software is critical to ensure that rogue behavior is not programmed into the devices. The number of combination of interactions is high and the mobility and the agility of CRS is great, so the monitoring mechanisms are challenging tasks. However, in CRS with distributed cognitive networks, traditional cryptographic schemes are not adapted.

Sensing

Following challenge is about spectrum sensing, especially on the precision on spectrum occupancy decision, sensing time, and wicked enemy, taking into consideration the essential limits of spectrum sensing algorithms because the noise and multipath fading and shadowing. To solve hidden PU problem and reduce the effect of these issues, collaborate or cooperative spectrum sensing has been shown to be an effective method to progress the detection performance by utilizing spatial diversity in the observations of spatially located CRs. Challenges of cooperative sensing include reducing collaborate overhead, developing efficient information sharing algorithms. The coordination algorithm for cooperation should be robust to changes and failures in the network, and introduce a minimum amount of delay.

The distinct hardware trial for spectrum sensing thus far has been the FCC field trial conducted in 2008 by the office of engineering and technology. Although the spectrum sensing approach offered good sensitivities satisfying requirements, the future spectrum sensing hardware should improve the receiver selectivity and receiver desensitization, especially when the adjacent channels have high powers. The geolocation database-based approach is able to identify occupied channels with 100% accuracy. However, for identification of unoccupied channels, it did not exhibit the best performance, presumably due to incomplete information in the database. This shows that the spectrum sensing alone works to some degree, but the performance could be further enhanced especially in the identification of occupied channels. Combining a geolocation database with spectrum sensing may be a better option provided that the CR device cost and power dissipation are decreased [9].

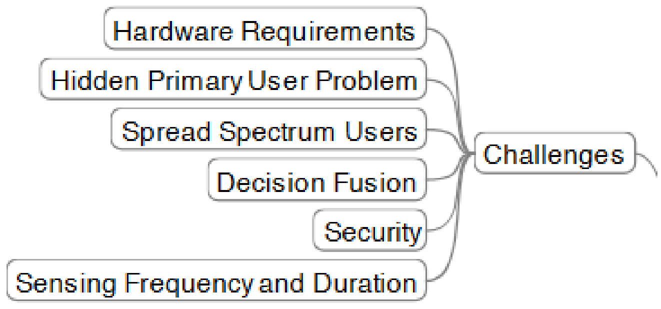

Figure 6: Spectrum Sensing Challenges

Spectrum Mobility Issues

The spectrum mobility jobs in a CRN let an unlicensed user to shift its operating spectrum dynamically according to the spectrum situations. This issue can be classified in following ways.

Explore for the Better Frequency Band: A CR must hold path available frequency bands so that if necessary (as example authorized user is discovered), it can transmit promptly to other frequency band. During transmission by an unlicensed user, the case of the frequency band has to be observed. In a comparable path to spectrum sensing, this would of course assume some overhead. The monitoring can be completed in a proactive approach or in an on demand basis. The status of the ready or free channels is periodically observed and the knowledge about these channels is continuously updated. In an on request approach, channel observation can be performed only when an unlicensed user needs to switch the channel.

Protocol Stack Adaptation: A long time ago due to handoff spectrum can be high, Adaptation and modification of the other ingredients in the protocol stack is required. For example When the user is not authorized channel switching, and timer in the TCP transport layer can be idle to avoid any interpretation of Miss Delays resulting from the recognition of a message. The framework of cross-layer optimization adaptable protocol has to be developed to conquer with the mobility spectrum.

Self Coexistence and Synchronization: When the user is authorized or PU processes of the spectrum shift must be taken into account two issues. The first the currently or target channel be used by any other primary user (i.e. the self coexistence requirement), and the receiver of the corresponding secondary link must be notified of the spectrum handoff (i.e. the synchronization requirement). Broker spectrum can be used to manage the distribution of the spectrum. To synchronize, it must be designed with the MAC protocol providing for the exchange of information spectrum handoff exchange [3].

6. Previous Studies

This paper provided an overview for delivering intelligence toward the 5G of wireless/mobile broadband by taking into account the complex context of operation and essential requirements such as QoE, energy efficiency, cost efficiency, and resource efficiency [10].
In this paper the policy that addresses the spectrum scarcity problem that is encountered in many countries. The spectrum sensing problem has gained new aspects with cognitive radio networks. The cognitive radio and cognitive based networking are transforming the static spectrum allocation based communication systems in to dynamic spectrum allocation. Cognitive radios are intelligent devices with ability to sense environmental conditions and can change its parameters according to the requirements to get the optimized performance at the individual nodes or at network level Thus, CR is widely regarded as one of the most promising technologies for future wireless communications [11].

The objective of this paper is to investigate this technology buy introducing descriptive analysis of the hardware and software requirement in addition to previous study [12].

In this paper it is to provide an overview of the evolution of CRN and summarize the issues and key technologies. The introduction of the basic concepts of the CRN, including cognitive cycle model, network architecture, and the ability of cognitive functions intelligent decision, in detail based on the recent developments. Key issues for each subject, and then with the recent research on the theory and method, and then are classified and are presented developments manufacturing testbeds CRN-based system and cellular standards TD-LTE briefly. Finally, it was to reach conclusions about the views and orientations for future development [13].

This paper makes a review of secure cooperative spectrum sensing in cognitive radio networks. The main objective of these protocols is to provide an accurate resolution about the availability of some spectrum channels, ensuring the contribution from incapable users as well as malicious ones is discarded. Issues, advantages and disadvantages of such protocols are investigated and summarized [14].

7. Conclusion

Previous studies touched for an overview of the radio-technical cognitive as well as policies that address the problem of the scarcity of spectrum as one of the most promising technologies for communications wireless in the future, taking into account the complex context of the process of fundamental, such as QOE and requirements, energy efficiency, cost and resources. As well as has been verified to provide a descriptive analysis of the requirements of hardware and software, as well as the.

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