# Interference Management in Dynamic Spectrum Sharing Cognitive Radio

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*Abstract-* **Cognitive radio is an exciting and new way of thinking and researching about wireless Communications. Indeed, it is already being considered as one of the key candidate technologies for the fourth-generation (4G) wireless systems. There are several drivers for the development of cognitive radio. Perhaps the most pressing of them is improved utilization of the electromagnetic radio spectrum: a highly valuable natural resource. Careful studies of the current usage of the radio spectrum by several agencies have already revealed that a large fraction of the radio spectrum is inadequately utilized. This basic finding has led to numerous research initiatives. Cognitive radios that are employed in a network with dynamic frequency assignments must operate efficiently in the presence of uncertainties and variations in the propagation characteristics of the network's communication links. One fundamental challenge is to ensure the quality of service (QoS) of the primary link while maximizing the transmission rate of the secondary links. Cognitive radio is an advanced technology for more efficient spectrum utilization systems based on opportunistic spectrum sharing and spectrum security, which finds white spaces and apply policies to determine when and in which bands they may communicate.**

*Keywords-* **Cognitive radio, security framework, dynamic spectrum sharing, interference management**

## I. INTRODUCTION

Cognitive radio (CR) is an intelligent wireless communication system which has been put forward to make efficient use of scarce or underutilized radio frequency spectrum. It introduces "adaptiveness" and "intelligence" to traditional radios i.e. to analog and digital radio. The term "cognitive radio" was initially coined by Joseph Mitola over a decade ago [1].The electromagnetic radio spectrum is a precious and natural resource which generally is regulated by governmental agencies. With the emergency of new wireless applications, the spectrum becomes more & more scarce. Meanwhile, the licensed spectrum is highly underutilized according to the studies from the US Federal Communications Commission (FCC). In 1999, Joseph Mitola defined that CR is capable of sensing their environment, learning about their radio resources and user requirements, and adapting behavior by optimizing their own performance in response to user request. *Cognitive Radio Network* (CRN) is a group of opportunistic users communicating with each other using the spectrum holes i.e. white spaces. Also CR paradigm is imposing human-like characteristics into the radio network, it may be beneficial to consider and look into the fields of social science and human behavior and psychology, to examine the mechanisms employed in the human network security model and determine if these can be applied to CR networks [5]. Figure 1 below shows the cognition cycle.

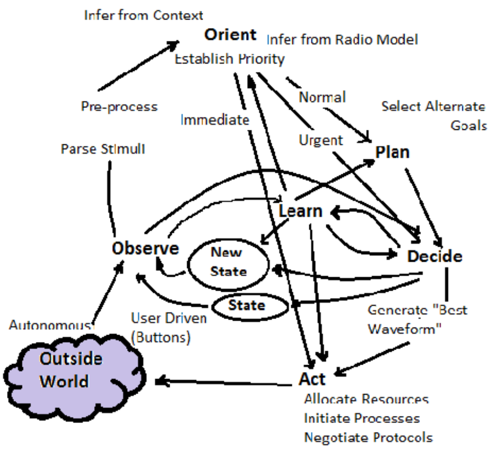


Figure 1. *The cognition cycle.*

## II. COGNITIVE RADIO NETWORK PARADIGMS

There are three main cognitive radio network paradigms: underlay, overlay, and interweave.

*A. Underlay Paradigm:* It allows cognitive users to operate if the interference caused to noncognitive users is below a given threshold. Here, the cognitive radio is often called a secondary user, which cannot significantly interfere with the communication of existing (typically licensed) users, who are referred to as primary users.

*B. Overlay Paradigm:* The cognitive radios use sophisticated coding and signal processing to maintain or improve the communication of noncognitive radios while also obtaining some additional bandwidth for their own communication. The enabling idea for overlay systems is that the cognitive transmitter has knowledge of the noncognitive users' codebooks and its messages as well. The codebook information could be obtained, for example, if the noncognitive users follow a uniform standard for communication based on a revealed codebook. Alternatively, they could broadcast their codebooks periodically.

*C. Interweave Paradigm:* The interweave paradigm is based on the idea of opportunistic communication and was the original motivation for cognitive radio. The cognitive radios opportunistically exploit spectral holes to communicate without disrupting other transmissions [9].

## III. COGNITIVE RADIO - SECURITY FRAMEWORK

Cognitive Radio is expected to become an increasingly important part of wireless communication networking landscape [5]. Therefore, Security in wireless networks is challenging. Security in cognitive radio networks (CRN) is even more important & challenging. This is because a CRN consists of cognitive radios (CR) which have many more functions and processes to account for, such as sensing, geolocation, spectrum management, access to the policy database etc. Each of these functions and processes need to be assessed for potential vulnerabilities and security mechanisms need to be provided for protection of not just the secondary users of the spectrum but also the primary users or the incumbents [6].

Due to the unique characteristics of the CRs in a CRN, improved security mechanism is required. The security mechanism in CR is divided into several sub-layers which protect non-cognitive as well as cognitive functions of the system and the interaction between two [6]. Here cognitive radio paradigm introduces entirely new classes of security threats and challenges and providing strong security may prove to be a most difficult aspect of making cognitive radio a long-term commercially feasible concept[5].

To achieve the goal of CR, all the functions of cognitive radio is required, but the fundamental requirement is that the unlicensed secondary users (SUs) must perform spectrum sensing to detect the presence of the licensed primary users (PUs) signals and avoid significant interference to PUs. Afterall the successful deployment of CR and realization of their benefits will depend on the essential security mechanism in a very robust form so that misuse of system should be avoided. Consider the scenario depicted in Figure 1, in which primary users (in white) communicate to their dedicated (primary) base station. Secondary base stations *{BS*1, *BS2, BS3, … BSK}* are cooperatively sensing the channel in order to identify a white space and exploit the medium.

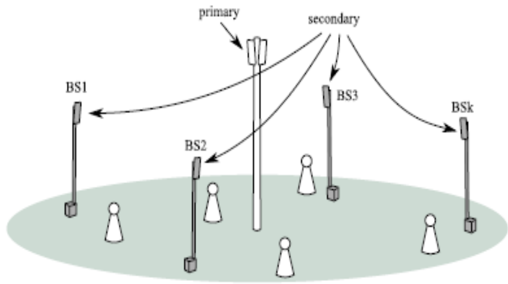


Fig.2 Considered scenario for spectrum sensing.

Modern communication Systems are prone to suffer from narrow-band interferences. Cognitive radios (CR) have attracted great interest recently as a means to resolve the critical spectrum shortage problem. After the Federal Communications Commission (FCC)'s seminal report, it is now well known that spectrum access is more of a problem than physical scarcity of the spectrum, and that more flexible spectrum access techniques instead of the conventional command-and-control regulations should be adopted. Under this general theme, dynamic spectrum access (DSA) based on cognitive radio techniques becomes a promising approach. DSA and CR techniques have many potential commercial and military applications. An immediate commercial application under developing is the exploitation of some of the less utilized TV spectrum. The TV band is attractive not only because TV broadcasting has regular and predictable schedule of occupancy, but also because TV broadcasting is currently under digitalization with some TV bands to be freed. By the year 2009 in USA and 2010 in Europe, all the TV signals will be digital, which will reduce the bandwidth requirement and give more opportunity to DSA and CR techniques[4].

## IV. SPECTRUM SHARING COGNITIVE RADIO

A Spectrum Sharing Cognitive Radio is defined by IEEE as *a radio frequency transceiver that is designed to intelligently detect whether a particular segment of the radio spectrum is currently in use, and to jump into (and out of, as necessary) the temporarily-unused spectrum very rapidly without interfering with the transmissions of other authorized users[1].*

There are three main radio network functions in the DSA cognitive radio networks: spectrum sensing, spectrum analysis and decision, and spectrum mobility. One of the primary supplies of cognitive networks is their ability to scan the spectral band and identify vacant channels available for opportunistic transmission. As the primary user network is physically separate from the secondary user network and the primary users are expected to be legacy systems; the secondary users do not get any direct feedback from primary users regarding their transmission. The secondary users have to depend on their own individual or cooperative sensing ability to detect primary user transmissions. Since the primary users can be spread across a huge geographical area, sensing the entire spectral band accurately is a challenging task. The secondary users have to rely on weak primary transmission signals to estimate their presence. Most of the research on spectrum sensing techniques falls into three categories: transmitter detection, cooperative detection and interference based detection. The main aim of all these techniques is to avoid interference to primary transmissions.

For this term proposed is the dynamic spectrum access, there are three major models namely, commons use, shared-use, and exclusive-use models. In the commons-use model, the spectrum is open for access to all users. This model is already in use in the ISM band. In the shared-use model, licensed users (i.e. primary users) are allocated the frequency bands which are opportunistically accessed by the unlicensed users (i.e. secondary users) when they are not occupied by the primary users. In the exclusive-use model, a licensed user can grant access of a particular frequency band to an unlicensed user for a certain period of time [8].

The goal of dynamic spectrum allocation is to increase the efficiency of use of the radio spectrum. In a multiradio environment comprised of disparate systems, such as cellular and broadcast networks (e.g. UMTS and DVB-T), there will be significant variations in the traffic demand (and therefore spectrum utilization) on the networks over both time and space. DSA attempts to improve efficiency by allocating the spectrum dynamically over space or time, as required by the networks, whilst managing or preventing any resulting interference [7].

Dynamic spectrum access can be either centralized or distributed for different types of cognitive radio networks. In the case of centralized dynamic spectrum access, a central controller makes the decision on spectrum access by all unlicensed users. For this, the central controller will need to collect information about the spectrum usage of the licensed users as well as information about the transmission requirements of the unlicensed users. Based on this information, an optimal solution (e.g. one which maximizes total network throughput) on dynamic spectrum access can be obtained. The decisions of the central controller are broadcast to all unlicensed users in the network. However, information collection and exchange to and from the central controller can incur a considerable overhead. In the case of distributed dynamic spectrum access, an unlicensed user can make a decision on spectrum access independently and autonomously. Since each unlicensed user has to collect information about the ambient radio environment and make its decision locally, the cognitive radio transceiver of each unlicensed user requires greater computational resources that are required in centralized dynamic spectrum access.

As shown in Figure 3 distributed dynamic spectrum access can be implemented in both infrastructure-based and infrastructureless cognitive radio networks. However, a centralized dynamic spectrum access can only be applied in an infrastructure-based network since it requires a central controller to plan, schedule, and optimize spectrum access by the unlicensed users. In the case of a multihop infrastructure-based network, one of the relay stations can assume the responsibility of controlling dynamic spectrum access [8].

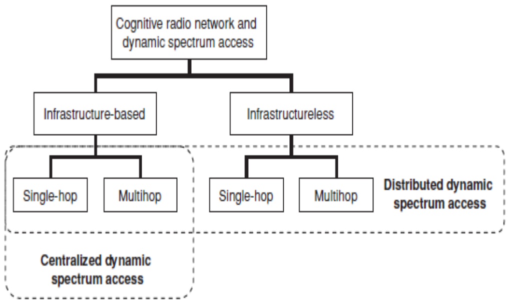


Fig. 3 Infrastructure-based/infrastructureless cognitive radio networks and centralized/distributed dynamic spectrum access.

## V. INTERFERENCE MANAGEMENT

At the early beginning of radio-communication, interference plays an important role in spectral governance. With the radio communication one must realize that depending on the frequency used, radio waves can travel quite a distance and during the same period, are able to disturb the other communication service. As the radio spectrum resource scarce in nature, it is necessary to reuse the frequencies, so that there will be full use of available spectrum. Interference management is essential in cognitive radio technique to increase the spectrum utilization. Recognizing the significance of spectrum shortage problem, FCC is considering opening up liscened band to unliscened operation on non-interference basis to the primary user. If Secondary user opportunistically operates in fallow liscened spectrum band, then it will help in increasing the efficiency of spectrum utilization. Cognitive radio is a paradigm for wireless communication in which either a network or a wireless node changes its transmission or reception parameters to communication efficiently avoiding interference with licensed or unlicensed users. The central role of spectrum sharing is interference management in that Secondary Users are authorized to use spectrum only when Primary Users are not harmfully interfered by them and the Secondary Users should achieve a spectrally efficient operation under interference from the Primary Users [3].

Ability of a software defined radio to dynamically modify its operating parameter can surely help for managing the interference. There is a question how much is the harmful interference that ultimately depends on the application. There are two approaches to avoid harmful interference below:

i. Overlay Approach (Interference-Free Approach)

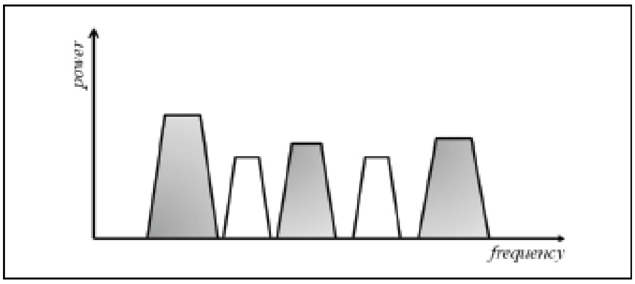


Fig.4 Overlay system

In this approach, the secondary users access the portion of the spectrum that is not used by primary users. As a result, there is virtually no interference to the primary users.

ii. Underlay Approach (Interference-Tolerant Approach)

In this approach, the secondary users access the network by spreading their signals over a wide frequency band. The underlay approach imposes severe constraints on the transmission power of secondary users.

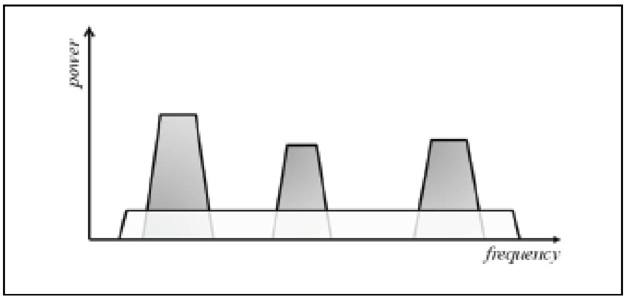


Fig.5 Underlay system

Operating below the noise floor of primary users, the secondary users are allowed to interfere with primary users up to a certain tolerable level [3].

## VI. CONCLUSION

Cognitive radio is a key technology that will enable flexible, efficient and reliable to the real-time conditions of the environment. This cognitive radio paradigm introduces entirely new types of security threats and challenges to wireless networks and makes the development of effective security models and mechanisms very challenging. In this paper, we presented Dynamic spectrum access concept which is useful for spectrum sharing by both primary and secondary user, so that they can co-exist in same frequency band. Also this will help in providing security and managing the interference in the radio communication.

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