A STUDY OF RECENT TRENDS IN COGNITIVE RADIO COMMUNICATIONS AND NETWORKS FOR LICENCE FREE CONNECTIVITY

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***Abstract*—In recent trend all the organization wants connectivity by utilization of unlicensed spectrum as a medium for inexpensive connectivity in rural/remote areas and innovation by serving as a barrier-free and cost-effective platform for testing and implementing of new technologies. wide and dynamic spectrum is available to make radios and wireless networks truly cognitive, however, is by no means a simple task, and it requires collaborative effort from various research communities, including communications theory, networking engineering, signal processing, game theory, software-hardware joint design, and reconfigurable antenna and radio-frequency design. Cognitive radio (CR) is the enabling technology for supporting dynamic spectrum access the policy that addresses the spectrum scarcity problem that is encountered in many countries. For access this spectrum which is used many criterions like signal processing techniques for spectrum sensing, cooperative spectrum sensing, and transceiver design for cognitive spectrum access with design and consideration for quality-of-service. These include the study of dynamic spectrum allocation methods, spectrum sensing, cooperative communications, incentive mechanisms, cognitive network architecture and protocol design, cognitive network security, cognitive system adaptation algorithms and emergent system behaviour.**

Keywords*—Cognetive Radio; Dynamic Spectrum Access ; Spectrum sensing; Quality of service.

I. INTRODUCTION

The anticipated explosion of wireless applications creates an ever-increasing demand for radio spectrum. Unfortunately, spectrum is a finite resource and because of the tremendous social value of the finite spectrum, it is carefully managed at the national and international level. Wireless devices are becoming ubiquitous, placing additional stress on the fixed radio spectrum available to all access technologies. To eliminate interference between different wireless technologies, current policies allocate a fixed spectrum slice to each wireless technology [5]. This static assignment prevents devices from efficiently utilizing allocated spectrum, resulting in spectrum holes and very poor utilization .These results further motivate the Open Spectrum approach to spectrum access. Open Spectrum allows unlicensed (secondary) users to coexist with legacy (primary) spectrum holders, thereby “creating” new capacity and commercial value from existing spectrum ranges. Secondary users opportunistically utilize unused licensed spectrum on a non-interfering or leasing basis based on agreements and constraints imposed by primary users. Open spectrum focuses on controlling the behaviour of secondary users while keeping the system transparent to primaries. While maximizing spectrum utilization is the primary goal of dynamic spectrum systems, a good allocation scheme is also needed to provide fairness across users. We hereby use user to represent secondary user[7]. A user seizing spectrum without coordinating with others can cause harmful interference with its surrounding neighbours, and thus reducing available spectrum.

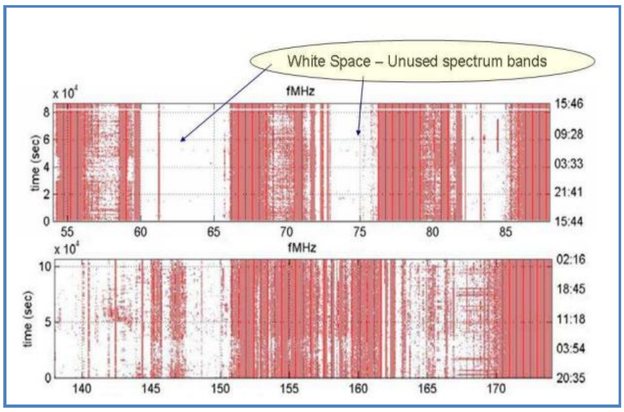

Fig. 1. Example of White space in spectrum usage [4]

II. COGNITIVE RADIO

A Cognitive Radio may be defined as an intelligent wireless communication system that is aware of its surrounding environment, learns from the environment and adapts its internal states to statistical variations in the incoming RF stimuli by making corresponding changes in certain operating parameters in real time[1]. In general the cognitive radio may be expected to look at parameters such as channel occupancy, free channels, the type of data to be transmitted and the modulation types that may be used. It must also look at the regulatory requirements. In some instances it may be necessary to use a software defined radio, so that it can reconfigure itself to meet and achieve the optimal transmission technology for a given set of parameters. Accordingly Cognitive radio technology and software defined radio are often tightly linked [13]. The states in the above CR cycle defining the spectrum management process consists of following major steps:

1. Spectrum Sensing: A CR user can only allocate an unused portion of the spectrum. Therefore, the CR user should continuously monitor the Radio Environment for the availability of free spectrum bands, capture their information, and then detect the spectrum holes.
2. Spectrum Decision: Once the available spectra are identified, it is essential that CR users select the best available band according to their QoS requirements.
3. Spectrum Sharing: The transmissions of CR users should be coordinated by spectrum sharing functionality to prevent multiple users colliding in overlapping portions of the spectrum.
4. Spectrum Mobility: If the specific portion of the spectrum in use is required by a PU, the communication must be switched to another vacant portion of the spectrum.
5. Radio Environment: The idea of Radio Environment Maps (REMs) design is to decide what type information must be stored and how this would be available to the various radios. The REM information can be updated with observations from CR nodes and disseminated throughout CR networks

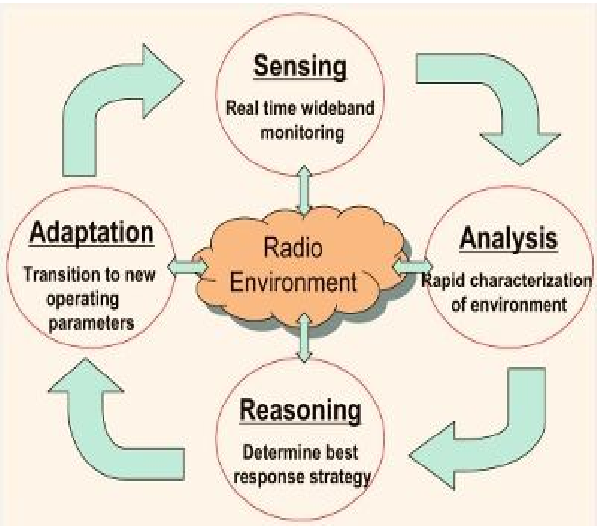

Fig. 2 Cognition Cycle [14]

III. Managing Unlicensed Spectrum

The 2.4 and 5 GHz band are popularly used for wireless computer networking. These bands, and others, are known as the industrial, scientific, medical (ISM) bands. Energy from microwave ovens falls in the 2.4 GHz band. Consequently, it is impractical to license that band for a particular purpose. However, Wi-Fi (802.11) and Bluetooth applications are specifically designed to coexist with a variety of interference waveforms commonly found in this band as well as with each other. Various types of equipment utilize a protocol to determine which frequencies or time slots to use and keep trying until they find a usable channel. They also acknowledge correct receipt of transmissions, retransmitting data packets when collisions cause uncorelatable bit errors.

IV. Architecture of Cognitive Radio

Cognitive radios (CR) and cognitive radio networks (CRN) is studied for the concept of interoperability and dynamic spectrum access (DSA) to reach its full potential. Several layers of the traditional network protocol stack will need to be enhanced to accommodate the additional functionalities of cognitive radios [8].Cognitive radios merge Artificial Intelligence and wireless communications. The field is highly multidisciplinary, mixing traditional communications and radio work from engineering while applying concepts from computer science. The cognitive radio architecture shown in fig 3. Here, the intelligent core of the cognitive radio exists in the cognitive engine. The cognitive engine performs the modeling, learning, and optimization processes necessary to reconfigure the communication system, which appears as the simplified open systems interconnection (OSI) stack. The cognitive engine takes in information from the user domain, the radio domain, the policy domain, and the radio itself. The user domain passes information relevant to the user's application and networking needs to help direct the cognitive engine's optimization.

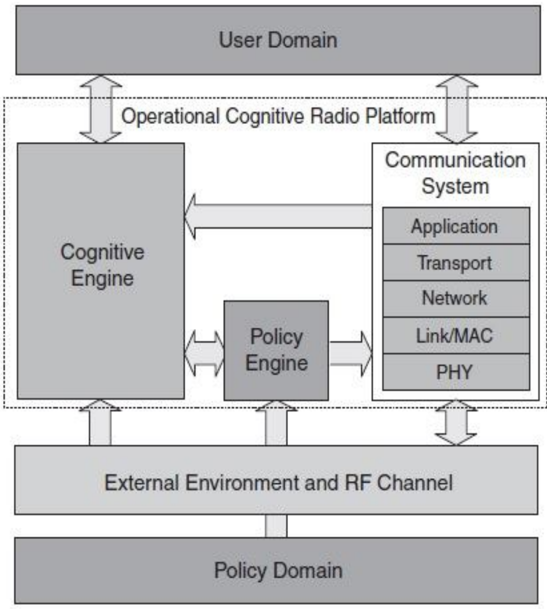

Fig. 3 Generic cognitive radio architecture[8].

The radio domain information consists of radio frequency (RF) and environmental data that could affect system performance such as propagation or interference sources. The policy engine receives policy-related information from the policy domain. This information helps the cognitive radio decide on allowable (and legal) solutions and blocks any solutions that break local regulations.

*A. Dynamic Spectrum Access in Cognitive Radio***:** In order to break away from the inedibility and inefficiencies of static allocation, a new concept of Dynamic Spectrum Access (DSA) is being investigated by network and radio engineers, policy makers, and economists. In DSA, spectrum will be accessed dynamically depending on need of the service providers which in turn depends on end users demands in a time and space variant manner. Emerging wireless technologies such as cognitive radios is poised to make DSA a reality. This method of spectrum sharing is more efficient and will help service providers. With the new paradigm of cognitive radio technology, it will be possible to operate at any unused frequency channel to maximize the spectrum usage opportunity [4].In DSA policy cognitive radios must not interfere with the incumbent radio operation in a band – who are the prioritized users of that band. To make the DSA mechanism successful cognitive radio systems perform spectrum sensing, dynamically identify unused ("white") spectrum, and operate in this spectrum band when it is not used by the incumbent radio systems – who are the primary users of this band. Upon detecting incumbents in any band cognitive radio must automatically switch to another channel or mode [15].

TABLE 1: TYPICAL FREQUENCY BANDS [2]

Radio Service	Frequency Bands
Radio navigation	9 – 14 kHz
Mobile (Distress & Calling)	495 – 505 kHz
Broadcasting	535 -1605.5 kHz
Maritime Mobile	2065 – 2107 kHz 2170 – 2173.5 kHz 2190.5 – 2194 kHz
Amateur & Amateur Satellite	7000 – 7100 kHz 18068 – 18168 kHz
Fixed, Mobile, Broadcasting Radio Astronomy	610 – 806 MHz
Mobile, Fixed Broadcasting Mobile satellite	890– 960 MHz 942 – 960 MHz
Radiolocation	1350 – 1400 MHz
Mobile Satellite (s-E)	1535 – 1559 MHz
Mobile, Fixed, Space Operation, Space Research	1710 - 1930 MHz

B. Limitations of static spectrum Access technology: In existing implemented technology static radio devices are dominantly functional. However, static radio devices have the following disadvantages:

• The static radio devices can operate only on a single frequency channel in the entire network at a time. Lack of interoperability due to such constraints is clearly a major issue with the static radio.

• The static radio device can not automatically configure itself to switch to other frequency bands even if there are multiple orthogonal frequencies available in the network.

• In the legacy IEEE 802.11 system, a single wireless card can connect to only one wireless access point (AP) in the infrastructure mode or a single ad hoc network in the ad hoc mode, using only one frequency channel in the entire network even though there are multiple frequency bands available in a IEEE 802.11a/b/g network.[15]

• Simultaneous connections to multiple networks are not possible with the static radio device.

V. COGNITIVE RADIOS APPLICATIONS [3]

Leased network: the PR network may provide leases for CR networks to access opportunistically its frequency band, in order to improve the overall spectrum-efficiency; Cognitive wireless mesh network: to provide cost-effective broadband connectivity and robust communications; Emergency wireless network: for example, to provide reliable communications in the case of natural disaster; Short-distance wireless communications: nowadays, there are a lot of short-distance wireless services, which may benefit from cognitive radio techniques; Military network: for example, for adapting the harsh radio environments of battlefield;

Vulnerability challenges: The attack may happen in the form of Jamming - malicious intention of distorting normal secondary communication, Denial of Service attack - emulating characteristics of primary users of the spectrum band, eavesdropping by emulating characteristics of secondary users. The cognitive radio has no sense of sight which severely limits the ability to detect the environment [5]. This can lead to the hidden terminal problem where the sensing secondary user is unaware of the presence of a primary user because it cannot reliably detect its presence. A PU terminal and a SU terminal can be separated by some physical obstacle opaque to radio signals. They can also be out-of-range of each other so that the reliable sensing of primary transmission becomes impossible, Security**-** The challenges of employing cognitive radios for the policy community also include that of ensuring secure device operations. Security in this context includes enforcement of DSA rules. Enforcement for static systems is already a challenge due to the amount of resources necessary to authorize equipment, the requirement of obtaining proof that violations have occurred, and the determination of the violators' identities. As the systems become more dynamic, there is an increase in the number of potential interactions that can lead to a violation.

VI. CONCLUSION

In Cognitive Radio Communications and Networks sensing/detection of the attacks from malicious users is an important task to build efficient and secure DSA system so that these attacks cannot shut down a first responder or similar emergency tactical networks during critical periods. Security against these classes of attacks cannot be achieved through cryptographic means alone. Cognitive radio offers the ability to manage this situation more effectively by utilizing the ability to sense the actual propagation conditions that occur, and to adjust the radio dynamically to best fit these conditions.

VII. REFERENCES

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