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COGNITIVE SPECTRUM FRAMEWORK ON COOPERATIVE ENVIRONMENT: A STUDY

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Abstract- The Cognitive Radio network emphasis itself on Dynamic Spectrum Access process by allocating the spectrum bands and also includes methodologies that incorporates Centralized Cooperative Spectrum Sensing which would sense the spectrum holes and enables a continues flow of energy to accomplish efficient throughput with respect to its enlarged network . The distribution of white spaces in the primary channel is gathered using various algorithms when there is heavy need for resources from the idealized primary channels. Cognitive radio learns about its network and the available band such that demand for wireless applications could be established in an efficient way. The spectrum sensing ,analyzing managing ,distribution of energy and highly reliable communication will be take care in a cognitive cooperative form of network .
Keywords –Cognitive Radio, Cooperative, spectrum sensing.

1. INTRODUCTION

Wireless communication is widespread and has become a revolutionary change in technology. Cognitive radio network works as a knowledge based wireless network. The currently used Software Defined Radio (SDR) technology has reached a different dimension in radio communication which enables the user and the network to minimize the congestion on the network and also fulfills the needs such as resources of large wireless network.SDR was more versatile ,cost effective and could easily upgrade itself . SDR plays a very important role for the evolvement of Cognitive Radio Networks. Cognitive Radio coordinates with the radio system to use the radio band which optimizes the usage of radio frequency spectrum with minimized interference of other users. The sensed spectrum holes are made use by the secondary users who are in need of transmitting to avoid traffic in the network .More over to make the network more consistent the awareness of the spectrum could be triggered to the hidden nodes that to each and every individual nodes in the network through Cooperative sensing schemes.

The paper is organized as follows. Cognitive Radio & Cooperative Sensing is explained in section II. Challenges are presented in section III. Concluding remarks are given in section IV.

2. COGNITIVE RADIO & COOPERATIVE SENSING

2.1 Cognitive Radio Network –

Cognitive Radio Network is a novel approach in Wireless communication era and was first introduced by Joseph Mitola with his researchers. Cognitive Radio [1][2] helps in understanding the method of building and learning of it environment and internally changing its state with the incoming of the radio frequency waves. This potential helps us to achieve high reliable communication during humungous traffic in the network and to effectively utilized the unveiled bandwidth. Cognitive radio waveform has the advantage to program its hardware platform, called software-defined radio(SDN) as show Figure 1.

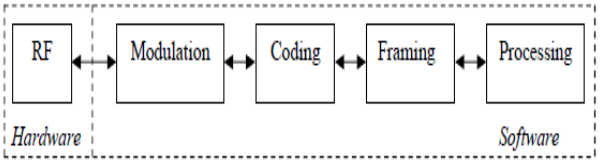

Figure 1 SDN

The accessing of the radio spectrum is influenced by licensed or unlicensed spectrum. Mostly the licensed spectrum, uses allocated spectrum bands that are exclusively channelized to various operators, and in the unlicensed spectrum, sealed spectrum bands are often announced to be free for use by any individual labeled with specific regulations. Cognitive radios (Figure 2) has two major attractions [3]: (i) adaptable and (ii) gains ability on spectral productivity. They upgrade the

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network information by themselves and alter their transmission rule (routing paths) their spectrum schemes as well. The network quickly adapts to different spectrum policies. The diagram shows the process flow of a SDR network and a CR network.

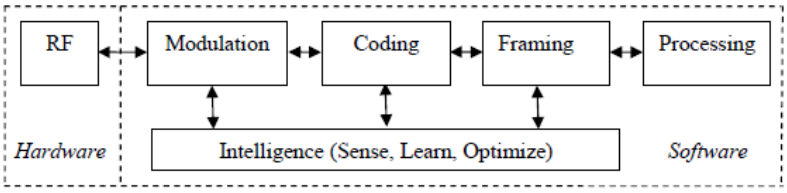

Figure 2 Cognitive Radio Network

The functions of cognitive radio are[5][2]:

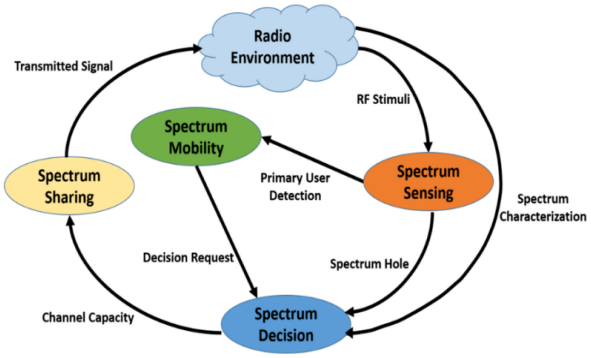

Figure 3 Cognitive Radio Network Features

a) Sensing

The spectrum is freely available for licensed channel and it is the core function of cognitive radio technology .It takes care in such way that the licensed channel is utilized efficiently without the interference with primary user.

b) Management

The spectrum sensing process senses spectrum holes (unused frequency bands) makes best use of the bandwidth without the interference with primary user in order to attain quality of service.

c) Sharing

The spectrum is shared in such a way that there is no collision between the users. A priority based sharing is done in order to avoid loss of valuable information and delay in the network.

d) Mobility

The secondary users make use of the bandwidth (spectrum holes) that is available with the primary user channel that increases the flow of energy efficiently without congestion.

Characteristics of Cognitive radio:

- *Cognitive capability:*

The Cognitive environment [3] has the capability to capture or detect the information's about its environment, directs itself its path, creates or organizes , confirms, and then applies according to its radio network is show in fig 2

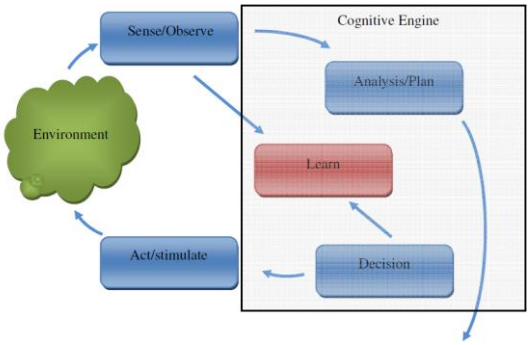

Figure 4 Cognitive Radio Network Characteristics

Sensing determines the spectrum holes that are available, plans the path of routing of the packets and also learn the environment the deal with in the network. The analysis, decision and learn are the modules which frame the interior part of

the cognitive radio system, which makes the entire network intelligence which is controlled by the Cognitive Engine shown in Figure 4.

- *Reconfigurability:*

It is the key characteristics [3] of a cognitive networks which adapts and has the ability to change its parameters based on the surrounding as it travels in the network.

2.1.1 Spectrum Sensing

The probability of detecting or sensing the spectrum uses various techniques there are three ways used for spectrum sensing for processing they are:[4] Energy detection, Matched filtering and Cyclostationary detection shown in the block diagram Figure 5

- *Energy detection*

It non-coherent process that simplifies the matched filtering process. The intensity or magnitude needed for the deduction of primary user spectrum is highly susceptible. Energy detector helps in finding out the difference in the modified signals, the disturbance and the interferences mixed with it. The received signals could increase its robustness of the incoming signal marked with features such as intonation type, speed of communication of data, or the type of signal.

- *Matched Filter*

It is the best optimal way of demodulate the primary user signal that is it has the ability to have knowledge of the primary signals at the layers like the PHY and MAC layers .This leads to performing timing synchronization and also equalizes the channels to achieve coherency in signals. It needs a dedicator receiver to constantly monitor the incoming signal.

- *Cyclostationary detection*

The signals that are captured includes the carrier waves that are sinusoidal, square waves, spreading the signal repeatedly which display the results in regular intervals. Then the signals are further categorized through its statics, mean and auto correlated with the signals and exhibit periodicity. The receiver signal exhibits estimation of certain parameters such as the direction of signals arrival ,the time taken for its arrival at its point and the carrier phase.

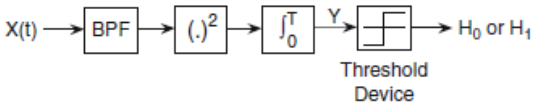

Figure 5 Energy Detector

The input signal X(t) enters through the band pass filter (BPF) where the center frequency and the bandwidth is taken as W. Then the device is squared and integrated over the period T. The secondary users receives an output Y which is integrated with the amount of received energy and the distribution depends on the presence of primary user. This is decided on two hypothetical conditions:

$$x(t) = \begin{cases} n(t), & H_0 \\ h \cdot s(t) + n(t), & H_1 \end{cases}$$

where x(t) indicates secondary users received signal, s(t) is the signals transmitted by the primary user's , additive white Gaussian noise (AWGN) is indicated as n(t), and amplitude gain as h on the channel .γ represents the signal-to-noise ratio (SNR). The integrator output Y is shown as

$$Y = \begin{cases} \chi^2_{2TW}, & H_0 \\ \chi^2_{2TW}(2\gamma), & H_1 \end{cases}$$

The chi-square is randomly denoted as qualities of central as well as non-central form of distributions, where 2TW is the degrees of freedom on a non central parameter 2γ used in latter distribution of the signals.

$$Y = Y_\chi + Y_e, \qquad H_1,$$

This concludes after T seconds for each secondary user i with the detection os energy to get the measurement as Yi $\in$ R^+.

2.1.2 Dynamic Spectrum Access (DSA)

The dynamic spectrum access [6] has an efficient way of identifying spectrum holes (unused frequency band of primary channel user which is free to be utilized by the secondary channel user) or it is also called as white spaces without the interference with primary channel users. The DSA [7] mainly takes care two types of interference (i) interference due to malfunctioning of the transmitter and receiver device and (ii) interference caused by unknown or unwanted malicious user. Figure 6 shows DSA models have been created for cognitive radio and are categorized as :-

a) dynamic exclusive model b) open sharing model c) hierarchical access model

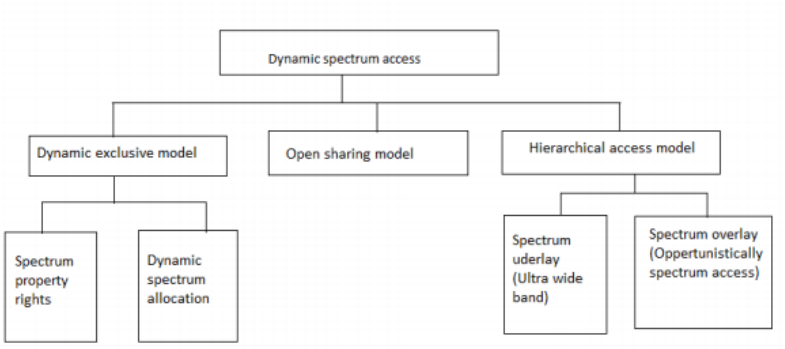

Figure 6 Dynamic Spectrum Access Block diagram

a) Dynamic exclusive model: -
This model [6] are to improves the flexibility and spectrum efficiency by managing finer scales of time in the spectrum, its space and frequency with its dimensions. The use of this model [6][7]is the spectrum property rights: An auction oriented approach that is allowed to sell and trade spectrum and Dynamic spectrum allocation: The assignment of the spectrum is dynamically initiated by using the spatial methods and during the increase in traffic of different services.

b) Open sharing model: -
It shares the resources among peer-users and implants a formation of managing a spectral region. This kind of phenomenal approach is view in industrial, medical and scientific model. There are three types:

i) Uncontrolled commons
When there a spectrum band available or managed there is no other entity intrudes in between the process

ii) Managed-commons
It specifies the order in which the spectrum has to be shared to avoid collusion between the resources available.

iii) Private-commons
There is a central controller in the spectrum which takes in charge of setting the rules to utilize the resources.

c) Hierarchical access model: -
In this model the spectrum is shared equally between the primary and the secondary users it also decides accordingly if the spectrum is utilized fully or partially .There are two types of models:-

i) Spectrum overlay:-
Secondary users plays an important part by boosting the secondary communication and also relay remaining spectrum when needed by primary transmission like TDMA, FDMA, and OFDMA system.

ii) Spectrum underlay: -
The spectrum that is available below the noise floor is well handled by the transmission power of secondary users. Due to the scattering of wide range of frequencies it is possible to achieve high data rate over a short-range of distance with minimized transmission power

2.2 Cooperative Network –
Cognitive Radio cooperative spectrum sensing[8] is a method where a group or network of CRs share the sensing information deducted by the primary user. This approach plays a vital role in improving performance during fading, shadowing and noise[2][3] uncertainty.

Two approaches to cooperative spectrum sensing:-
i. Centralised approach:
A central controller FC (fusion centre) is present within the network which gathers all the sensing information from the nodes within the Cognitive Radio network. The reports of each nodes are collected by the reporting channel .each and every transmission is monitored in such a way every information that is needed is collected efficiently(Figure 7) .

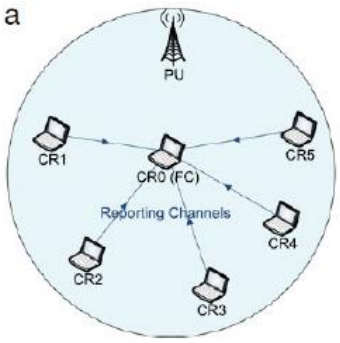

Figure 7 Centralized cooperative network

ii. Distributed approach:

There is no centralized control in this type of approach. Each and every individual data is merged that has been received by the sensing data which provides higher level of independence which would be more appropriately needed in an Adhoc environment (Figure 8).

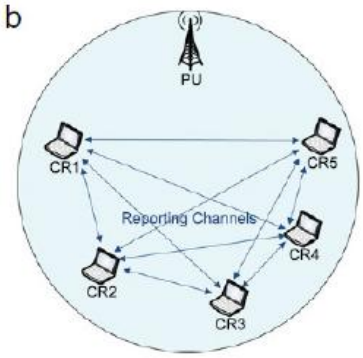

Figure 8 Distributed cooperative network

3. CHALLENGES

In this part we aim on the challenges happening when implementing the cognitive cooperative framework and also the research done on this environment [8][9][10]

3.1 Spectrum Decision

Decision is mainly dependent upon the environment it chooses to transmit the signals (Centralized or distributed) and also implements algorithms like genetic and neural network algorithms and optimization techniques like particle swarm and ant-colony optimization techniques that satisfies the needs of the environment.

3.2 Learning Process

This process inhibits the machine learning in two ways supervised and unsupervised. Its aims in avoiding making inappropriate choices in making decisions on the network. It takes into account of all previous information's or decisions that are made in the network in order to attain liable communication.

3.3 Geo-location

Geo- location is depends on the access point that transmits the signals towards its actual location by collecting all the information's from the database. It also includes master-slave technology for identifying the functionalities from the database that helps in retrieving the information's stored by the primary user. This helps in retaining the cost and complexity of search.

3.4 Cross-Layers

The type of network is based on the location is a very challenging task. It mainly depends type of environment the network is placed either homogeneous or heterogeneous environments .The conditions involved depends on the quality, noise, topology, density of the signal or demand and the traffic involved that supports cross-layer communication.

3.5 RF Front-Ends Challenges

The cognitive radio transceiver has the capability to adapt to multiple accessing met should have the ability to adapt to multiple accessing methods and change to the modulation schemes through switching of links, and also communicate simultaneously to two or more points at the same time. This increases the bandwidth during communication.

3.6 ADC and DAC Challenges

The dynamically changing environment can cause the analog-to-digital converter (ADC) [11] digital to analog convertor (DAC) that are highly sensitive towards the receiver with interference of temperature is also analyzed. The major issues faced in designing of receiver (Rx) sensing algorithms implementation like broadband, high linearity and dynamic range with low noise.

3.7 Sensing Algorithm Implementation Challenge

A spectrum sensing algorithm is mainly used in detection of spectrum holes, false alarm, and miss leading probabilities while deducting might cause loss in Signal to Noise Ratio regime, time and frequency for sensing the signals, and complications of implementing the signals. The algorithms [11] takes the decision making of accuracy, the spectrum sensing time and its malicious combatant, because of the limits on the spectrum sensing algorithms which includes noise and uncertainty in the multipath routing strategies like fading and shadowing of hidden PU problem .

4. CONCLUSION

This paper presented an overview of the framework of cognitive and cooperative networks and the challenges in that environment. It also focuses on implementation on both kind of network. We have also summarized the key benefit of using those environment and the structure and challenges that to be focused has also been viewed. The characteristics of cognitive radio and the their features shows how liable a network can perform when implemented and certain parameters like its energy efficiency transmissions of signals has also been discussed briefly. To make the an intelligent network more intelligent the cooperative network can also be implemented to attain effective results in spectrum utilization. A comparative table can be obtained with the parameter involved to brief out the study.

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