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A Survey on Advanced Fuzzy Logic System for Opportunistic Spectrum Access using Cognitive Radio

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Abstract:-

A fundamental problem facing the future wireless systems is where to find suitable spectrum bands to meet the demand of future services. While essentially all of the radio spectrum is allocated to different services, applications and users, observation provide evidence that usage of the spectrum is actually quite low. In order to overcome this problem and improve spectrum utilization, cognitive radio concept has been proposed. This paper provides an overview of cognitive radio for opportunistic spectrum access and related research topics. Cognitive radio objective is to use scarce and limited natural resources efficiently without causing excessive interference to the primary licensed users. Consequently, cognitive radio has to sense and understand its spectrum environment, identify temporarily vacant spectrum, transmit adaptively and learn from its behaviour.

A number of promising concepts for cognitive radio were briefly presented and discussed in this paper in the area of passive and active spectrum awareness, spectrum management and transmit power control. Opportunistic spectrum access approach is enabled by cognitive radios which are able to sense the unused spectrum and adapt their operating characteristics to the real-time environment. However, a naive spectrum access for secondary users can make spectrum utilization inefficient and increase interference to adjacent users.

Keywords: - Cognitive Radio, Opportunistic Spectrum Access, Spectrum Awareness, Spectrum Management, Transmit Power Control

1. INTRODUCTION

Radio spectrum is a valuable commodity, and a unique natural resource shared by various types of wireless services. Unlike other natural resources, it can be repeatedly re-used, provided certain technical conditions are met. In practice radio spectrum can accommodate a limited number of simultaneous users. Therefore, radio spectrum requires careful planning and management to maximize its value for all users. Currently, spectrum regulatory framework is based on static spectrum allocation and assignment policy. Radio spectrum is globally allocated to the radio services on the primary or secondary basis. This is reflected in the Radio Regulations published by the International Telecommunication Union (ITU), Large discrepancies in radio spectrum allocation, assignment and actual radio spectrum usage indicate that spectrum shortages result from the out-dated spectrum management policy

rather than the physical scarcity of usable radio spectrum. In order to satisfy EU Digital Agenda goals and future market demand for mobile and broadband services, we can envisage deployment of next generation broadband wireless networks and services which will need rapid and more flexible access to the radio spectrum in the UHF band. The general trend towards more flexible and efficient spectrum management is further driven by the continuous development of new technologies.

Most of today's radio systems are not aware of their radio spectrum environment as they are designed to operate in a predefined frequency band using a specific spectrum access system. The idea of cognitive radio was first presented officially in an article by Joseph Mitola III and Gerald Q. Maguire, Jr in 1999. Regulatory bodies in various countries found that most of the radio frequency spectrum was inefficiently utilized. As elaborated in the introduction, investigations of spectrum utilization indicate that spectrum is not efficiently utilized most of the time. Overall spectrum utilization can be improved significantly by allowing secondary unlicensed users to dynamically access spectrum holes temporally unoccupied by the primary user in the geographical region of interest as shown in Fig 1.

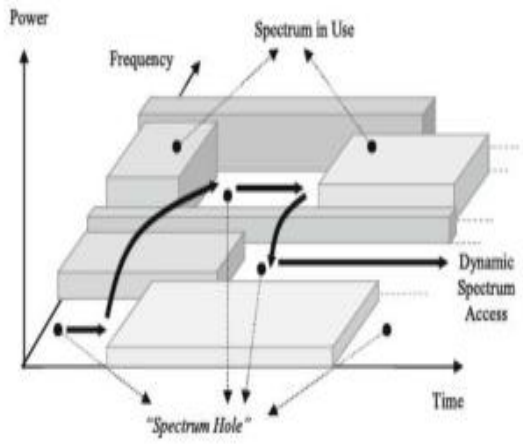

Figure: 1 (Radio Spectrum Hole)

A spectrum hole [10] (or also called white space) is a band of frequencies assigned to a primary user, but at a particular time and specific geographic location, the band is not being utilised by that user. Spectrum hole concept can be further generalised 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.

2. SPECTRUM MANAGEMENT AND TRANSMITTER POWER CONTROL

Active coexistence of primary licensed and secondary users in space, time and frequency domain impose unique challenge to the spectrum management in cognitive radio systems. Basic spectrum management functions are spectrum decision, spectrum sharing and spectrum mobility [15, 26]. Spectrum access models can be categorized as exclusive use and shared use models [7,8]

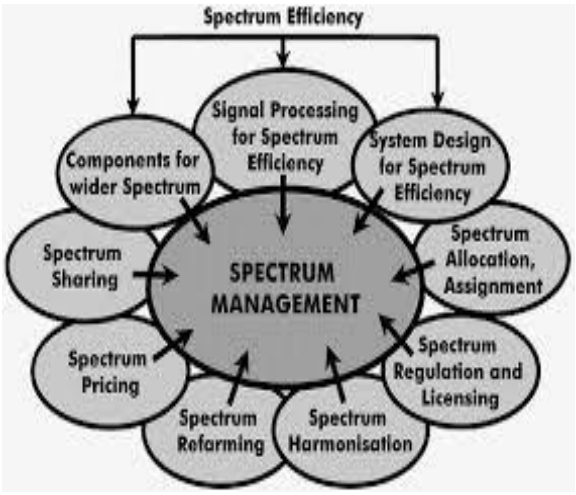

Figure: 2 (Spectrum Efficiency Management)

Command and control model and long-term exclusive use are traditional spectrum access models used in conventional radio systems [28]. Characteristic of dynamic exclusive

model is that radio spectrum is used exclusively by one system in determined spectrum hole. In order to improve spectrum efficiency some level of flexibility is introduced. At different points in time, the cognitive users can access the radio spectrum under defined rules. Flexibility helps licensees to put spectrum to its most valuable use with the most effective technology, without waiting for a regulator's permission. Two approaches have been proposed under this model: spectrum property rights and exclusive dynamic spectrum allocation [7-9]

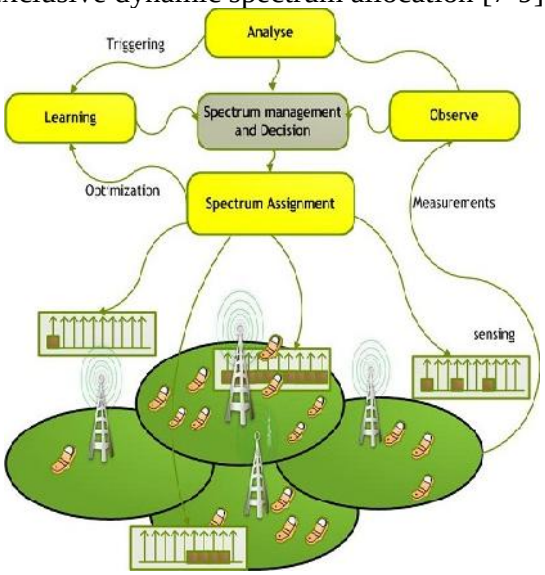

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Figure: 3 (Spectrum Management and Decision)

The concept of opportunistic spectrum access is used in order to efficiently utilize the spectrum which is underutilized. The opportunistic spectrum access improves the spectrum utilization by cognitive radio adopting the secondary user to use the unused spectrum of the primary user. This opportunistic spectrum access, avoids the spectrum scarcity. For example, cellular network bands are overloaded in most parts of the world, but amateur radio and paging frequencies are not. This can be eradicated using the dynamic spectrum access. The key enabling technology of dynamic spectrum access techniques is cognitive radio technology, which provides the capability to share the wireless channel with licensed users in an opportunistic manner. From this definition, two main characteristics of the cognitive radio can be defined as follows: Cognitive capability: It refers to the ability of the radio technology to capture or sense the information from its radio environment. Through this capability, the portions of the spectrum that are unused at a specific time or location can be identified. Consequently, the best spectrum and appropriate operating parameters can be selected. Reconfigure ability: The cognitive capability provides spectrum awareness whereas reconfigure ability enables the radio to be dynamically programmed according to the radio environment. More specifically, the cognitive radio technology will enable the users to determine which portions of the spectrum are available and detect the presence .

3. SPECTRUM SENSING TECHNIQUE

Some studies have revealed that utilization of spectrum is dependent on two things. One is time and other is place. Already allocated frequency bands don't allow other users to use this band even when it is not being used. Many regulatory bodies in world are considering this point, whether to allow unlicensed users in licensed frequency bands without any interference. This research leads us to cognitive radio for dynamic spectrum access. Actually, Cognitive Radio systems access spare/unused sections of the radio frequency spectrum. Also, it keeps monitoring the spectrum to make ensure that this does not cause any undue interference. Designed Cognitive radio spectrum should be capable to detect/analyze any other transmissions in region. Then it should be informed to central processing unit within the Cognitive Radio so that the required action can be taken. [4] Spectrum management: Out of large number

of idle channels, the SU has to select the best channels that will satisfy its QoS requirements. The spectrum management functions can be classified as spectrum analysis and spectrum decision.
Spectrum mobility: Due to appearance of the primary user on the channels occupied by the SU at that time, the SU has to change instantly its operating channels to other idle channels. The switching to these idle channels should be seamless so that there is minimum QoS degradation of the application running on the SU. Spectrum sharing: After deciding the transmitting channel, the SU handshakes with its receiver and starts transmitting. A fair spectrum scheduling mechanism is to be devised for sharing of the spectrum with other SUs.
In this work, a spectrum sensing controller is designed by using fuzzy logic in MATLAB. Cognitive radio performs following three main tasks. One is spectrum sensing, second is spectrum analysis and third is spectrum allocation. Cognitive Radio presents a technique for utilizing the spectrum holes. Spectrum usage has its characteristics. These characteristics have many dimensions like

1. Time
2. Space
3. Frequency
4. Code
5. Type of signals for spectrum

3.1 Fuzzy Logic Technique

Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth -- truth values between "completely true" and "completely false". It was introduced by Dr. Lotfi Zadeh of UC/Berkeley in the 1960's as a means to model the uncertainty of natural language.
In this paper, We design a controller in which we have two inputs and one output fuzzy logic is MATLAB tool which is used to design a controller. Fuzzy logic technique is used to analyse nonlinear systems. It deals with those systems which are difficult to resolve using conventional mathematical models. The concept of fuzzy logic to solve the problem has been reported first time by Lotfi Zedeh. He also reported the concept of linguistic variables. For designing, here we utilize mamdani model in fuzzy logic tool to control different parameters of cognitive radio.
The two parallel systems doing same control function. One is fuzzy logic base system and other is non fuzzy logic base system. In fuzzy logic design, we deals only three steps:- first is understand physical system. Secondly control requirement and the third is design the controller by using fuzzy rules. Simulate and implement design. Fuzzy logic includes different processes in itself such as

1. fuzzification
2. defuzzification
3. membership functions domain
4. Linguistic variables and rules

Domain determines the range of values in which membership of fuzzy is defined. The basic part of fuzzy sets is membership function.
The relation between a domain value and its degree of membership is determined by membership function. Fuzzy logic has many similarities and differences with Boolean logic. Fuzzy logic performs Boolean logic results when all the fuzzy membership functions have range from 0 to 1.FL uses natural/common language techniques and variables. These are based on the degree of truth. And it is easier to understand for human beings. Fuzzy control is based on fuzzy logic. FL provides us an effective means of confining, approximate, inexact nature of real world. The important part of this logic is linguistic control rules. Rules are defined by our requirements based on if-then statements. Then fuzzy logic controller provides an algorithm which convert linguistic control strategy into an automated

control system. Fuzzy logic controller is an approach between mathematical control model and human decision making control approach [7].

In this paper work author design a control system for elid grinding. This control system avail fuzzy logic design consist of four inputs and matlab based fuzzy tool having output to control the system[8].We can create and edit fuzzy inference systems with Fuzzy Logic Toolbox software. we can create these systems using graphical tools or command-line functions, or we can generate them automatically using either clustering or adaptive neuro-fuzzy techniques. By accessing to Simulink® software, you can easily test your fuzzy system in a block diagram simulation environment. The toolbox also lets you run your own stand-alone C programs directly. This is made possible by a stand-alone Fuzzy Inference Engine that reads the fuzzy systems saved from a MATLAB session. We can customize the stand-alone engine to build fuzzy inference into your own code. All provided code is ANSI® compliant.

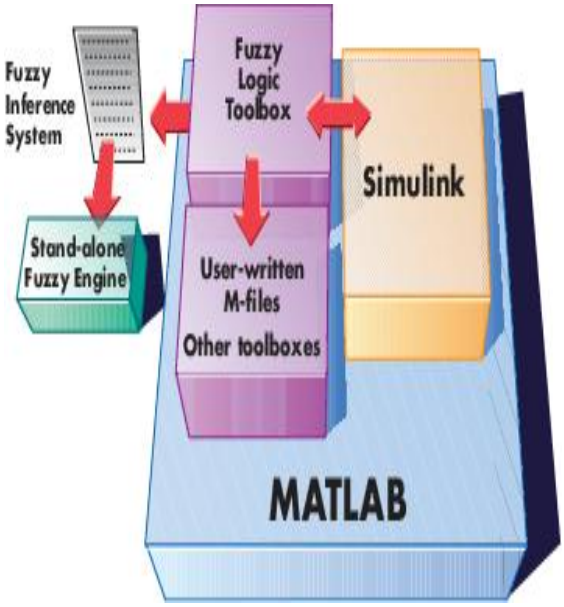

Figure : 4 Simulation Structure

Because of the integrated nature of the MATLAB environment, you can create your own tools to customize the toolbox or harness it with another toolbox, such as the Control System Toolbox

CONCLUSION

Radio system founded on cognitive radio technology is challenging and promising concept, leading to new directions in developments of wireless communications and leap progress in radio spectrum usage efficiency. It is seen as a groundbreaking and founding technology of future wireless systems.

Nevertheless, cognitive radio is not a magic wand which will instantly solve radio spectrum scarcity problems, liberate all the frequency bands and abrogate radio spectrum regulation. As we look in the future, we see that cognitive radio has the potential for making a significant difference in the way how the radio spectrum can be accessed and used by wireless systems.

However, cognitive radio is still in its infancy. Development of cognitive radio systems are cross related and dependent to developments in many different technical and non-technical areas like: software defined radio, digital signal processing, artificial intelligence and machine learning, but also bioinspired intelligence, social group behaviour, economical studies, etc. Emergence of full cognitive radio capable radio system is still years, even decades far away from practical realization.

What we currently see is:

many research advances in the area and Gradual implementation of various cognitive radio Related technological Concepts in Modern communication systems.

Even if only Thirty percent of predicted Cognitive radio system functionalities Will be realized in radio devices in The forthcoming years, This would Bring significant advances to future wireless communications systems.

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