Frequency of Dynamic Spectrum Using Cognitive Radio in Wireless Ad-Hoc Networks

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***Abstract*—The users may use cognitive radio frequency (CR) in wireless communication systems which senses the radio frequency for data and message communication. The modern investigate gives the issues related to spectrum utilization is a function of time and space calls for dynamic access strategies that adapt to the electromagnetic environment. The usage of free spectrum sharing between primary users (licensed) and secondary users, being license-exempted and has been incontestable within the recent experimental trails supported TV whitespace networks. The technique of dynamically accessing unused spectrum victimization Dynamic Spectrum Access (DSA) is gaining momentum. Many experimental trails on dynamic spectrum networks are being disbursed within the TV-band spectrum to check the technology and enact rules. During this work, a summary of psychological feature radio i.e. spectrum sensing, spectrum sharing, spectrum management and spectrum quality square measure mentioned. This work can explore the dynamic spectrum technologies as a precursor to full-fledged psychological feature radio networks.**

I. Introduction

The cognitive radio (CR) frequencies are the radio systems that autonomously coordinate the usage of radio band. Naturally, very limited frequencies are available for emerging wireless communication [1], [2]. Cognitive radio technology is predicted to change dynamic spectrum networks like TV white space networks that are being tested intensively in many countries. Software Defined Radio (SDR) lies at the heart of cognitive radio technology ranging from simple function device to a radio that senses, reacts to its radio frequency operative surrounding and geo-location. Intensive analysis and innovation is directed around the topic of cognitive radio and dynamic spectrum networks [3].

In this work, we presented a different range of functional mechanisms like Dynamic Channel Allocation (DCA), frequency assignment, spectrum coexistence together with spectrum access both to the licensed and unlicensed frequency bands though timeously spectrum remains unused, free and difficult to find. Licenses are required for a specific frequency band operation, up to date the spectrum allocated has not been utilized properly. Each country governs the use of radio spectrum by corresponding with government agencies [3], [4]. Real-time Dynamic Spectrum Management (DSM) algorithms govern the traffic on the used carriers radio or system that senses surrounding environment and dynamically adjust its radio parameters to communicate efficiently [4].

Efficient utilization of dynamic spectrum of CR can be improvised by allowing secondary user to use these licensed bands when the primary user is absent. The cognitive radio technology promises intelligent and efficient use of Radio Frequency (RF) spectrum, the TV spectrum provides features that ensure lager coverage areas for wireless access than the current Wi-Fi system.

Cognitive radio arrangement employs the technology that allows the arrangement to admission the advice of its operational RF and bounded environment, accustomed behavior and its centralized accompaniment to dynamically and apart acclimatize its operational ambit and protocols according to its acquired knowledge. This will advise approaching wireless network, to calmly advance deficient spectrum assets and accomplish predefined objectives, to apprentice from the after-effects obtained. When because the abstraction of activating spectrum admission area a radio identifies unused, changeless portions of accountant spectrum and utilizes the spectrum after opposing the impact on the primary licensees [6]. This work is arranged as follows: Section I: Introduction, Section II: Dynamic spectrum access, Section III Dynamic Spectrum Access Technology, section IV Cognitive Radio (CR), Section V Cognitive Radio Software VI Cognitive capacity Section VII TV whitespace networks and finally Section IX Concludes the work

II. Dynamic Spectrum Access

The goal of Dynamic Spectrum Access (DSA) is that coexistence between primary (licensed users) and secondary (unlicensed) users. The claiming is to accomplish abiding that there is administration of the authorization spectrum after arrest amid the two users. DSA algorithms admeasure unutilized abundance channels calmly and finer to the accessory user. Assigning altered anchored bandwidth to altered systems is not bearing an abounding account of accepting dynamically aggregate bandwidth. Mentions that DSA can advise to abbreviate bare spectrum bandage referred to as spectrum aperture or white spaces. Cognitive Radio (CR) has one important action that the appliances of the white amplitude have to not baffle with accountant band. When the primary user wants to advance the accountant band, the CR enabled accessory have to accomplish abiding that the accountant bandage is acclimated after arrest from the accessory user who takes advantage of the white space[7], [8]. These CR enabled devices uses the DSA strategies shown in fig.1

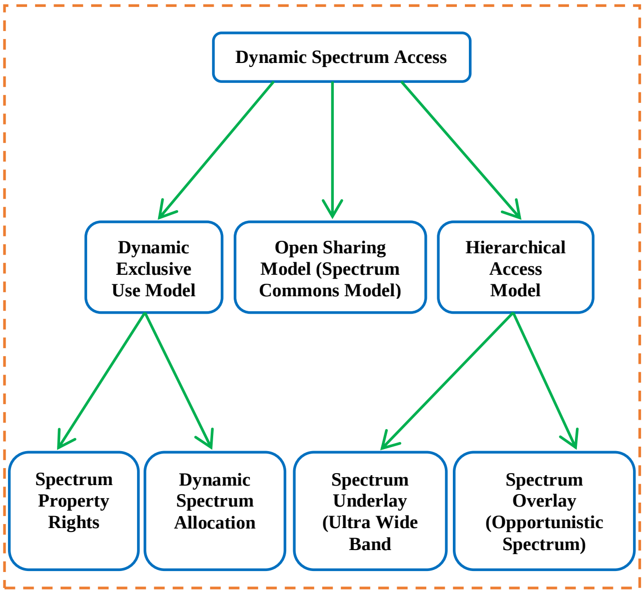

Figure 1: Taxonomy of Dynamic Spectrum Access

A. Dynamic Exclusive Use Model

The fundamental structure of the present spectrum regulation policy is maintained during this model, the spectrum bands are a unit licensed to services for exclusive use. The most plans are to introduce flexibility to enhance spectrum potency. There are a unit alternative two approaches beneath this model: Spectrum Property Rights and Dynamic Spectrum Allocation.

The first approach permits licensees to sell and trade spectrum, to freely select technology. Licensees have the correct to lease or share the spectrum for profit, such behaviour isn't licensed by the regulation policy. The second approach improves spectrum potency through dynamic spectrum assignment by exploiting the spatial and temporal traffic statistics of various services [8].

B. Open Sharing Model

Open sharing model is besides called spectrum commons model. In spectrum commons model, every user has equal rights to use the spectrum. This is also known as open spectrum model, has been successfully applied for wireless services which operate in the unlicensed industrial scientific and medical (ISM) radio band (example: WLAN) Open sharing among users as the foundation for managing a spectral region used by this model. There are three types of spectrum commons model i) Uncontrolled- commons, ii) Managed-commons and iii) Private-commons [7], [8].

- Uncontrolled-commons: When a spectrum band is managed and uses the uncontrolled commons model, no entity has exclusive license to the spectrum band.
- Managed-commons: Managed-commons represent an effort to avoid the tragedy of commons by imposing a limited form of structure of spectrum access. This is a resource which is owned or controlled by a group of individuals or entities and it is characterized by restrictions on when and how the resource is used.
- Private-commons: The concept of Private Commons was introduced by FCC in its Second Report on the elimination of barriers to development of Secondary markets for spectrum. This concept grew on allowing use of advanced technologies which enable multiple users to access the spectrum.

C. Hierarchical Access Model

This form adopts a Hierarchical Access Structure with primary and secondary users. This model opens licensed spectrum to Secondary Users (SUs) while restrictive interference perceived by primary users (licensees). The other two models beneath this one the spectrum underlay and the spectrum overlay. The underlay approach executes severe limitations on the transmission power of secondary users so that they operate below the noise floor of primary users by spreading transmitted signals over Ultra Wide Band (UWB). Secondary Users (SUs) can potentially achieve short-range high rate with extremely low transmission power. Based on a worst-case assumption that primary users transmit all the time, this approach does not rely on detection and exploitation of spectrum white space. This model restrict on where and when spectrum can transmit [8], [9].

III. Dynamic Spectrum Access Technology

The major enabling technology of Dynamic Spectrum Access (DSA) is the cognitive radio (CR). This cognitive radio technology provides the aptitude to use or share the spectrum in a very dynamic or timeserving manner. The DSA involve independent observation of radio frequency spectrum by a secondary device that, then choose and frequently adapts the selected frequency band to avoid interference. This high-speed data network of the DSA type is covered by the IEEE 802.22 standard which utilizes TV white space as permitted by the FCC (Federal Communications Commission).

The first DSA technology permits the CR to function in the best available channel and allow the users to decide which portions of the spectrum are unused and detect the presence of licensed users as shown in fig. 2 when a user uses the licensed band the first process is called spectrum sensing.

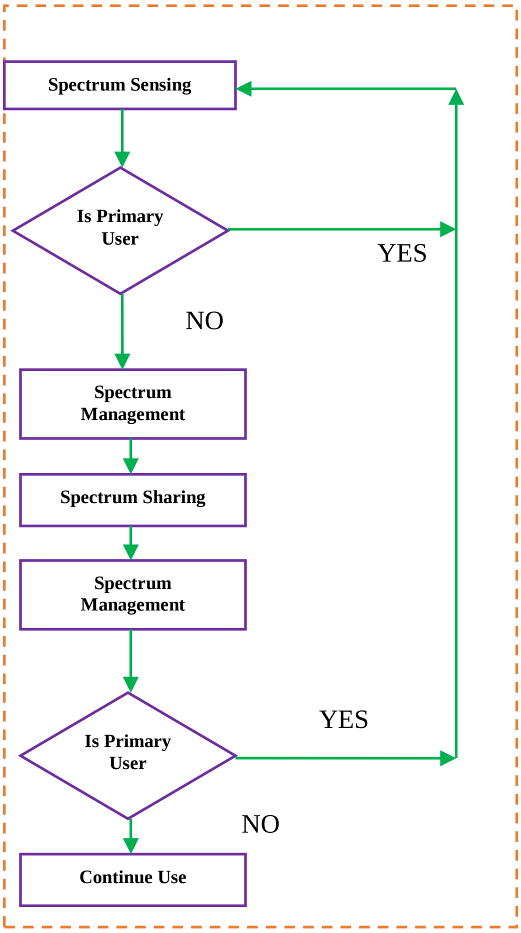

Figure 2: Process of Usage of Licensed Band

The basic hypothesis model for transmitter detection can be used, mathematically, the detected signal maybe represented by the following signal model [10] as in.

$$a\,(b) = z\,(b) + y\,(b) \qquad (1)$$

Where a (b) is the received signal and y (b) denotes addictive white Gaussian noise. When assuming that channel occupancy follows a binary model for being either occupied or unoccupied, then the following binary hypothesis may be formulated as in.

$$a\,(b) = \begin{cases} s(x) & T0 \\ z(b) + y(b) & T1 \end{cases} \qquad (2)$$

Where z (b) is the primary user's transmitted signal, y (b) is the Addictive White Gaussian Noise and channel's amplitude gain is h. T0 is a null hypothesis, T1 is an alternative hypothesis. Then secondly it selects the best available channel this process is called the spectrum management, then thirdly with others coordinate the access to this channel in the process called spectrum sharing lastly when the licensed user is sensed it vacate the channel this process is called spectrum mobility.

After the whole process the CR has a challenge to make adaptive the network protocols to the available spectrum.

IV. Cognitive Radio (CR)

CR is the very important technology that allows DSA to exploit the spectrum in a dynamic manner CR is enhanced by its use of spectrum resources, reduced engineering, planning time, adaptation to current operating conditions and looking at some of the features of CR includes: sensing the current radio frequency spectrum environment, policy and configuration database, self-configuration, security, distributed collaboration, adaptive algorithms and mission oriented configuration.

V. Cognitive Capacity

Cognitive capability enables the cognitive radio to sense the information from the radio environment in order to find out the unused radio frequency spectrum at a precise time or location. Then the proper portion will be selected for the communication without coursing harmful interference to the other users.

Cognitive cycle requires adaptive operation in open spectrum access. Three major parts of the cognitive cycle are:

- Spectrum Sensing: determine which portion of spectrum is available to detect the presence of licensed users and spectrum hole. The spectrum sensing techniques are:
  - ✓ Primary transmitter detection
  - ✓ Primary receiver detection
  - ✓ Interference temperature management
- Spectrum Analysis: performs estimation of spectrum hole through spectrum sensing.
- Spectrum decision: a CR determines the channel capacity, spectrum whole information along with data rate and bandwidth of the transmission. Appropriate spectrum band is chosen for transmission of the signal. Parameters to define the presentation of a particular spectrum bands are:
  - ✓ Interference – estimate permissible power of the CR.
  - ✓ Path loss - closely related to distance and frequency.
  - ✓ Wireless link errors – depending on the modulation scheme and the interference level.
  - ✓ Link layer delay – different types required at different bands.

VI. Reconfigurability

The cognitive capability provides spectrum awareness whereas Reconfigurability implies that the radio frequency spectrum is dynamically changeable according to the surroundings of the functions.

It can transmit and receive on a variety of frequencies, use different access technologies i.e. cognitive radio can change the radio frequency, transmit mission power, modulation scheme, and communication protocol without any modification of the hardware environment. Fig. 3 explains the components of a typical cognitive radio; cognitive radio has a goal of providing adaptability to wireless transmission through dynamic spectrum so that the wireless transmission performance can be optimized, as well as the improving the utilization of the frequency spectrum.

The main function of the CR system includes the spectrum sensing, spectrum management, and spectrum mobility. After the spectrum sensing, the targeted radio spectrum information must be obtained and used by the CR user, that information is exploited by the spectrum management function to investigate the spectrum opportunities and make decisions on spectrum access, When the position of the targeted spectrum changes, the spectrum mobility function controls the change of operational frequency band for the CR users.

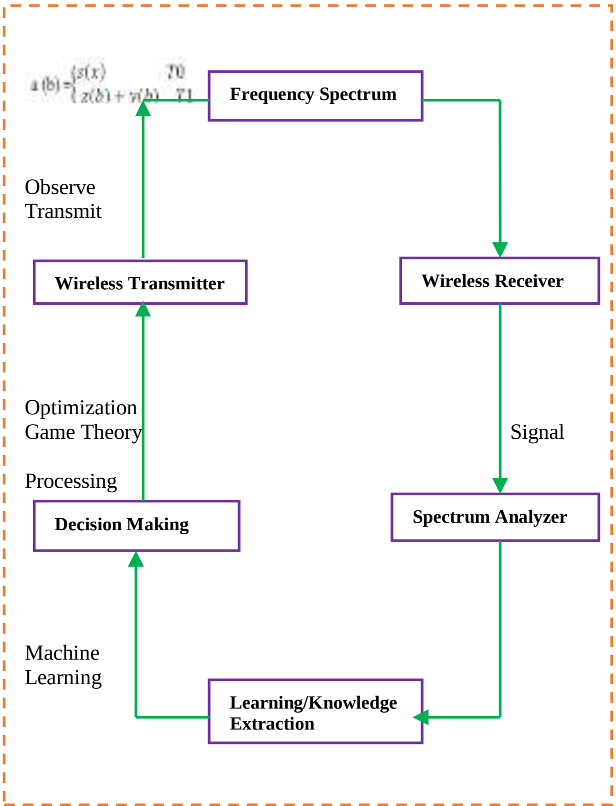

Figure 3: Components of Cognitive Radio Node

VII. Cognitive Radio Software

The wide software system of cognitive radio entails the essential function to perform its capabilities. A preliminary depiction of a possible software organization for a cognitive radio will be discussed below, the growth of cognitive radio technology is developing very fast and the function of this preliminary cognitive radio includes [16], [17], [19]:

A. The Radio Hardware

- It contains a radio frequency circuitry and signal processing device.
- To provide a description of its capabilities to enable self-configuration

B. Software Modules

- Field Programmable Gate Arrays (FPGAs), Digital Signal Processors (DSPs), or embedded general purpose processors has been loaded with software codes.
- Each software modules defines its own interface to other software components.
- A common language to describe the interface would be very useful.

C. Middleware

- It attempts to reduce the details of specific devices and software modules to common abstractions.
- Example:
  - ✓ Setting the transmitting frequency of the radio frequency circuitry
  - ✓ Setting the encryption key of a software module
- Creating a middleware system will require development of a common model for a wide range of hardware/software modules.

D. Logical Radio Layer

- The operation of logical radio layer depends on the hardware and software to act like multiple radios available links.
- Example,
  - ✓ The radio might support communications on several frequencies, time slots, or CDMA codes, each of which looks like an independent link.

E. Device Manager

- The radio constitution is being loaded by the device manager into hardware components and sets-up the logical radios [27].

F. Configuration Manager

- Configuration manager on the physical layer and manages application loading into hardware.
- It also interacts with modules libraries below to determine which radio modules are needed to meet user requirements.

G. Module Libraries

- The libraries modules are collections of radio functions
- Example:
  - ✓ Modulations (AM, FM, BPSK, QPSK, etc.)
  - ✓ Error control
  - ✓ Encryption
  - ✓ Adaptive algorithms

- The libraries modules are built with a variety of tools
- Example:
  - ✓ General purpose compilers, cross compilers, hardware design languages, and FPGA design tools.
- Coordinating the multiple sources that may go into building a specific module is a challenging task.

H. Rules Engine and Policies

- The operations of the radio is very limited due to regulatory, geographical, or physical constrains the policies are used.
- Policies should be usable independent of a particular radio.
- To interpret policies and to determine the allowed operation (device managers, logical radios, middleware, and hardware drivers) a "rules engine" is used.

I. Smart Controller

- It governed radio resources interface with in the wireless networks.
- It enhanced wide range of radio communication and wireless networking services.
- It provides reliability, and robustly manages all the components that compose up a cognitive radio.

VIII. TV Whitespace Networks

Geo-Location White Space Spectrum Databases (GLWSDBs) is an emerging technology. It will enable the sharing of spectrum and existing as an expert in co-occurrence planner and manager of White Space Devices (WSDs), fixed WSDs queries the GL-WSDB to access locally available TV channels in order to build dynamic spectrum wireless broadband networks and provide broadband Internet connectivity and associated services.

Successful operations of CR technology or white space devices (WSDs) for secondary operations depend on the successful detection of TVWS and the ability to avoid harmful interference to the incumbents. With a geo-location database approach, the PU may be registered in a database and the CR user will have to first determine its location and then interrogate the databases periodically in order to find the free and available channels [11].

Both database and spectrum sensing techniques will be used together in order to have flexibility and achieve maximum efficiency for secondary use of shared spectrum without incurring undue interference to the surrounding networks. The database combines information about spectrum in use with information about the geography of the region and performs a propagation model calculation to determine where current broadcasting networks coverage, reach and on which frequencies are in use [11], [12].

IX. Conclusion

Radio frequency spectrum is an important resource in wireless communication systems and it is an emerging technology. Cognitive radio is a promising technology which enables spectrum sensing for opportunistic spectrum usage by providing a means for the use of white spaces. Considering the challenges raised by cognitive radios, the use of spectrum sensing method appears as a crucial need to achieve satisfactory results in terms of efficient use of available spectrum and limited interference with the licensed primary users [11].

In this work, we have been discussed an overview of cognitive radio technologies and different modules of dynamic frequency spectrum, as the future development for efficient spectrum sharing in wireless networks, so called dynamic spectrum networks [5]. Some of the challenges in cognitive radio that are remaining to be solved are: computationally efficient and accurate spectrum sensing algorithms. Furthermore, efficient management of cognitive radio devices with possible interference between primary, secondary users and also interference between secondary users.

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