Sustainable development in communication networks with dynamic spectrum access techniques in CRNs

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***Abstract*—** The major issue in wireless networks is to discover appropriate spectrum bands to satisfy the request of future services. While the greater part of the radio spectrum is apportioned to various services, applications, users, perception demonstrates that use of the spectrum is quite low. To overcome this issue, enhance the spectrum use, cognitive radio idea has been developed. Remote or wireless communication, in which a sender and recipient can identify communication channels that are being used and those which are not being used are known as Cognitive Radio, and it can move to unused channels. This makes the utilization of accessible radio spectrum efficient while minimizing obstruction with different users. CRs must have the ability to learn and adjust their wireless transmission according to the radio environment. The use of Artificial Intelligence approaches in the Cognitive Radio is exceptionally encouraging since they have an incredible significance for the execution of Cognitive Radio systems engineering. Dynamic spectrum access is a excellent way to deal with spectrum shortage that wireless communication confronts now. The major aim of this approach is to reuse the unoccupied spectrum spaces in such a way that it should not cause interference with the other users in the spectrum. Dynamic spectrum access approaches are reviewed in this paper.

Keywords*—cognitive radio; dynamic spectrum access;radio spectrum; spectrum;*

I. INTRODUCTION

Studies have demonstrated that the majority of the licensed radio-wave spectral bands are under-utilized in time and space area [1, 3, 4], results in unused "white spaces" in the time-frequency network at a specific area. The most spectrum is used around specific parts of the frequency while a lot of the frequency is unutilized as portrayed in Figure 1. As it can be noticed, frequency usage is more serious and focused at frequencies beneath 3 GHz while the frequency is under-used in the 3-6 GHz groups [1]. The Federal Communications Commission (FCC) has likewise reported the temporal and geographic varieties in frequency usage to run from 15% to 85% [3].

On the other hand, fixed spectrum allocation agreements don't take into consideration reusing of the once in a while utilized frequency distributed to licensed users by unlicensed users. This issue combined with the quickly expanding interest for radio spectrum and wireless services has prompted to spectrum shortage for wireless applications. This has required another communication standard that permits unlicensed (secondary) users to use the unused bands which are assigned to licensed (primary) users. In any case, this strategic access should be in a way that does not discontinue any essential procedure in the band. Subsequently, the secondary users must know about the action of the primary users in the target band. They ought to detect the spectrum holes and the idle state of the primary users keeping in mind that the end goal is to exploit the free spectrum bands, furthermore instantly vacate the band when the primary user becomes active. Cognitive radio, incorporate this awareness by changing the parameters so that secondary users must not interfere with the primary users.

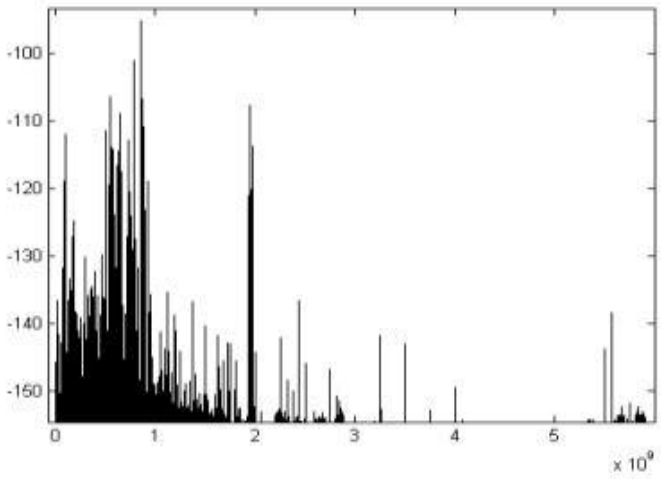

Fig 1: Measurements of Spectrum Utilization [1]

Cognitive radio is a promising technology for dynamic spectrum access. This technology has potential to utilize the unused spectrum band efficiently. When Cognitive users are allowed to use the spectrum holes then the overall performance of the spectrum system can be increased. Mainly there are two types of users involved in this process. Primary users, who have legal authorization to use the spectrum. Secondary users, also known as cognitive users, who attempt to sharply get to the unused licensed spectrum in such a way that it should not cause interference to primary users. There are some functions of cognitive radio that needs to perform efficiently to increase the performance.

Spectrum sensing: In spectrum sensing, one cognitive user sense the channel that is being used by primary users. CR user searches for the spectrum holes so that these holes can be used by them.

Spectrum decision: After searching spectrum holes, cognitive user determine which band can be used effectively so that it will not cause interference to the primary users.
Spectrum sharing: How the spectrum holes are shared among all the cognitive radio users.
Spectrum mobility: CR changes its frequency of operations to use the spectrum in dynamic manner to operate in the best available frequency band. [5]
Time delay is a parameter that is used to determine the spectrum utilization efficiency as well as accuracy of the cognitive radio network system. [6]

II. DYNAMIC SPECTRUM ACCESS

Dynamic spectrum access is used to find out the spectrum holes (white spaces) and it uses these holes to communicate. So that the unutilized spectrum can be utilize efficiently. Dynamic spectrum access is the one of the most important application of cognitive radios. The licensed user's bands are accessed by the unlicensed user networks in such a way that the interference caused by the unlicensed user to the licensed users is negligible. It is a dynamic technique by which various spectrum holes are chosen by radio system. The main task of Dynamic spectrum access is to overcome two types of interference: i) and harmful interference caused by malicious user ii) harmful interference caused by device malfunctioning [7]
There are three primary functions of Dynamic Spectrum Access [8]: i) cognitive handling, ii) spectrum access, and iii) spectrum awareness.
Cognitive handling is the basic leadership and decision making work that performs a few subtasks like learning of the radio environment, planning sensing effective, and access strategies which oversees interference for conjunction of the SU systems with the PU systems.
Spectrum access is the process in which spectrum holes are accessed by secondary users. These holes are used by CR users to increase the performance of the system.
Spectrum awareness makes awareness about the Radio Frequency environment when spectrum access gives the approaches to utilize the accessible spectrum moments for reuse effectively.

III. DIFFERENT APPROACHES OF DSA MODEL

Dynamic spectrum access techniques can be classified into main three parts as shown in figure 2: i) exclusive use model. ii) Open sharing model. iii) Hierarchal access model.

A. Dynamic Exclusive use model:

The fundamental structure of the present spectrum direction approach are kept up in this model: Spectrum bands are authorized to administrations for exclusive utilization. The fundamental idea is to enhance spectrum proficiency by presenting adaptability, flexibility. Two methodologies have been considered under this model [5]: i) dynamic spectrum allocation ii) Spectrum property rights.

Dynamic spectrum allocation: approach intends to enhance the proficiency of spectrum through dynamic spectrum assignment by utilizing the spatial and temporal measurements of various administrations i.e., spectrum is dispensed to services for selective use in a given area and at a given time.
Spectrum property rights: Economy and market will play an essential role in using the limited resources effectively to obtain profit. Spectrum property rights approach permits licensees to offer and exchange spectrum and to choose innovation openly.

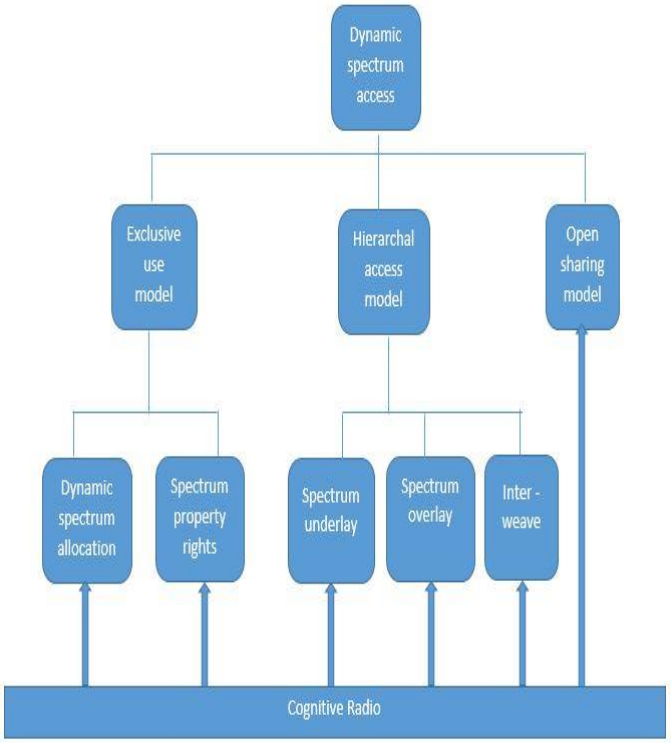

Fig 2: dynamic spectrum access techniques

For instance: Television supporters may incidentally rent parts of TV bands to portable mobile operators to give cell network coverage to important celebrations or occasions. While, the last distributes the spectrum in a more dynamic way as far as time and area as per the activity qualities of various operators. For example, the spectrum allocation can be performed all the more as often as possible, e.g., hourly, for remote applications with quickly changing traffic.[9]

B. Hierarchal access model:

Hierarchal access model works in a manner that users are divided among two categories: primary users and secondary users. Primary users are the users who have the authority to use the spectrum. Secondary users are the users who can use the spectrum left unused by the primary users in non-interference manner. Primary users are considered as 'hosts' and secondary users are treated as 'guests'. [9]Such that guests should not cause interference to the hosts. Only then this model will work efficiently. There are major three types of this model: i) spectrum overlay. ii) Spectrum underlay. iii) Inter-weave

Inter-weave: The inter-weave model depends on the possibility of on sharp re-utilize the spectrum in the spatial space i.e., the essential spectrum is used by cognitive radio networks in the geographical regions where essential action is missing. Exploitation of the supposed "spatial spectrum gaps (holes)" is obtaining an enthusiasm, since numerous current authorized frameworks like, TV broadcasting and cell frameworks.

Spectrum underlay: This approach works in a framework where PSD i.e. transmission power spectral density of secondary users is strictly controlled. The PSD of the secondary user is kept below than the noise of the primary users. A small interference caused by secondary users are treated as background noise by the primary users. So this interference is ignored. So the main idea of this approach lies with controlling the PSD. UWB i.e. ultra wide band can be considered as a good example of this approach. By spreading the secondary signal into many very low frequency bands, the PSD can be kept low.

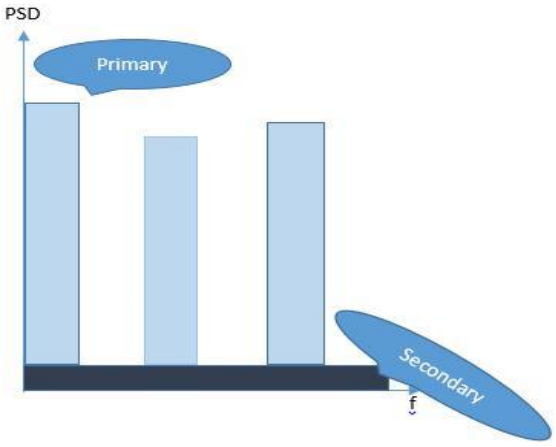

Fig 3: spectrum underlay approach

Spectrum overlay: This technique is also known as opportunistic spectrum access (OSA).In this approach, no constraints regarding power spectral density is applied on secondary users.

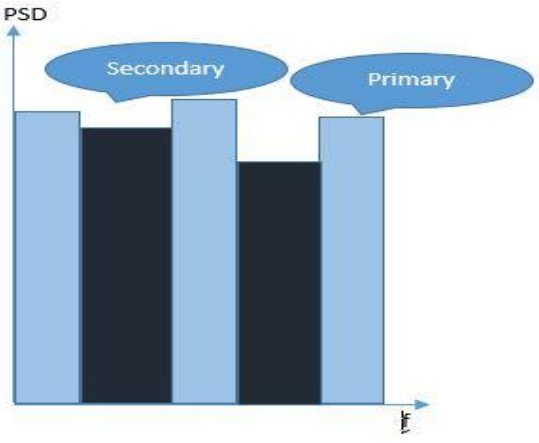

Fig 4: Spectrum overlay approach (OSA)

Furthermore it's the responsibility of secondary users to sense the spectrum carefully, so that it must not cause disturbance to the licensed users. [9]. This overlay technique allows higher power that can results in interference. This problem can be solved by allowing transmission only at unused areas at a specific time. This how spectrum overlay works. [10]

C. Open sharing model:

In open sharing model, each client has equal rights to utilize the spectrum. It has been effectively connected for remote services which works in the unlicensed industrial scientific and medical (ISM) radio band (e.g., WLAN). Spectrum commons model is another name of open sharing model. There are three sorts of spectrum commons model [7]: i) Managed-commons, ii) Private-commons and iii) Uncontrolled-commons. Open sharing among clients as the establishment for dealing with a phantom district utilized by this model [8].

Managed-commons: Managed-commons describes an efforts to keep away the deplorability of commons by forcing a constrained type of structure of spectrum access. This is an asset which is possessed or controlled by a group of people or entities and it is portrayed by confinements on when and how the asset is utilized.

Uncontrolled-commons: When a spectrum band is overseen and utilizes the uncontrolled common model, no entity has restrictive permit to the frequency band.

Private-commons: This idea developed on permitting utilization of emerging technologies which empower different users to access the spectrum. The idea of Private Commons was presented by FCC in its Second Report on the end of obstructions to improvement of Secondary markets for spectrum [11].

IV. CONCLUSION

Cognitive radio is an emerging technology for wireless communication where transmission or receiver parameters are changed by a system or a wireless hub to interact properly and avoid impedance with authorized or unlicensed users. Here in this paper, various dynamic access strategies are discussed. Dynamic spectrum access is utilized to discover the spectrum holes and it utilizes these gaps to interact the secondary users with the spectrum. So that the unutilized range can be used effectively. Dynamic spectrum access is a standout amongst the most critical use of cognitive radios.

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