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Simulation of Cognitive Radio System Using Matlab

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***Abstract*:** *In this paper, the simulation of cognitive radio system to must detect the presence of primary user to avoid interference. Spectrum sensing to detect the spectrum holes (unused bands of the spectrum) providing high spectral resolution capability. Allowing the secondary users to operate at the spectrum vacant bands which allocated the primary users. They should spot the spectrum holes and the idle state of the primary users in order to exploit the free bands and also promptly vacate the band as soon as the primary user becomes active. The simulation using MATLAB result it has been shown that how the cognitive radio works.*
***Keywords*:** *Cognitive Radio, spectrum sensing, Primary User, Secondary User, MATLAB.*

I. Introduction

Cognitive radio (CR) is wireless communication technologies where a transceiver can intelligently detect the channels for communication which allow unlicensed users to access the radio spectrum when it is not occupied by licensed users. Historically, the spectrum bands have been assigned to license holders for long term and over large geographic areas, which solve the spectrum scarcity problem by exploiting radio spectrum unused by licensed users. This optimizes the use of available radio-frequency (RF) spectrum while minimizing interference to other users. This is a paradigm for wireless communication where transmission or reception parameters of network or node are changed for communication avoid interference between users and enhance wireless communication network's efficiency with licensed or unlicensed users [1] .

A CR terminal interacts with its radio environment, senses and detects free spectrum bands and then uses them opportunistically. Accordingly, it has enough capabilities to effectively manage radio resources.

The dynamic spectrum access technique to solve problem and allows wireless nodes to use spectrum sensing to identify the 'white spaces or spectrum holes' in licensed spectrum. The cognitive radios will then opportunistically utilize these white spaces. To avoid any interference with the primary users, a secondary user must leave the occupied channels if it detects a primary user. An illustration of this concept is shown in Figure 1.

In cognitive radio networks, there are two types of users: licensed or primary users (PUs) have high priority or legacy right in using specific part of the spectrum, other band unlicensed or secondary users (SUs)which have lower priority, exploit this spectrum and allowed to use the spectrum in such a way to avoid interference to primary users .PUs can access the wireless network resources according to their license while SUs are equipped channel with cognitive radio capabilities to opportunistically access the spectrum. Cognitive radio capability allows SUs to temporarily access the PUs' under-utilized licensed channels. To improve spectrum usage efficiency, cognitive radio must combine with intelligent management methods [2] [3].

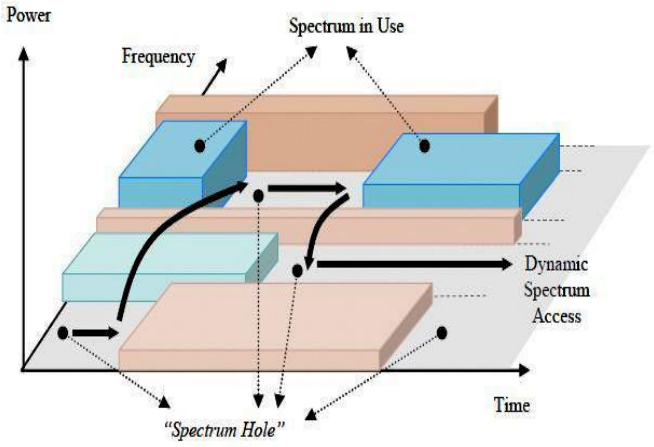

Fig1: Illustration of the Spectrum Hole concept [4].

II. Characteristics of CR

Cognitive radio has two main characteristics [5]

- **Cognitive capability:** Cognitive Capability defines the ability of the radio technology to capture or sense the information from its radio environment. It captures the temporal and spatial variations in environment the radio and avoids interference to primary user.
- **Reconfigurability:** Cognitive capability is provides spectrum awareness, Reconfigurabilityrefers to radio capability to change the functions and enables the cognitive radio to beprogrammed dynamically according to radio environment (frequency, transmission power, modulation scheme, communication protocol).

III. Functions of Cognitive Radio

CR has been divided into four main functions of cognitive radio. Fig 1 show the cycle of the cognitive radio as secondary radio system which involve spectrum Sensing, spectrum mobility, spectrum decision and spectrum sharing [6].

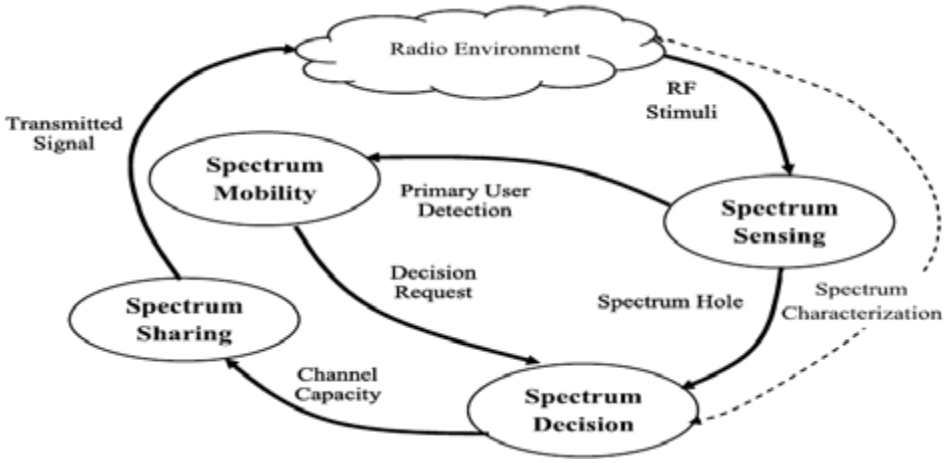

Fig 2: Cognitive radio cycle [7]

- **Spectrum sensing:** It refers to detecting unused spectrum and sharing the spectrum without harmful interference with other users.
- **Spectrum management:** It is Capturing the best available spectrum to meet user communication requirements.
- **Spectrum mobility:** It is defined as the Maintaining seamless communication requirements during the transition to better spectrum.
- **Spectrum sharing:** refers to providing the fair spectrum scheduling method among coexisting xG users.

IV. Spectrum Sensing

An important requirement of the CR is to sensing the spectrum holes. It is designed to be aware of and sensitive to the changes in its surrounding. The spectrum sensing function enables the cognitive radio to adapt to the environment by detecting the primary users that are receiving data within the communication range of an CR user [8].

the spectrum sensing are two-fold: one to ensure CR or secondary user does not cause interference to a PU and two, to assist CR or secondary user to identify and exploit the spectrum holes for the required quality of service (Popoola and van Olst 2011c).

The spectrum sensing is to decide between two hypotheses which are:

$x(t) = w(t)$, H0 (Primary User absent)

$x(t) = h\, n(t) + w(t)$, H1 (Primary User present)

Where x(t) is the signal received by the CR user, n(t) is the transmitted signal of the primary user , w(t) is the Additive White Gaussian Noise(AWGN) , h is the amplitude gain of the channel. H0 is a null hypothesis, which states that there is no licensed user signal.

V. Simulation process

The Simulation are following parameter

- **Initialization**: Initialize the 6 Carrier Frequency Bands for Users and also initialize Message Frequency and the Sampling Frequency.

- **Modulation**: Modulates user data over the respective frequency band using amplitude modulation
- **Adder**: Addition of all the modulated signals to create a carrier signal
- **Period gram**: For estimation of the power spectral density.
- **Allocation of unused slot**: When a new User arrives he is allotted to the first spectral hole.
- **Emptying a slot:** If all the slots are engaged ask user to empty a specific slot.

VI. Simulation Result & Discussion

The cognitive radio system using spectrum sensing cognitive radios find out the spectrum holes and secondary users are allowed to use that spectrum holes as long as it does not interfere the primary (licensed) users. In this system six primary users are assumed. The carrier frequencies used for 6 signals are 1, 2, 3, 4, 5, and 6 KHz, respectively. To illustrates the PSD of the transmitted signal suppose 1st, 3rd and 6th primary users are present and 2nd, 4th and 5th primary users are not present as shown in fig 3 (a). The Cognitive Radio system will search the first available Spectrum hole of slot and automatically assign it to the secondary user this is illustrated by Fig. 3. (b). again the spectrum will search the next available spectrum hole of slot and automatically assign it to the secondary user this is illustrated by Fig. 3. (c). finally we have one vacant area (spectrum hole) which will get filled by addition of another Secondary user as shown in Fig. 3. (d) And that all of the spectrum bands are efficiently in use after the last spectrum hole is occupied by secondary user3.

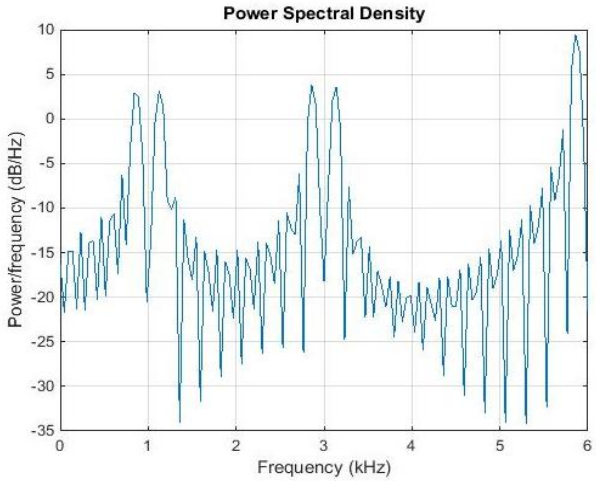

Fig 3. (a) Used bands and unused bands

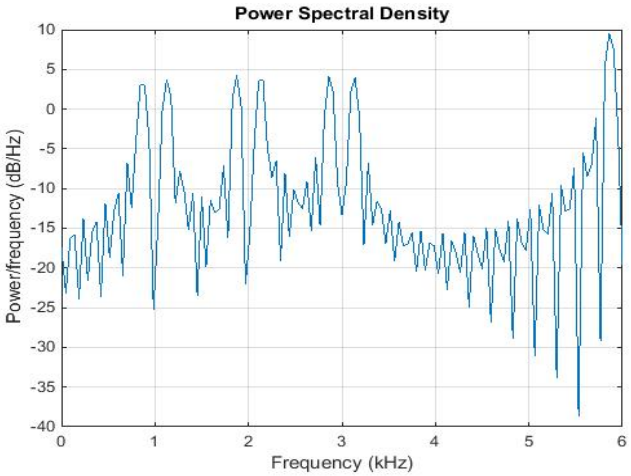

Fig 3. (b). 1st unused band assigned to the secondary user 1

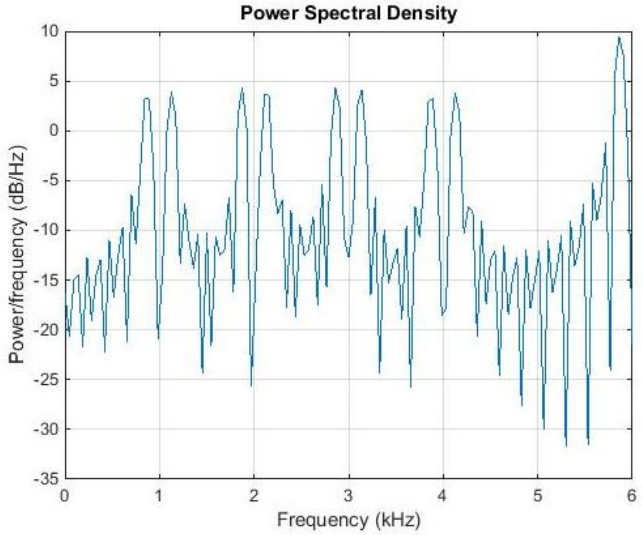

Fig 3.(c). 2nd unused band assigned to the secondary user 2

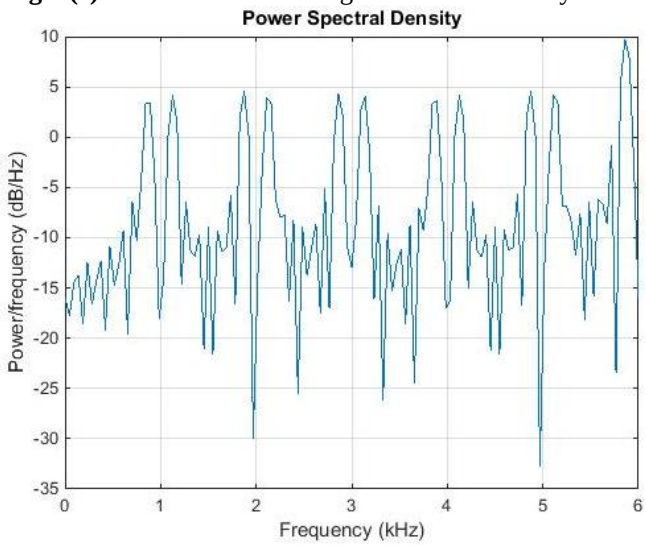

Fig . 3. (d) All of the Spectrum bands are in use

VII. Conclusion

CR technology using spectrum sensing cognitive radios find out the spectrum holes and secondary users are allowed to use that spectrum holes as long as it does not interfere the primary (licensed) users. Similar, the system assigns the 2nd, 4th and 5th slots the secondary user. This leads the spectrum utilization of about 85% of sampling value. The above mentioned process is simulated using MATLAB. Simulation result depicts that to spectrum holes are occupied by the secondary user. In turn all spectrum bands are utilized this is shown by fig 3 (d).

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