ARTICLE

COGNITIVE RADIO: NEXT FACE OF COMMUNICATION

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ABSTRACT

Cognitive Radio is the new technology in the field of communication. It is the demand of the modern era. Due to the high increase of the number of users, the call congestion or the call drops are big problem today. CR is developed as a permanent solution of these issues. Without increasing the resources, Worldwide, it is taken as a ideal and dynamic approach for improving the exploitation of a precious natural resource: the radio electromagnetic spectrum it is also enhancing the quality of services and efficiency. This technology is dedicated to use the available resources optimally and provides the solutions. This Spectrum deployment can be enhanced extensively by making it possible for a secondary user (who is not being serviced) to access the unoccupied/unused spectrum hole at any instant of time by the primary user at the right location and the time in question. This paper presents the brief introduction of the concept; types and working style of CR. A few enlightenments are also spread over the development the CR.

KEY WORDS
Unused Channel, White Space, Frequency Spectrum, Call Congestions, Call Drops

INTRODUCTION

Cognitive radio (CR) is a 5G machinery that comes beneath IEEE 802.22 WRAN or telecom Regional Area complex levels. Nowadays, it is undergoing through rapid development due to the ability of solving several issues, which influence and in terns degrade today's telecom network systems. The major aim for the introducing cognitive radio networks is to enhance the quality of communication. Though it is not a vital renowned technology, therefore it is necessary to make its knowledge generalized [1]. Again, due to it is a newly established techniques, there are various aspects which need to be optimized or discovered by the researchers worldwide in order to improve the services and make CR technology stable. Cognitive Radio is arranged and designed in order to use the best and available telecom channels in its proximity to ignore call drops and overcrowding. This radio spontaneously discover available, accessible and convenient channels in telecom spectrum then according to the requirement of the service it conveniently changes the necessary parameters for further synchronous telecom transmissions in a provided band of spectrums at any position. This procedure is a strong kind of spectrum authority.

CR WORKING

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According to the operator's orders the cognitive engine efficiently construct radio network structure limits based on some specific parameters such as waveform, protocol, operating frequency, networking etc. These parameters acted as an independent unit in the communication surrounding and provide the required information of the network, systems and other cognitive radios available. A cognitive radio supervises its own performance continuously based on the achieved output. Then CR utilize this data to discover or detect the RF surrounding, channel conditions, link performance, etc. in order to modify the settings to optimized the quality of services at its best level in terms of user necessity , operational limitations, and regulative restrictions.

A few smartest radio plans merge the telecom network systems forcefully and changes the path of the messages among the nodes with the help of cooperative diversity technique. The frequency band of the massages is continuously flipped by the cognitive radio and also the protocols of the transmission are dynamically changed by using software defined radio to prevent the hand-off/overcrowded situations.

In other words, it is observed that the CR must possess two major characteristics for proper working i.e., [2]

Cognitive capability:- This measures the degree of identification of the fully or partially unused spectrum at very precise time or exact position during real-time interaction with the radio environment. It also defined the spectrum selecting, sharing and exploiting ability of the CR [x]. Key factors on which the cognitive capability depends are:

a. Spectrum Identification
b. Spectrum Analysis
c. Spectrum Decision

Re-configurability: This defined the capability of CR for selecting the best spectrum band and proper working parameters and flexibility of reconfiguring of the selected one if necessary within at instance [x]. The major parameters, on which the reconfigurability follows are:

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a. Transmission Power
b. Operating Frequency
c. Communication Technology
d. Modulation Techniques

HISTORY OF CR

The idea of CR (cognitive radio) was initially introduced by Joseph Mitola III in a conference organized at KTH in the year 1998. It was a novel proposal in the field wireless communications, which was described by Mitola as:

"The point in which wireless personal digital assistance and the related networks are sufficiently, computationally intelligent about the radio resources and related computer to computer communication to detect user communications needs as a function of use contexts and to provide radio resources and wireless services most appropriate to those needs "

Cognitive radio should be developed as completely re-configurable telecom transivers, which need to be accommodated within the transmission framework of the system and can act according to the requirement of the service/user. Usually regulative parameters are made for analog model and there is no such rules developed for the CR. Again, these bodies from worldwide reported not proper/unsufficient usage of the frequency spectrum [1]. As an example the cellular network facing heavy load whereas another frequency bands dedicated to other applications are free most of the time. According to the various studies and researches, it is observed that the load of the frequency spectrum is highly dependent on the time and place, which in terns shows the insufficient consumption of the channels. The permanent allotment of the frequency spectrum to any application is prevents from the interference. But due to the limited frequency band and overcrowding situation it is necessary that the allocation must be dynamically. Now the regulatory bodies are forced to arrange a system, which can assign/allow the unlicensed users to use the licensed bands without creating any types of interference. This need leads to the path towards the cognitive radio technique. In order to establish the concept of cognitive radio, IEEE first set the standards in the year of 2011. This standard mainly focused on, to spread the awareness of CR concept through the spectrum sensing and geo-location. These parameters first combined with the database of the licensed transmitter and identify the accessible channels. Now, these standards are designed in such a way that it can use or reuse the available frequencies for a time slot in desired location according to the requirement of the service and without disturbing that licensed user. However CR is not capable to use the same frequency band for all the time.

HISTORY OF CR

There are two major types of cognitive radios:

Mitola radio (complete cognitive radio):- In this arrangement, the wireless node is advised to observe all the necessary parameters [3].

Spectrum sensing:- In this arrangement only the frequency spectrum is advised to observe.
Other CRs depends on the following parts of the spectrum for acquiring the channels as per the need:

- Licensed Band Cognitive Radio: It has the capability of accessing the licensed user bands. It works under WRAN and usages the unused television channel frequencies named white spaces.
- Un-licensed Band Cognitive Radio: it can only access the unlicensed radio frequency spectrum. The system under which it is working is defined by the IEEE 802.15 task group. It is mainly focus on the co-existence of two different specifications i.e. IEEE 802.11 and Bluetooth connectivity.
- Spectrum Mobility: It uses the mobility feature as its major advantage. The CR flipped its operational frequency consistently. Its major focus is to use the spectrum dynamically and operates at the best frequency in order to continue seamless communication during hand-off/shifting radio spectrum situations.
- Spectrum Sharing: It is mainly operating by sharing the licensed spectrum bands. The issue of interference is maintaining low or under a threshold value by limiting the transmitting power of CR [4].
- Sensing based Spectrum Sharing: In this scheme, at first the CR is assigned with the licensed spectrum in order to estimate the situation of the licensed users present at that frequency band. After estimating the condition, the CR selects its transmission plan. If the licensed bands are available, cognitive network uses the bands, however if it is not free the network shares these spectrum bands with the users and maintain their transmission power low in order to avoid the interference [5].
- Database enabled Spectrum Sharing: In this scheme, at first the demand is placed for accessing the white space database. On the basis of several algorithms few mathematical models are developed under the local regulatory bodies for the prediction of the utilization of the spectrum bands. After processing these criteria, the decision of allocation or denied is made. The risk

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assessments, crowding condition and geo area are also considered before taking the decision [6].

CONCEPT BEHIND TECHNOLOGY

Initially, the concept of CR is considered as the expansion of software defined radio. Several research works are on-going, where the main focus is to analyse the spectrum sensing feature of CR. The major obstacle in this is to design the high quality algorithm or protocols for sensing the data. The detection of the availability of signal can't be assured by a conventional energy analyzer. Therefore the need of more precise techniques for sensing the frequency spectrum and fetching information about the regular swapping of data among nodes are highly required. As the enhancement in cooperative sensing nodes, the chance of failure or false detection reduces. Hence, the concept behind the development of the CR is highly based on cognitive networks which can maintain or organize the grid of cognitive radios smartly. The [Table 1] below represents some of the major previous works done by the researchers from worldwide [7].

Table 1: Some Major Previous Work along with their Findings and Loopholes

Sl. No.	Author Name	Objective	Findings	Loopholes
1	S.A. Jafar et. al. [8]	To find out the overall potential of CR	The status of the spectrum is identified by the spectrum sensing. It also senses the activity of licensed users by sensing the target frequency band.	Not implemented yet
2	Shi Gaungqiang et. al. [9]	To share the cooperative spectrum between multiple PU's and SU's	It has confliction between the PU and SU for exchanging the resources in terms of relay power and time allocation	The design is not completely developed for PU's
3	Gautam Ghosh et. al. [10]	To implement the CR architecture, which is enabled with the artificial intelligence	For improving the communication efficiency, the opportunistic access of the available channels are allowed by the dynamic spectrum to users	Security issues
4	Ian F. Akyildiz et. al. [11]	To study on xG network for developing and enhancing the standards and resolving the issues of wireless network CR	CR is able to identified and accessed the best available channels using dynamic spectrum techniques	It faces the transport and cross layer challenges
5	M. Sisk Behaei et. al. [12]	To study about the usage of full duplex and half duplex in order to enhance the CR efficiency	Primary channels are sensed by the half duplex radio	Some channels are dedicated as full duplex in network
6	Bijal K. Jariwala et. al. [13]	To afford more wireless devices with additional frequency and band reliability	CR is highly reliable communication mode due to having capability of changing operative parameters according to the requirement of users, services and environment	Limited spectrum
7	Shewangi et. al. [14]	To study about the re-configurability of SDR	It is possible to make CR as re-configurable SDR due to its ability of detecting changes in environment and acting accordingly	Unwanted disturbance due to the CR devices are not detected by Primary users in CSMA (carrier sense multiple access) scheme
8	G. Manikandan et. al. [15]	To study about the spectrum sensing ability of cooperative and non-cooperative parameters in order to enhance the efficiency of CR	CR is highly reliable communication mode and one of the ideal approach for proper utilization of natural resources	False interpretation due to uncertain strength of received signals

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SPECTRUM SENSING

As The major motivation behind the cognitive radio is the efficient utilization of spectrum. To process in this direction, CR proceeds through following steps:

a. Sensing of available spectrum
b. Management of spectrum and hand off
c. Sharing and allocation of spectrum
d. Spectrum mobility

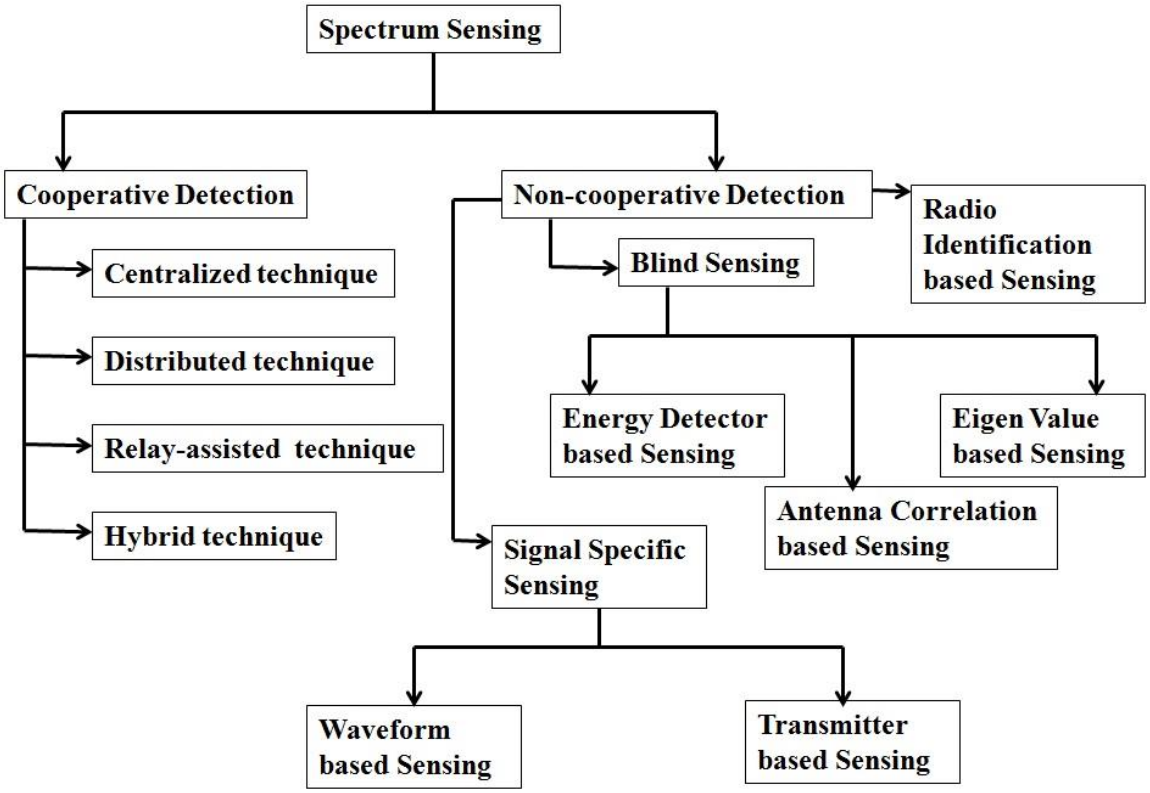

Fig. 1: Various Spectrum Sensing Techniques

As discussed, at first CR needs to sense the spectrum efficiently, which is the key function for the working of CR. There are mainly two different types of approach namely Cooperative Detection and Non-cooperative detection. The Spectrum Sensing techniques are represented in [Fig. 1].

Cooperative detection:- In this method, the secondary user collects and transmits all the information about the availability of unoccupied channels of the spectrum. This information is then transmitted to the central coordinator, which is responsible for the selecting the appropriate one according to the required parameters such as time, situation etc. and revert its decision to the secondary user [16]. The CR systems also share this information among one another in order to enhance the efficiency of the system [17].

There are mainly three different types of techniques used for the cooperative detection.

A. Centralized technique:- In this technique, there is a dedicated central processor, which controls entire network. This processor is responsible for the identification, collection and analyzes the spectrum in order to determine the available channels and share this information with other CR networks. To reduce the fading effect, the central processor can also control the cognitive radio traffic [18].
B. Distributed technique:- In this technique, nodes are capable to analyze the free channels and share this information with the other existing nodes. This technique reduces the cost due to less infrastructure requirement in terms of central processor but it needed large storage and computation ability for efficient processing [18].
C. Relay-assisted technique:- In this technique, channels are sensed and the information is transmitted to the target node through several intermediate hops. These working hops are relays. This structure is also known as multi-hop cooperative structure sensing [16].

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D. Hybrid technique:- In this technique, the decentralized scheme is used for sharing information. All the channels identification are done by users themselves and the acquired channels are immediately vacate when the primary user needs for it without sharing this information to other nodes. Using this technique saves the time, although a dedicated separate hardware unit is required for the efficient processing, which increase the cost factor [17].

Non-cooperative detection:- In this method, all the measurement, acquisition and analysis regarding the spectrum occupancy is done by the radios itself (individually). These local radios are act as an autonomous body and carry all the information about its spectrum.

Broadly three different approaches are dedicated to this detection technique.

A. Blind Sensing:- This technique is also based on a devoted node named as Fusion Center, which collects and analyzes the information getting from the sensing nodes present in the entire network in order to determine the frequency, which is used as a key parameter [16].
B. In blind sensing model, there are several schemes such as:
    - Energy Detector based sensing:- A simple method that is implemented using Fourier transform algorithms. In this technique, the information about the primary user is very limited. Again, here the threshold value is highly depends on signal to noise ratio (SNR) [19].
    - Eigen Value based sensing:- In this method, the threshold value is one of the quantized value of the ratio of maximum to minimum eigen value. This eigen values are determined using the covariance matrix of the received signal [20, 21].
    - Antenna Correlation based sensing:- In this method, the threshold value is chosen by exploiting antenna correlation based detector from time domain to space domain [22].
C. Signal Specific sensing:- This technique is based on the prior information about the primary user [16].
D. Various models are used under this sensing technique:
    - Waveform based Sensing:- This method is also known as coherent sensing technique, which is only applicable to a system when the signal pattern of the system is already identified [23-25].
    - Transmitter based Sensing:- This technique is based on the weakest signal, which is transmitted by the primary user. Again the method of energy based sensing and correlation based sensing is used to proceed further in order to make an efficient network [16].
E. Radio Identification based Sensing:- This model concentrate on the level of the interference at the receiver end. This measured interference is named as interference temperature [16].

CONCLUSION

CR is highly intelligent technology and an important breakthrough achieved by the human being in the field of communication. It seems to be a solution of call congestions and call drops without arranging any extra resources. This technology ensures that the resources are completely and optimally used for the services. The unused channels are allocated and work efficiently to fulfill the requirements and if the call comes from their dedicated users, with the help of CR techniques, the services shift to the other available resources and the previous channel again assigned back to their original defined duty. In this way the CR enhance the potential of the spectrum without increasing the natural resources and make a significant difference to wireless communications, hence, referred as “disruptive, but unobtrusive technology”. Both the licensed and unlicensed users can be benefitted with the CR. This technology is the remedy of the channel deficiency and next face of communication.

CONFLICT OF INTEREST
There is no conflict of interest.

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