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INTERFERENCE MANAGEMENT IN COGNITIVE NETWORKS

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Abstract: **Cognitive radios are being studied intensively these days. The major motivation for this is the heavily underutilized frequency spectrum. Cognitive radio is basically the technique to reuse the unused spectrum to increase the total system capacity by allowing a group of secondary users to share the radio spectrum originally allocated to the primary users. This sharing of the spectrum is termed as dynamic spectrum access. In the process of spectrum sharing cognitive radio locates the idle frequency bands to transmit the data. During the transmission of data cognitive radio repeatedly checks the reappearance of the primary users and immediately stops the transmission and moves to the other idle frequency band once the primary user is detected. The collision of cognitive radio's transmitted data with the primary user's data due to some missed detection is termed as the "Interference" and leads to degradation of quality of service of the primary user as well as cognitive radio user. This paper reviews the enabling technology of cognitive radio and the techniques employed for the mitigation of the interference.**

Keywords: *Cognitive radio, Interference management*

I INTRODUCTION

Over the past decade, the demand for the electromagnetic spectrum has exploded due to the extensive use of the spectrum for various services. This increasing demand is putting a heavy strain on the spectrum allocation and management policies for a flexible modification of the existing fixed spectrum allocation. The idea of fixed spectrum allocation originated in 1927, as a solution to the problem of interference faced by multiple radio emitters. So all radio services were allocated different frequencies for different users and some technical rules like power limits, modulation type in order to prevent interference [1]. Over time, due to change in technology as well as consumer demand, this fixed allocation of frequency bands started posing severe problems e.g. at that time a fixed frequency band of 6MHz was allocated to TV channels as per the need of technical requirement of TV broad casting. Moreover to avoid out of band interference guard channels were allocated between each channel. But today's technology of digital TV transmission is much more efficient in its spectrum use, so much less spectrum could carry the same information. As a result a large amount of spectrum remains underutilized. On the other due to increase in number of communication services even small portion of the frequency band are being sold at huge cost. The efficient way out to avoid this problem of spectrum underutilization and cost management is provided by the cognitive radios [2]. Cognitive radio technology has the capability to improve the spectrum utilization by using the spectrum "AS and WHEN required". The cognitive radios can sense their environment and as per the requirement reconfigure themselves to avoid interference with other radios [3-8]. Cognitive radios can find the spectrum bands not being used by primary users and can transmit in these frequency bands under the condition that the cognitive radios transmission will not create interference to the primary users. Thus the requirements of both primary users and secondary users can be satisfied by sharing the same frequency band, under the condition of interference avoidance.

The rest of paper is organized as follows. Section II highlights the building blocks of cognitive radio. Section III presents a broad description of dynamic spectrum access and Section IV describes the various sources of interference to the primary users and the interference mitigation techniques. Section V concludes the paper.

II BUILDING BLOCKS OF COGNITIVE RADIO

Cognitive radio works in a periodic manner where it acquires information from radio environment, analyzes this information, decided the next step and finally acts to achieve the predefined goal [3-8]. The sequence of tasks which are repeated periodically is called as a cognitive cycle as shown in figure 1,

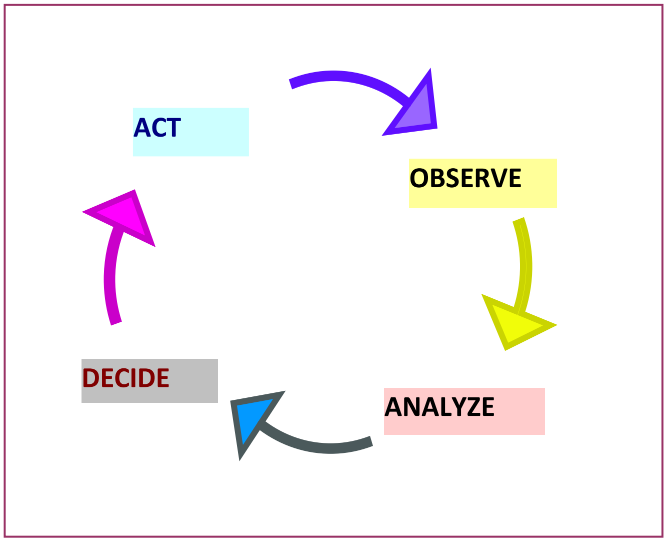

Figure 1 Cognitive Cycle.

A broad definition of cognitive radio can be stated as, "Cognitive radio is an intelligent, adaptive and goal oriented radio".

Cognitive radio is intelligent as it can observe the environment, analyze the information and decide what to do and how to do? These concepts of observing, analyzing and deciding are implemented in practical world using electronic components or software based computations.

- Observation using sensors.
- Analyze using predictive modelling.
- Decision using cognitive Processing.

Cognitive radio is adaptive and goal oriented because it takes the decision, keeping in view the goal to be achieved. To implement the decision the cognitive radio acts adaptively by adjusting its transmission parameters like transmission power, modulation type, bandwidth etc. This type of adaptive behaviour is made possible as a result of underlying SDR technology [2].

III DYNAMIC SPECTRUM ACCESS

Using cognitive radio dynamic spectrum access can be achieved in two ways as described below [9]:

- A license holder can agree to share his frequency band with a third party.
- Parties can negotiate for spectrum use on an ad-hoc or real time basis without any prior agreement between them.

Depending on these spectrum sharing scenarios different spectrum sharing models have been proposed as shown in figure 2 [9]. For a detailed description of these models the reader if referred to view [10-15].

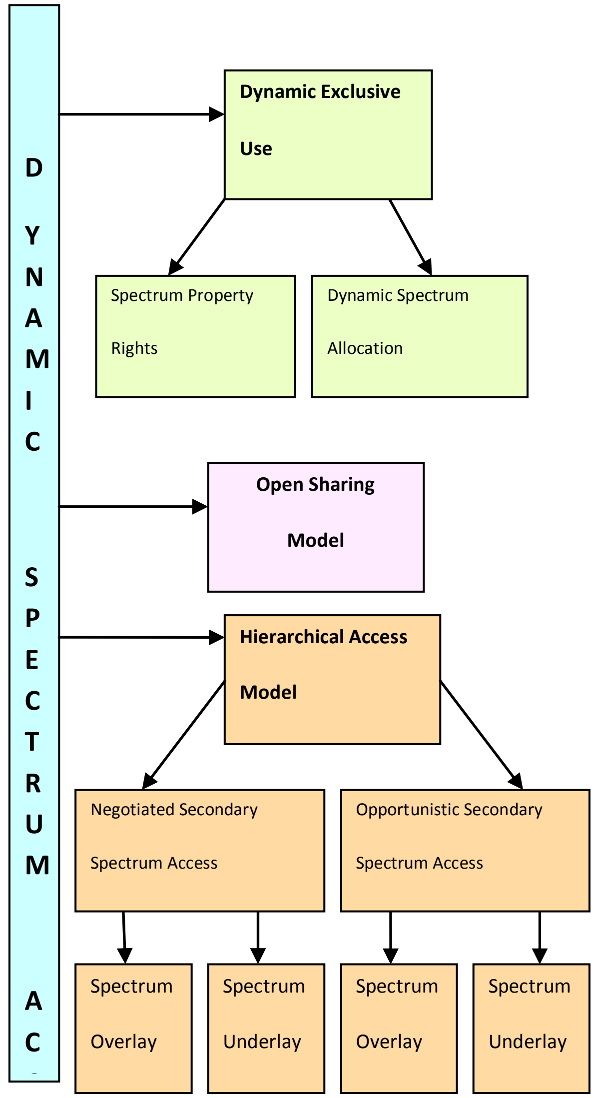

Figure 2 Dynamic Spectrum Access Models

IV INTERFERENCE IN COGNITIVE NETWORKS

Interference is an unavoidable feature of cognitive radio networks, as multiple transmissions often take place simultaneously over a common communication channel. Due to coexistence of primary and cognitive users, interference management is one of the important issues to be resolved. This necessitates research toward interference avoidance and mitigation which is a significant concern when many users are sharing the spectrum. This review mainly focuses on the inter-network interference which is the mutual interference between the primary and CR networks. Here the cognitive user transmission can interfere with the primary user transmission, resulting in degradation of quality of service of the Primary users.A cognitive radio can access the idle frequency bands of the licensed users under the dynamic spectrum sharing scheme. But the licensed users which own the spectrum rights are unaware of the presence of secondary users. Hence the burden of interference management relies mainly on the secondary system. There are three basic techniques that a cognitive radio employs to avoid the interference to primary users. These techniques are based on the interference temperature control, power control and use of directional antennas. A description of techniques is given in the text that follows.

A. Interference temperature control

The interference temperature control method is a receiver centric approach that uses the interference temperature limit as a measure of interference at the receiver. Interference temperature limit is a term to define maximum interference level that the primary system is able to tolerate. The secondary activity is to be kept within this limit [16]. The interference temperature model is a useful tool to characterize the interference from CR to primary networks. In the interference temperature model all the cognitive radios near the primary user should be considered and the total interference from all in terms of radio-frequency (RF) energy is to be calculated to set a maximum limit on their aggregate level. CR users are then permitted to use a frequency band till their transmission limit is under the interference temperature limits. Implementation of such ideal interference temperature model needs knowledge of interactions between CR transmitters and primary receivers at all times and is therefore considered as impractical [16]. Some more reliable models are put forward in [17, 18]. Model described in reference [17] is based on the interference caused by a single secondary user to the primary user by considering the factors such as CR signal modulation, antenna gains, and power control. In reference [18] the collective interference effect of multiple cognitive users is considered.

B. Power control

In wireless networks, transmission power decides network topography and evaluates network capacity. Long-distance direct transmission relies on use of high transmission power and is associated with low network capacity. On the other hand multi-hop relaying consumes less power and enhances the network capacity. [19, 20].

This tradeoff in CR systems is, however, much more complex. The transmission power of a cognitive radio not only determines its communication range but also affects the chances of spectrum opportunities. If a secondary user is to use a high power to reach its required receiver directly, it must wait for the opportunity that no primary receiver is active within its relatively large interference region, the chances of which are very fade. If, on the other hand, it uses low power, it must rely on multi-hop relaying, and each hop must wait for its own opportunities to emerge. Thus the spectrum opportunities are enhanced at low power transmission.

Thus optimal power allocation techniques to cognitive users are used to minimize the interference to primary users and maximize the spectrum opportunities. These allocation techniques are based on game theoretic models [21]. Reference [22] has proposed the price auction approach for optimal power allocation. Some other proposals in this regards are given in [23-25].

C. Use of directional and multi- antennas

In this case the cognitive radios can utilize the spatial sharing opportunity instead of frequency or time sharing. In this case a short-range secondary system coexists with a large range primary system that employs directional antennas. If the cognitive radio is located within the service area of the primary system, there are locations in the service area of the primary system where the cognitive radio can reuse the frequency of the primary system without disturbing it or being disturbed by the primary system. These locations are the spatial opportunity for communication in the secondary system [26-28].

Due to the different antenna heights, the path loss conditions are different, so the long range Primary transmission and the short range secondary transmission can simultaneously proceed without disturbing each other

V CONCLUSION

Cognitive radios are the intelligent radios that can be employed to handle the spectrum scarcity. Their working relies on data transmission through the idle frequency bands of the primary user. Cognitive users need to transmit data under the constraint of minimum interference to the primary users. The interference minimization techniques employ the interference temperature control, power control and use directional and multi- antennas to avoid the interference to the primary users. A lot of research is going on to improve these techniques further.

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BIOGRAPHY

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