Simultaneous Spectrum Sensing and Interference Mitigation in Cognitive Radio Networks

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Abstract- *A cognitive radio network is considered, where the parameters like detection probability, outage probability, and unexpected co-channel interference is calculated and the result is analysed. Interference is one of the most unavoidable factor that has to be considered, when we analyse a wireless communication network. Interference mitigation is the main aim considered here. A clearing signal is generated and transmitted by primary user(PU), in order to provide an information about its urgent requirement and thus interference can be mitigated in an acceptable limit.*

Keywords- Cognitive radio network, spectrum sensing, detection probability, outage probability, co-channel interference.

I. INTRODUCTION

Spectrum is the main source for every communication. As the need of communication increases day-by-day, an issue called spectrum scarcity is occurring in an intense manner. As a consequence, researchers developed a new technology/network called “Cognitive Radio Network(CRN)” as a meaningful solution for spectrum scarcity. In CRN, the researchers called the licensed users as primary user and unlicensed users as secondary user. Secondary user can access PU’s spectrum unless it is needed by PU.

In this communication process, spectrum sensing plays a key role. There are different methods for spectrum sensing. Quiet [1] and active [2] spectrum sensing methods are the most basic classification in this field. In quiet spectrum sensing, cognitive transmitter first senses the spectrum in a given time duration and then transmit data in the remaining time duration. Time lag is one of the main disadvantage of this method. Therefore, another method called active sensing scheme were introduced in which, simultaneous spectrum sensing and data transmission takes place. There are different techniques for spectrum sensing such as cyclostationary detection [3], matched filter detection [4], energy detection [5] etc. Among this most efficient and commonly used method is energy detection method.

In addition, to know more deeply about the importance of CRNs, a deep study on its applications has done. It is having applications in many of fields such as Satellite communication [6], Border Surveillance [7], Aeronautical communications [8], Tropospheric scatter communication [9] and so on. In wireless networks, secure communication has to be ensured at any cost.

Whatever is left of the paper is sorted out as takes after. In section II, the system model is described in which the block diagram is depicted. In section III, the analysis section is considered such as detection probability, outage probability and co-channel interference. Interference mitigation process is also described. In section IV, conclusion part is depicted

II. SYSTEM MODEL

A cognitive radio network, in which multiple PUs and SUs are considered. Theblock diagram of the framework demonstrate is appeared in fig. 1.

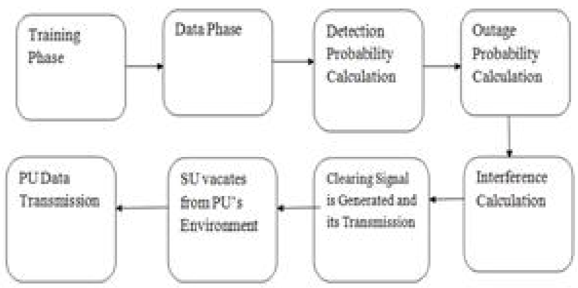

Fig. 1: Block diagram of the system model.

A: Training Phase

In the training phase, the process involved is channel estimation. To estimate the channel, initially orthogonal pilot sequences are generated. By the transmission of these pilot sequences, channel estimation can be effectively done. The received signal is communicated as demonstrated as follows .

$$Y=Hx+n \qquad (1)$$

Where, x is the transmitted pilot sequence, H is the channel parameter and n is the AWGN noise.

In channel estimation, both the channel aging effect and channel estimation error effects are considered. The expression for the received signal including these effects is shown below.

$$Y = Gs + Es + n \quad (2)$$

G_s is the channel aging effect and E_s is the channel estimation error effect

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B: Data Phase

In data phase, we consider signal detection and spectrum sensing technique. For effective signal detection MMSE can be performed. Energy detection method is used for spectrum sensing. Let the remaining signal be defined as r, then (2) becomes,

$$r = G_p S_p + E_p S_p + n \quad (3)$$

The energy value is taken as the modulus square of the remaining signal. In energy detection method, the energy value is compared with a threshold value (λ). Threshold value is taken as the inverse of probability of false alarm. The test hypothesis [10] is formed as,

$$T_{ED} \triangleq \sum_{l=0}^{L-1} \|r(l)\|^2 < \lambda,\ H_1$$
$$> \lambda, H_2 \quad (4)$$

H_1: No signal is present.

H_2 : Presence of any signal.

III. PERFORMANCE ANALYSIS

A: Detection Probability

Detection probability performance analysis is considered here. Detection probability v/s probability of false alarm is analysed. Detection probability is calculated using the equation (5) as shown below [11].

$$P_d(\lambda) = Q_{NL}\left(\sqrt{\frac{2L\sigma^2{}_p Y}{N_0}} \sqrt{\frac{\lambda}{N_0}}\right) \quad (5)$$

Where λ is the threshold value. Then, detection probability v/s SNR is also analysed.

B: Outage Probability

Now we consider the outage probability of the system. Outage probability is defined as the probability that the SINR of the n^{th} stream falls below a certain threshold value (γ_{th}) [10].

$$\gamma_{th} = 2^R - 1 \quad = \quad (6)$$

Outage probability is defined in equation (7)

$$P_{out} = 1 - P_f(\lambda) * SINR + (1 - p_d) \quad (7)$$

C: Unexpected Co-Channel Interference

All the simultaneous secondary users should not cause any surprising co-channel obstruction (interference) to any primary user. In CRNs, primary user is considered to be more important than secondary user. So when we create a CRN, we should consider the unexpected co-channel interference more deeply. For finding the co-channel interference of secondary nodes towards primary, the power of the secondary user is considered. Total interference is the sum of powers of all secondary nodes.

D: Interference Mitigation

Here we consider interference mitigation technique. From analysis done above it is clear that, unexpected interference to primary node is not zero (not much less). In order to reduce the interference to an acceptable level, we are making the channel free when primary is transmitting.Before starting transmission of any data, primary user can check the channel. And give warning to secondary, about its urgent requirement of channel. By receiving the clearing signal, all secondary users must vacate from that channel. After this process, primary can transmit in an efficient way by neglecting the interference.

IV. CONCLUSION

In this platform, we consider a cognitive radio communication network. A deep analysis has done to get a detailed knowledge about this communication scenario. The accuracy of detection technique determines the efficiency of communication. Analysis on detection probability, outage probability and unexpected co-channel interference has done. From the analysis it has been found that the unexpected co-channel interference towards the primary node remains low, but not much minimum. From the proposed method, interference value is reduced to an acceptable level. Primary node can transmit in a secure and efficient manner.

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