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Enhancing Detection Probability using Cognitive Radio for 5G

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ABSTRACT:
In this paper, we conduct enhancing detection probability using Cognitive radio technology and focus on the current significant research progress in the full spectrum sharing towards the four scenarios. Currently, the radio-frequency spectrum is assigned and categorized between licensed and unlicensed frequencies, due to rigid regulatory policy, some frequency bands are increasing in deficiency, while large portions of the whole radio-frequency spectrum remain unused independently of time and area .Cognitive Radio is a current network example that enables a more flexible and effective utilization of the radio spectrum. Mostly, it is intended to let on wireless devices to opportunistically access region of the whole radio spectrum without inducing any adverse interference to licensed users. Simulations are performed on MATLAB Software using a Cognitive radio program to detect the empty slots in the spectrum is used as a performance matrix to plot the detection probability of empty slots for each combination of users. From the results it can be seen that the detection probability decreases with the addition of each secondary user.

KEYWORDS: *Cognitive Radio (CR), Spectrum Sharing, Primary User (PU), Secondary User (SU), frequency bands.*

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I. INTRODUCTION:

The cognitive radio is an arising technology in wireless communication system. It is still too early to inform what a cognitive radio seems to be for the various wireless applications because of complexity in implementation of cognitive radio in practical. The frequency spectrum may be a limited characteristic asset that's divided into spectrum bands. Within the course of the foremost recent century, spectrum bands are apportioned to diverse services, for instance, mobile, fixed, broadcast, fixed satellite, and mobile satellite services. As all the spectrum bands are as of now dispensed to diverse services, most frequently requiring licenses for operation, an important issue confronting future wireless system is to get suitable carrier frequencies and bandwidths to require care of the anticipated demand for future services. With Cognitive Radio being utilized as a neighborhood of varied applications, the territory of spectrum sensing has become progressively vital. As Cognitive Radio technology is being utilized to supply a way for utilizing the spectrum all the more productively, spectrum sensing is vital to the present application. The ability of Cognitive Radio frameworks to urge to spare sections of the radio-frequency spectrum, and to continue observing the spectrum to ensure that the Cognitive Radio framework doesn't build any unnecessary interference depends completely on the spectrum sensing components of the framework. For the general framework to figure feasible and to supply the specified change in spectrum efficiency, the Cognitive radio-frequency spectrum sensing framework must have the capacity to adequately recognize another transmissions, distinguish what they're and inform the central preparing unit inside the Cognitive Radio in order that the specified actions are often taken. Spectrum sensing see the spectrum and analyze occupied channels. IEEE 802.22 was developed to make use of the unused frequencies or fragments of time in a region. This white space is unoccupied television channels in the geo located locations. However, cognitive radio cannot take up the equivalent unused area all the time. As spectrum opening changes, the network accommodates to prevent interference with licensed transmissions.

It is a sort of wireless communication where a transceiver can intelligently distinguish the channels for communication which are getting used and which aren't getting used, and enter unused channels while maintaining a strategic distance from occupied ones. This enhances the use of obtainable radio-frequency spectra while interference is minimized to other users. this is often a perfect model for wireless communication. Where transmission or reception components of system are commutated for communication avoid interference with licensed or unlicensed users. There are two types of Cognitive Radios:Full cognitive radio and Spectrum sensing cognitive radio. Full cognitive Radio (CR) deal with all parameters. A wireless node can be used for every available parameter. Whereas, spectrum sensing cognitive radio detects channels in the radio frequency spectrum. Essential necessity in cognitive radio network is spectrum sensing. To improve the detection probability various signal detection techniques are utilized in spectrum sensing. There are two main characteristics of the cognitive radio and can be defined as: Cognitive ability and Reconfigurability: Cognitive Capability characterizes the capacity to catch or sense the data from its radio surroundings of the radio technology. Joseph Mitola initially analysed the cognitive capability described the cognitive cycle "a cognitive radio constantly observes nature, orients itself, makes plans, decides, and then acts ."In reconfigurability the Cognitive capacity gives the spectrum information, it refers to radio capability to alter the functions, allows the cognitive radio to be arranged dynamically as per radio scenario (frequency, modulation scheme, transmission power and communication protocol).

Wireless networks and data traffic have increased exponentially over the last decade, which has developed in a growing demand for the radio spectrum resources. The radio spectrum is a restricted resource composed by regulations and the acknowledged authorities, such as the federal communications commission (FCC) in US. The present radio-frequency spectrum allocation policy exists allocating the channels to specific users with licenses for specific wireless technologies and services. Those licensed users have access thereto spectrum region to transmit/receive their information, while rest are prohibited even when those spectrum regions are unoccupied. Recent studies show that the spectrum gives ranges from 15% to 85% within the US under the fixed spectrum allocation (FSA) policy. Allocated spectrum portions aren't used all the time by their owners, called primary users (PUs), which creates spectrum holes. A spectrum hole, also called white space, is a waveband assigned to a PU, but it's not getting used at a specific time and at a specific location. Therefore, the radio-frequency spectrum is inefficiently exploited. Thus, the scarcity and inefficiency of the spectrum management require an urgent intervention to reinforce the radio-frequency spectrum access and achieve high network performance. a far better way to overcome the spectrum scarcity issue is dynamically managing it by sharing unoccupied channels with unlicensed users, called secondary users (SUs), without interfering with the PUs signals. The opportunistic spectrum access (OSA), also called dynamic spectrum access (DSA), has been proposed to deal with the spectrum allocation problems. In comparison to the FSA, DSA acknowledge the spectrum to be shared between licensed and non-licensed users, during which the spectrum is split into various bandwidths allocated to at least one or more dedicated clients. In order to advance the utilization of the OSA, several solutions are proposed, including cognitive radio. A cognitive radio system can identify from its environment, accommodate to the environmental environment, and make judgment so as to effectively use the radio-frequency spectrum. It allows SUs to use the PU assigned radio-frequency spectrum when it's temporally not being utilized.

II. SPECTRUM MANAGEMENT AND COGNITIVE RADIO METHODOLOGY

The cognitive radio system analyses all level of flexibility (time, space and frequency) to call spectrum management. There are some agenda available for spectrum sensing. Spectrum sensing assess if a given frequency band is employed. There are various proposed schemes to identify the availability of signal transmission and can be used to enhance the detection probability. If the PU signal is absent, SU can approach to the PU channel. Otherwise, it cannot access to that channel at that time. Figure 1 presents the general model of the spectrum sensing.

Various sensing techniques have been proposed in the literature. These techniques are classified into two main categories: cooperative sensing and non-cooperative sensing. Our main focus is on Cooperative Sensing.In order to sense the wideband radio-frequency spectrum, communication systems must use multiple RF frontends simultaneously, which may end in long time interval, high hardware cost, and computational complexity. to deal with these problems, fast and efficient spectrum sensing techniques are needed. Compressive sensing is recommended as a low-expenses solution for dynamic wide band spectrum sensing in cognitive radio networks to increase up the adding to minimize the hardware cost. Over the last decade, variety of compressive sensing techniques are proposed to enable scanning the wideband radio-frequency spectrum at or below the Nyquist rate. These techniques experience from uncertainty due to random measurements, which reduce their performances to fortify the compressive sensing,

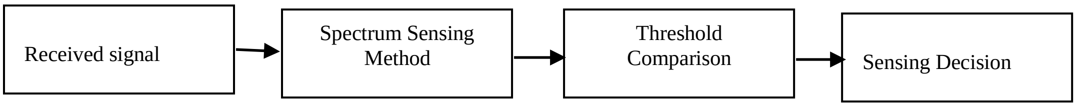

Fig 1: General model of spectrum sensing

efficiency decreases the degree of unpredictability and holding uncertainty, signal sampling requires a fast, structured, and strong sampling matrix and signal recovery need an accurate and quick reconstruction algorithm. Hence, efficient spectrum sensing and compressive sensing techniques are highly required so as to increase the wideband spectrum scanning, affect uncertainty, and perform accurate and reliable sensing occupancy measurements. Under the cooperative spectrum sensing category, the SUs collaborates and coordinate with one another taking under consideration the objectives of every user to form the ultimate common decision. This cooperation between the various SUs are often divided into two schemes: centralized and distributed schemes. For the distributed scheme, SUs exchanges their local observations and sensing results. Each SU takes its own decision taking under consideration the received results from the opposite SUs sensing an equivalent waveband.
This approach doesn't require any common infrastructure for the ultimate decision and therefore the detection is controlled by the SUs. For the centralized scheme, all the SUs sends their sensing results to a central unit, called fusion center, as illustrated in Figure 2.

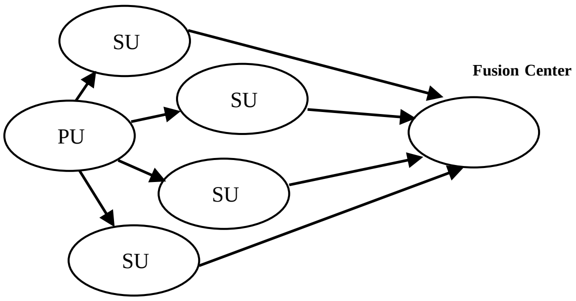

Fig 2: Centralized Cooperative spectrum sensing

The fusion centre decides about the spectrum access based on the received observations. The choice is often soft or hard combining decision with AND/OR rules. Under both spectrum sensing categories, SUs can perform the sensing employing a spectrum sensing technique.

III. ENERGY DETECTION TECHNIQUES

Energy Detection is a simple detection method used to build a blind signal detector in light of the very fact that it overlooks the structure of the very fact that it overlooks the structure of the signal. Energy detection is predicated on the rule that, at the receiving end, the energy of the signal to be detected is computed. It estimates the presence of a sign by comparing the energy received and a known threshold γ derived from the statistics of the noise. The aim of the spectrum sensing is to make a decision between two hypotheses which are

$$y(n) = \begin{cases} w(n) & H_0 \ : PU \quad \text{Absent} \\ h * s(n) + w(n), & H_1 \ : PU \quad \text{Present} \end{cases} \qquad (1)$$

where $n = 1 \ldots . N$, N is the number of samples, $y(n)$ is the SU received signal, $s(n)$ is the PU signal, $w(n)$ is the additive white Gaussian noise (AWGN) with zero mean and variance δ_w^2 and h is the complex channel gain of the sensing channel. H_0 and H_1 denote respectively the absence and the presence of the PU signal. The PU signal detection is performed using one of the spectrum sensing techniques to decide between the two hypotheses H_0 and H_1. The detector output, also called the test statistic, is then compared to a threshold in order to make the sensing decision about the PU signal presence. The sensing decision is performed as

$$\begin{cases} if\ T \geq \gamma, & H_1 \\ if\ T < \gamma, & H_0 \end{cases} \qquad (2)$$

and γ denotes the sensing threshold. If the PU signal is absent, SU can access to the PU channel. Otherwise, it cannot access to that channel at that time.

IV. RESULTS AND DISCUSSIONS

In figure 3 only one primary user is present and all slots are empty.most of the spectrum left and unsued. In this case the channel capacity will be minimum and dedection probability of empty slot ishighest as shown in figure 4. Now secondary user makes entry is the spectrum and occupies the second empty slot as shown in figure 5. The spectrum gets somehow occupied thus improving the channel capacity and deduction probability of empty slots gets decreased as shown in figure 6. In the third iteration secondary user again senses the spectrum and finds three empty slots thus occupies the third slot as shown in figure 7. The detection probability of empty slots also decreases as shown in figure 8.

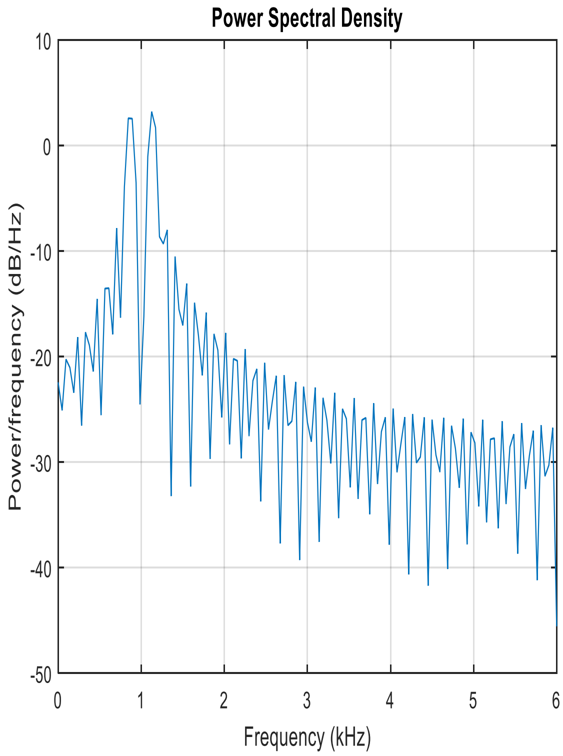

Fig 3: Only one primary user is present

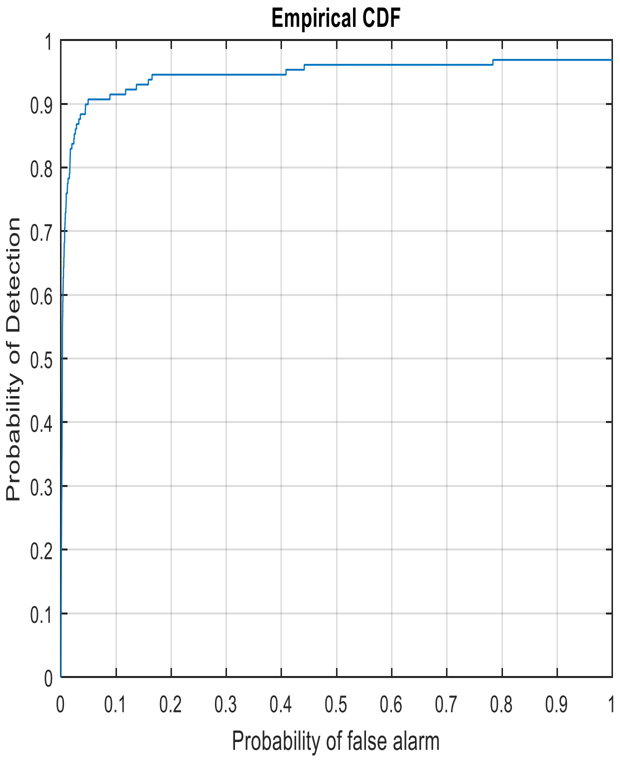

Fig 4: Probability detection of empty slots when only one PU is present

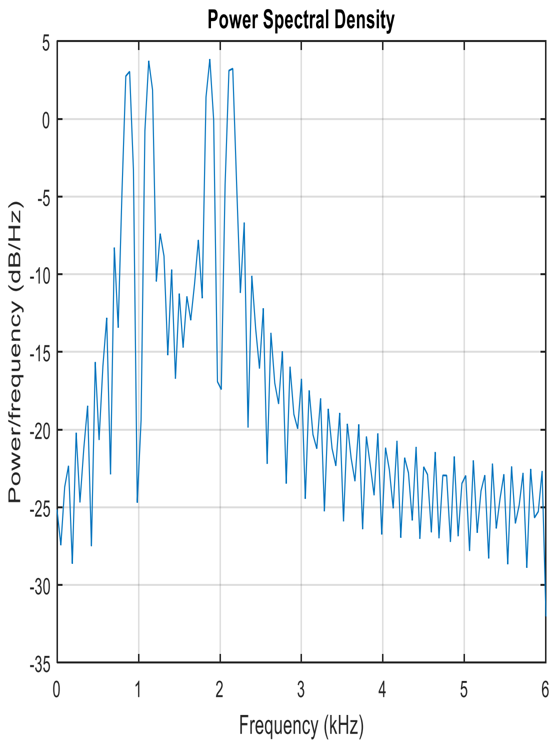

Fig 5:One PU and one SU are present

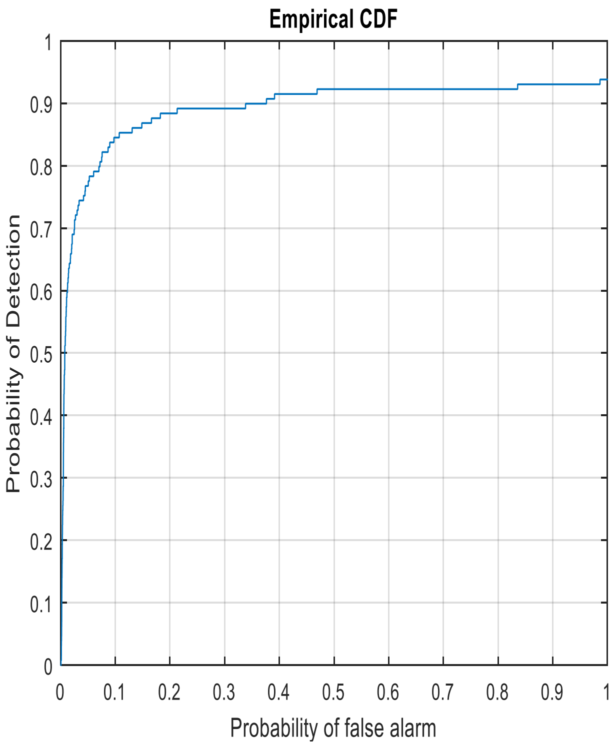

Fig 6:Probability detection of empty slots when two slots are occupied

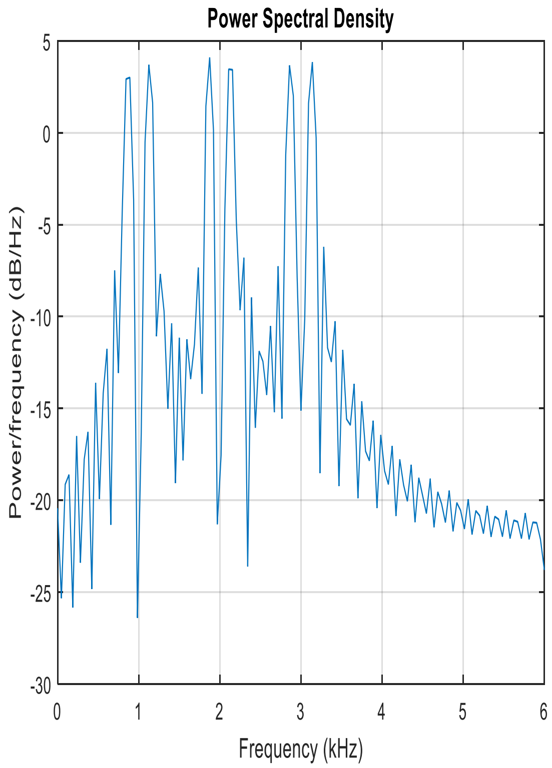

Fig 7: When one PU and two SUs are present

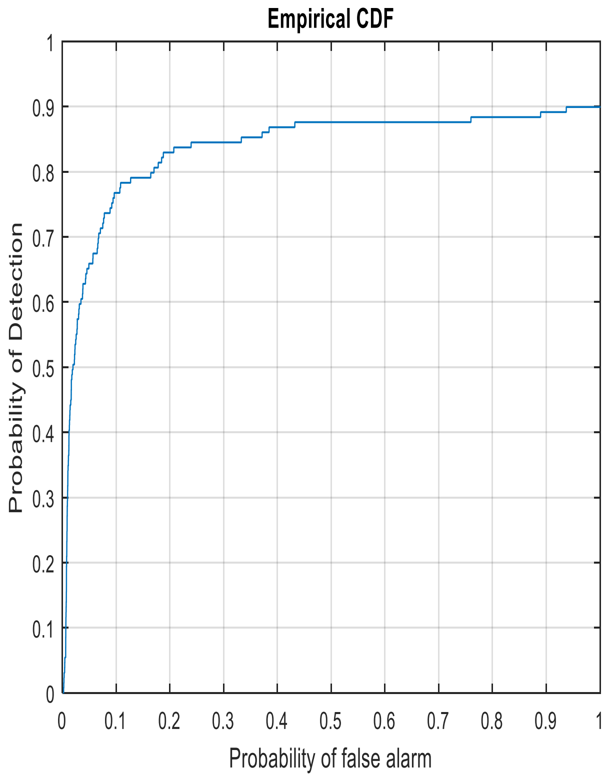

Fig 8: Probability detection of empty slots when three slots are occupied

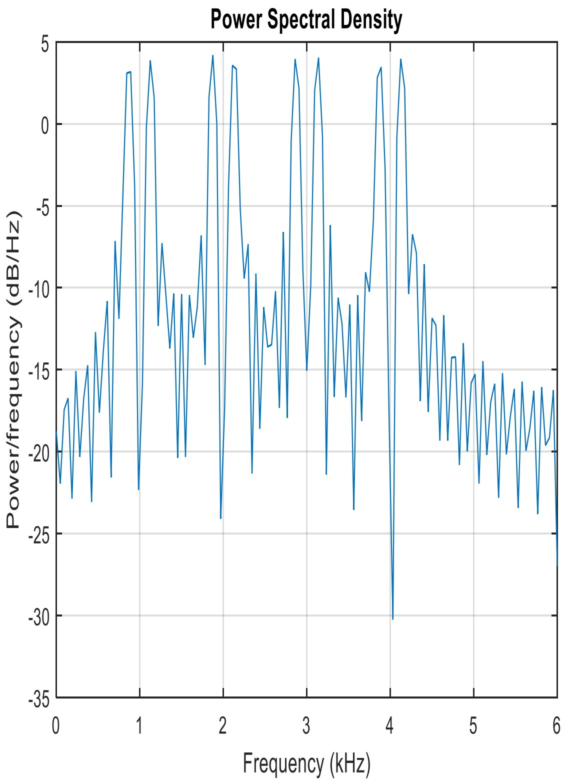

Fig 9: When one PU and three SUs are present

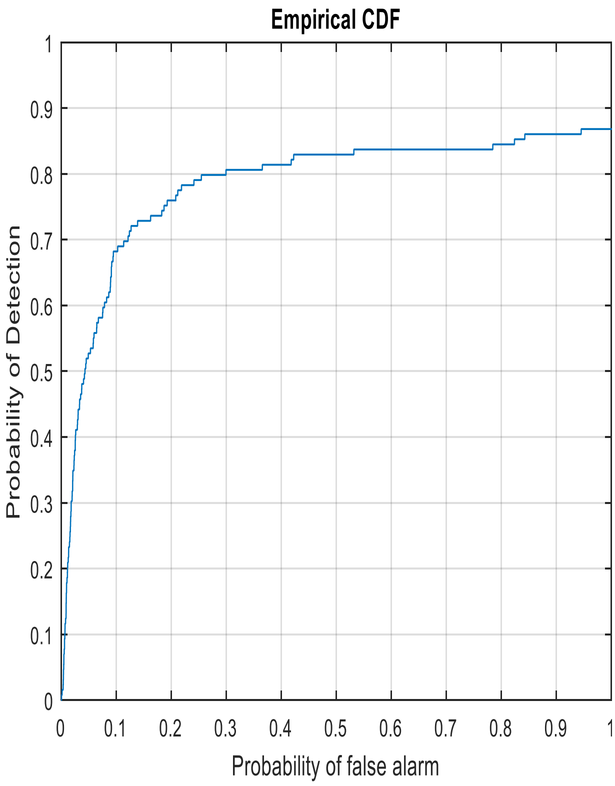

Fig 10:Probability detection of empty slots when four slots are occupied

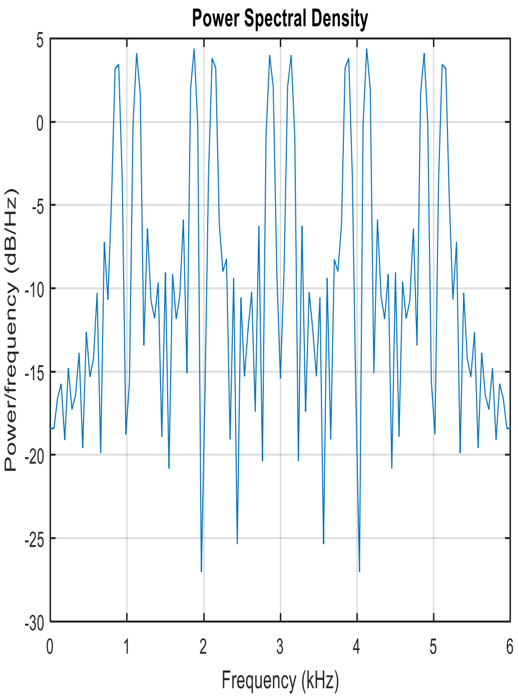

Figure 11: All slots are occupying in spectrum

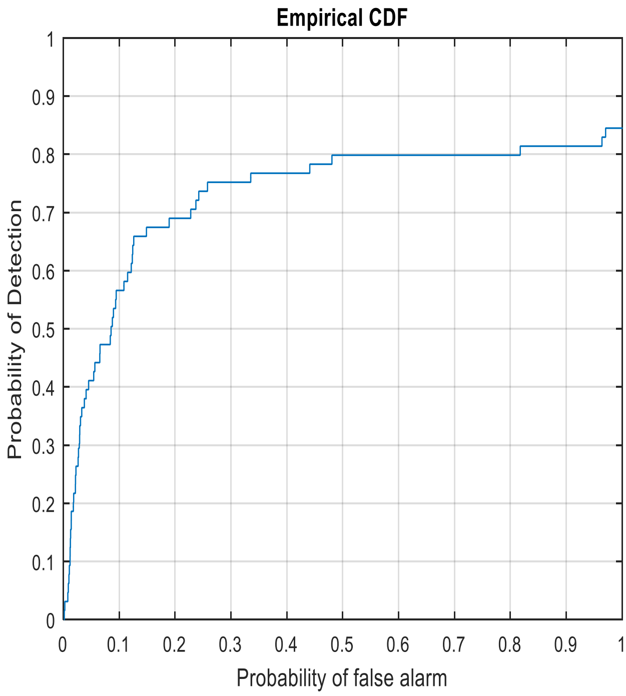

Fig 12: Probability detection of empty slots when all slots are occupie

Table 1: Probability of detection versus probability of false alarm

Sr. No.	Cases	Probability of false alarm (PF)	Probability of detection (PD)
1)	One slot is occupied	0.1	0.91
2)	Two slots are occupied	0.1	0.85
3)	Three slots are occupied	0.1	0.78
4)	Four slots are occupied	0.1	0.69
5)	Five slots are occupied	0.1	0.59

Two slots are still unoccupied which makes secondary user to futher sense the spectrum in the fourth iteration.Secondary user occupies the fourth slot in the next iteration as shown in figure 9.Again,the detection probabilty of empty slots further decreasesa as shown in figure 10. The spectrum is now left with only one empty slot which is filled by the secondary in fifth iteration as shown in figure 11. This case will now have maximum channel capacity and least detection probability of empty slots as shown in figure 12. Secondary user further senses the spectrum but finds all slots occupied and then leaves the spectrum without interfering any user. Table 1 shows Probability of detection versus probability of false alarm.

V. CONCLUSION

In this paper, cooperative spectrum sensing is performed using cognitive radio program developed on MATLAB software, five iterations are used for different combination of primary and secondary users. The channel is going from worst case to the best case that is only when only one slot is occupied till all slots get filled. For the worst case the detection probability of empty slots is maximum and for best case detection probability is minimum. Graphical results validate our analytical analysis.

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