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# Spectrum Sensing Optimization using Fuzzy Interface system in Cognitive networks

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**Abstract:** Spectrum sensing is one of the challenge in the hidden terminal which comes across in cognitive radio is .so has to overcome this we are proposing a optimal selection process for secondary nodes using fuzzy interface system. Using fuzzy logic rule the selection of secondary node play an important role in the enhancement of output of the cognitive radio spectrum sensing. if the node is not optimal the error rate will increase and packet transform may delay which may damage he data packet in forwarding process. So we implement energy detection system for taking decision by using the probability alarm by using fuzzy interface system we can reduce the spectrum sensing loss in forwarding the packets.

**Keywords:** Cognitive Radio, Fuzzy Inter face system Fuzzy Rules, SNR, Spectrum Sensing, error rate.

## 1. INTRODUCTION

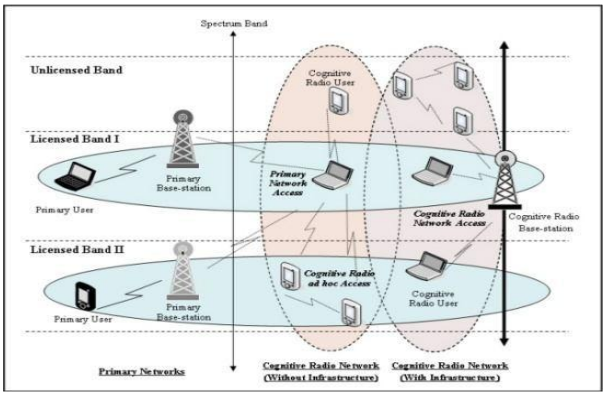
With Cognitive Radio being used in a number of applications, spectrum sensing is one of the important factors since the effectively and efficient using of spectrum is a key factor in cognitive radio. The main aim of cognitive radio system to access the section of radio spectrum to check the spectrum and to make sure that the cognitive radio does not cause any interface relies totally on spectrum sensing elements of the system. We need to make sure the overall system operates and provide the required improvement in spectrum sensing and has to detect the any other transmission and identify what are the important parts that central unit with the cognitive radio so that steps can be taken to perform the action. In many areas cognitive radio systems coexist with other radio systems, which use the same spectrum without interfering the same spectrum. While sensing the spectrum the cognitive radio has to take much consideration. Energy costs are increasing expenditure of a wireless network is a significant fraction (10 to 25 % [1]) of total operator services. Hence, energy consumption system should be cost effectiveness. Wireless technologies have major growth since last decade and more and more spectrum sensing is needed for emerging wireless services.

### Types of spectrum sensing

- **Continuous spectrum sensing**
- **Monitor for alternative empty spectrum**
- **Monitor type of transmission**

### Sensing Methodologies:-

- Spectrum sensing bandwidth
- Transmission type sensing
- Spectrum sensing accuracy
- Spectrum sensing timing windows




Most of the frequency bands are allocated to specific type of services within the current spectrum r framework and no unlicensed users is allowed. Spectrum scarcity is the issue that is the major problem in wireless system designers in telecommunications. In the Federal Communications Commission (FCC) survey, the licensed band is under-utilized in vast geographic dimensions [11] is stated. Cognitive radio (CR) technology has made to solve between spectrum scarcity and utilization. . A cognitive radio is an intelligent device that knows about the radio frequency environment. Spectrum sensing is the important component in cognitive radio technology. By sensing the environment, a cognitive radio fills the spectrum holes and provide to the desired users with causing interference problem to the licensed user. Executing spectrum sensing is the hidden terminal problem, which occurs when the cognitive radio is path in severe multipath fading or inside buildings with high saturation loss, while a primary user (PU) is operating in the environs [3] is one of the greatest challenges. Due to the hidden inscrutable problem, a cognitive radio may not notice the existence of the PU (Primary user) and then will come across to get connected to the licensed channel and source in the licensed system. Spectrum sensing performance can be enhanced by increasing the number of cooperative users [12]–[16]. Reduction of energy consumption and energy operation are the areas of interest of the operators Cognitive Radio Sensor Networks (CRSN) [2] has attracted attention in the recent time. CRSN is required to perform the operations on specific application data with limited energy consumption And CRSN nodes has to check the problem of interference to Primary User (PU) systems with spectrum sensing capability. As a smart combination of Cognitive Radio Networks (CRNs) and WSNs, however, the CR technique can reduce the energy consumption by checking and finding spectrum that is less error. This would enable communication with less contention for the medium, another major factor of energy consumption in wireless devices. Cognitive radio is the emerging technology in the field of wireless communication. In Cognitive radio we can change its parameters according to available environment. By ensuring to provide high bandwidth to mobile users via heterogeneous wireless architectures and dynamic spectrum access techniques. The main goal to provide maximum efficiency by using dynamic and efficient spectrum management techniques [8]. Fig. 1 show a cognitive radio network carrying two types of bands one is licensed and another is unlicensed. Listed are Spectrum Sensing, Spectrum Management.

## 2. RELATED WORK

Related research on various spectrum sensing technique are taken into the considerations for CRs. Spectrum sensing is one of the most important function of cognitive radio networks to overcome with the problem which may be harmful in interference with licensed users to identify the available spectrum to improve the maximum utilization. Ian F. Akyildiz [1] has revived the detection performance in practice with multipath fading, shadowing and receiver performance issues. To overcome across with these issues, cooperative spectrum sensing has been used for effective results. While using gain of the improved detection performance and sensitivity by which we can obtain cooperative sensing and can reduce the cooperation overhead.

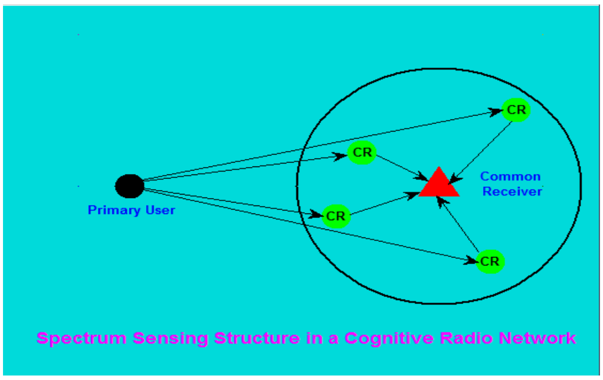



Figure 1Cooperetive Spectrum Sensing in Cognitive radio Network

The overhead which refers about the extra sensing time, delay, energy, and operations in cooperative sensing and their performance degrading. Jun Ma [2] has been taken into the consideration about "the state of-the- art survey of cooperative sensing to address the issues of cooperation methods gains and overheads. Robert W. [3] proposed a technique about the considering cooperative

Spectrum sensing based on energy detection in cognitive radio networks. In this work the combination of the energy consumption with the corporate users. Based on the Nyman-Pearson criterion, this obtained an optimal soft combination scheme that maximizes the detection probability for false alarm probability .and also it has been proposed a way to improve the sensing capability,. Dong-Chan Oh [4] has proposed a technique to optimize with energy detection with threshold value to improve the spectrum sensing performance. by keeping the threshold level to minimum spectrum sensing error his handles both reduction in collision probability with primary user and enhances usage level of free available spectrum, which improves in measuring the total spectrum efficiency. VahidJamali [5] has undergone investigation about a technique in which a secondary user referees about the existing of primary users of primary user in cooperative environment. Ajay Singh[6] proposed the scheme that by using multiple antennas at the CRs, it is possible to significantly improve reliability of spectrum sensing with extremely low interference levels to the PU at very low (much less than 0 dB) signal-to-noise ratio of the PU-CR link.

## 3. SYSTEM MODEL AND PROBLEM FORMULATION

Conserving about medium to large scale cognitive radio network. We take in account a CR network composed of k CRs (secondary users) and a common receiver, as shown in Fig.2 We assume that each CR performs spectrum sensing independently and then the local decisions are sent to the common receiver which can fuse all available decision information to infer the absence or presence of the PU. The essence of spectrum sensing is a binary hypothesis-testing.

## 4. PROPOSED SOLUTION

In proposed methodology we implement Fuzzy logic interface are described here. The proposed method provides better selection of secondary users and also it reduces the total error ratio about missing alarm and false detecting alarm message in the cognitive radio network having n number of CRs. This helps us to overcome problem of congestion which comes across because of the hidden terminal with cooperative sensing technique In our work we use a cognitive radio network is which uses cooperative spectrum sensing which checks for the existing of the primary users in cognitive radio networks and the secondary users communicate the data and perform the communication and communicates with unused spectrum during the absence of the primary user. Cooperative spectrum sensing is a technique in which all the cognitive users made their independent decisions and then send it to a common receiver. These can be achieved by employing with the using the optimization spectrum sensing technique which can be detect about the primary user. The main goal of Opportunistic spectrum usage approaches which and check for the unused spectrum and characteristics of the spectrum sensing technique in the real-time environment. But this can cause spectrum inefficient utilization and interface to the adjacent secondary users so has to overcome we implement and approach using Fuzzy Interface System (FIS) to control the spectrum access. To make sure to calculate the available spectrum and efficient spectrum sensing technique using fuzzy logic

Fuzzy Logic systems

In fuzzification, the two input variables are used as the antecedents and the output variable is used as the consequence in the Mamdani fuzzy control. A fuzzy relation is characterized by the same two items as a fuzzy set. First is a list

$$v_1, w_1\}, R_{11}\}, \{\{v_1, w_2\}, R_{12}\}, \ldots\ldots, \{\{v_n, w_m\}, R_m\}\}.$$

$$\{v_1, w_1\}, \{v_1, w_1\}, \ldots\ldots, \{v_n, w_m\},$$

$$\{R_{11}, R_{12}\}, \ldots\ldots, R_{nm}\}.$$

containing element and membership pairs,{{ Note that the elements of the relation are defined as ordered pairs,. These elements are again grouped with their membership grades. Which are values that range from 0 to 1, inclusive. The second item characterizing fuzzy relations is the universal space. For relations, the universal space consists of a pair o f ordered.

$$\{\{v_{min}, v_{max}, C_1\}, \{w_{min}, w_{max}, C_2\}\}$$

The first pair defines the universal space to be used for the first set under consideration in the relation, and the second pair defines the universal space for the second set. Universal spaces for fuzzy sets and fuzzy relations are defined with three numbers in this package. The first two numbers specify the start and end of the universal space, and the third argument specifies the increment between discrete elements.

**Rule Set Applications:**

The fuzzy logic rule set decides the scenario of the selection of the secondary node. Here in this research work the fuzzy logic has been used to select a secondary node on the basis of the angle of incidence which is explained in the below sections. The rule set classifies that if the search has to be set on the different angles what has to be the outcome of the result being a secondary node. Different angle of incidence or rotation angles have been configured like 0 to 100 degrees and then optimal selection rule has been utilized. The optimal selection rule depicts specific angles on which the transmission is possible. The fuzzy set has been drawn using the ANFIS tool which is easily available with MALAB 2010 and upper version selection of MATLAB.

The rule set has been designed in such a manner that if the node has to search the secondary node in either left, right, up or down direction it should only move with a marginal difference based on the angles set in the rule base.

Four directions have been configured namely

a) Left
b) Right
c) Vertical up
d) Vertical down

First of all the rule set is checked against the direction , if the direction is found to be ok then further optimization function is called . The load against each angle is calculated and the node with least load is utilized as a secondary node en the virtual backbone structure is formed afterwards the nodes send requests to the owner node for data items on the backbone nodes.

**FUZZY RULES**

The fuzzy using 'if' and 'then' statements. These fuzzy rules can be find out with the help of formula

$x^n = 2^2 = 4$.

Here x = input functions.

And n = total number of input

Table 1Rules in fuzzy logic

| IF | | | THEN |
|---|---|---|---|
| Rules | MOSU | TP | Spectrum Availability (SA) |
| RUL0 | Sm | Minimum | S |
| RUL1 | Sm | Medium | S |
| RUL2 | Sm | Maximum | N |
| RUL3 | Ad | Minimum | S |
| RUL4 | Ad | Medium | N |
| RUL5 | Ad | Maximum | L |
| RUL6 | Fs | Minimum | N |
| RUL7 | Fs | Medium | L |
| RUL8 | Fs | Maximum | L |

In this algorithm we utilize the four most wanted signal sources and estimate it in the desired directions. The desired angles may be 20°, 40°, 90°, 140° and 160° in the directions of primary users while the estimated angles having peaks values.

**Membership functions**

Table 2

| Functions | Range | MOSU | TP | Spectrum Availability (SA) |
|---|---|---|---|---|
| M1 | 0 to 100 | S1 | Minimum | S |
| M2 | 100 to 200 | AD | Medium | N |
| M3 | 50 to 200 | FS | Maximum | L |

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## 5. ANALYSIS

The performance of the proposed algorithm has been analyzed by taking different parameters like False alarm detection ( fAl ) against the Detections missed detections using Fuzzy Logic. It is shown in Fig. 3 that the False alarm rate decreases with the use of Fuzzy interface system. Then by analyzing the Fig.4, I t is found that the packet loss occurred obtained is only 3% in the proposed system. Fig .5 shows total error rate of cooperative spectrum sensing against the number of collaborative cognitive radios with 30 CRN when Fuzzy interface is used with fuzzy logic and fuzzy rules is used. it satisfies the given bound rate

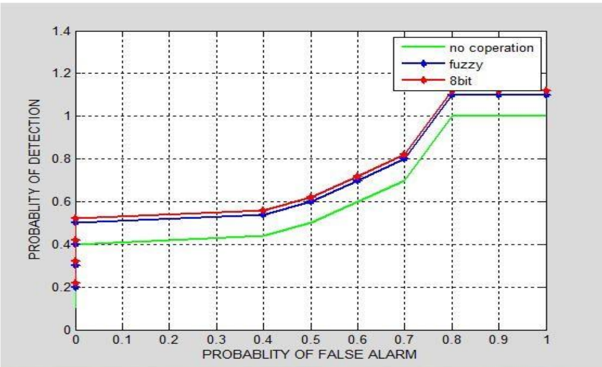


**Fig.2**. False alarm detections vs Detection of Missed alarms.

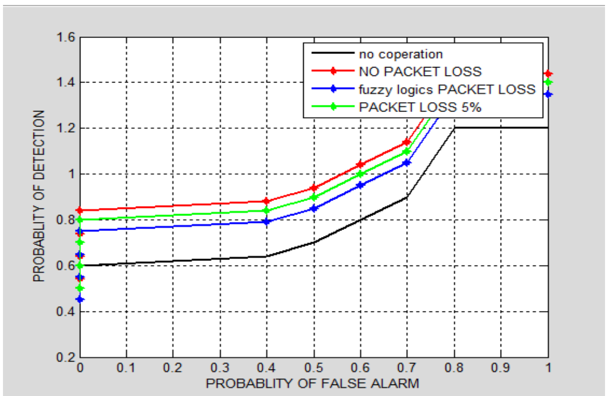


**Fig.3.** False Alarm Detections vs Detections with data loss

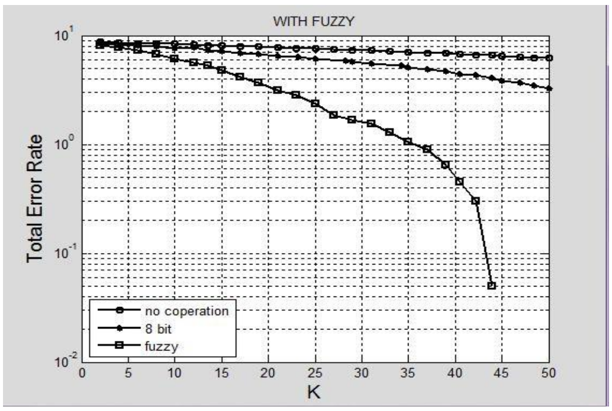


**Fig. 4** Total error rate versus Collaborative CRN

## 6. RESULTS

**After finding the composite rules and their values by using linguistic variables its singleton values calculated.**

| Rule | Membership function |
|---|---|
| Rul0 | f11 ^ f33 = 0.28^0.52 = 0.28 |
| Rul1 | f11 ^ f44 = 0.52^0.28 = 0.28 |
| Rul2 | f22 ^ f33 = 0.52^0.52 = 0.52 |
| Rul3 | f22 ^ f44 = 0.22^0.28 = 0.28 |

**Table 3: Composite Rules values**

| Rules | Mobility of SU | Transmit power | Saa | Singleton values |
|---|---|---|---|---|
| Rul0 | Adequate | Minimum | S | 0 |
| Rul1 | Adequate | Medium | N | 0.5 |
| Rul2 | Avg | Minimum | N | 0.5 |
| Rul3 | Fast | Medium | L | 1 |

**ERROR's**

Total error rate between simulated & designed value

| Results | Output Value |
|---|---|
| Simulated Value | 42.3 |
| Mathematically Model Value | 45 |
| Error Percentage | 4.2 |

## 7. CONSLUSION

With the large number of CRs, spectrum sensing has become impractical because in a time slot only one Cognitive radio could send its decision to the common receiver and separate decisions to the receiver end. To it will take more sensing time. To overcome these issues, we propose an efficient and effective sensing algorithm which is based on transmission decision at one time slot for one Cognitive radio and also guarantees a target error bound by taking few Cognitive radios form the network in spectrum sensing with energy detection in cognitive radio networks. It has been made a practical implementation minimize the total error probability with the ban half-voting rule. Optimal detection threshold has been presented. Efficient spectrum sensing algorithm has been proposed while satisfying a given error bound

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