



Comparison Between AND & OR Combining In Cooperative Spectrum Sensing

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Abstract: The rapid growth in wireless system and its application increases spectrum demand. However not all bands are fully utilized all the time. According to researches like FCC has reported that some of the bands inefficiently used while other are overcrowded. Therefore a technology is being needed that can utilizes spectrum properly. Researchers named it 'Cognitive Radio Communication'. The word Cognitive Radio was firstly described by Joseph Mitola. Cognitive Radio is a radio capable of analyzing the environment (as channels and users) and efficient way of using the available spectrum and adapting all of its operation parameters. It is still an open novel approach that is expected to solve the limitations of current systems. The principle for cognitive radio (CR) network regards the cognitive radio users as visitor in spectrum they occupy. They occupy the idle channel without causing interference with primary user and leave the channel when primary user activity is detected. The successful operation of these principles relies on the CR users' ability to be aware of their surroundings, which is done by spectrum sensing methods. The main reason for introducing the cognitive radio is the inefficient use of the radio resources and particularly the spectrum. There are drawbacks which arise due to multipath fading and shadowing effects false alarm and miss detection occur and these drawbacks are overcome by using cooperative spectrum sensing.

I. INTRODUCTION

In Cognitive Radio (CR) network there are two types of user they are Primary User (PU) and Secondary User (SU) [3]. Primary Users are those who actually pay for the spectrum like cellular network user and they have license to operate in specific band. Secondary User(SU) do not have any license to operate in specific band and they even do not pay for the spectrum, they use the spectrum in an opportunistic manner that is when PU do not use the spectrum SU utilizes the spectrum and SU vacants the spectrum as it sense the presence of PU.

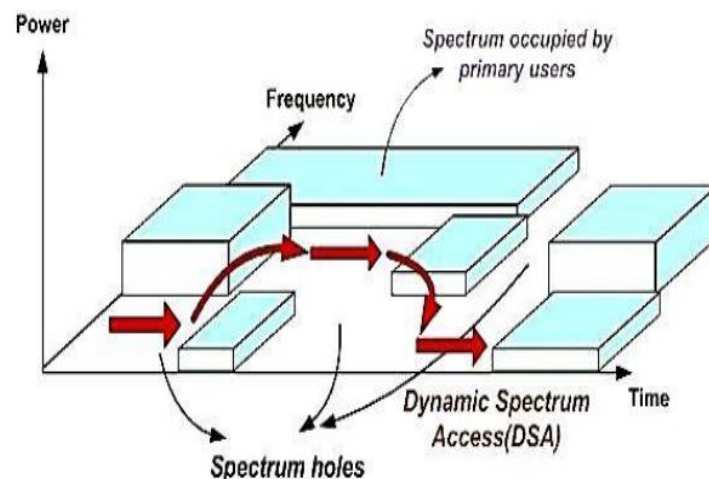


Figure 1 : Cognitive Radio Communication

In Cognitive radio communication when spectrum is not occupied by Primary user then it is utilized by cognitive radio user. The major problem is interferences that may occur due to path loss, shadowing and multipath. As we can see in figure 2 due to interference cognitive radio cannot detect the presence or absence of Primary user [2].

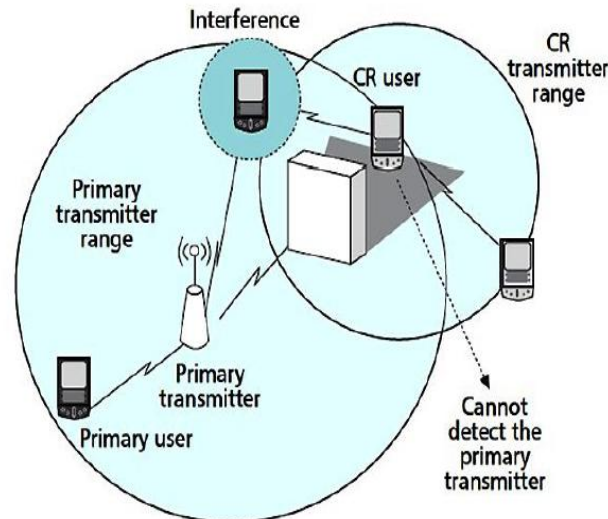


Figure 2: Drawback of single cognitive radio communication

Primary transmitter's signal could not be detected because of the locations of devices. It can be caused by many factors including severe multipath fading or shadowing observed by secondary users. Due to the lack of knowledge about the signals from primary transmitters (see Figure 2, the cognitive radio user alone cannot avoid causing interference to primary users since the CR user cannot detect the primary transmitter. Another problem is that the cognitive radio may have a good LoS to a primary transmitter, but may be not able to detect the signal from the primary transmitter, *because* of shadowing as shown in Figure 2 [3]. As a result false alarm or miss detection occurs. False alarm means primary user not present but it shows that PU is present. In Miss Detection Primary user is present but it shows that primary user is not present; as a result interference may occur. So the solution for these problems occur in single cognitive radio network is COOPERATIVE SPECTRUM SENSING.

II. COOPERATIVE SPECTRUM SENSING

The performance of a local detector degrades in the presence of propagation effects such as shadowing and fading caused by multipath. To overcome this problem cooperative spectrum sensing is used. In cooperative spectrum sensing, instead of single cognitive user, multiple user are use to sense the presence or absence of primary user.

Cooperative spectrum sensing can be done by two ways that are centralized and distributed.

A. CENTRALIZED SPECTRUM SENSING

In centralized cooperative spectrum sensing there is a central unit (called fusion center). In centralized individual node perform sensing and report to fusion center. Afterward, fusion center will decide whether primary user is present or not, then that decision is broadcasted to all other CR nodes.

B. DISTRIBUTED SPECTRUM SENSING

In distributed cooperative spectrum sensing there is no central unit (fusion center). In this decision is shared between all wireless networks. So, all nodes can act as a fusion center.

III. DATA FUSION

In centralized the combining is done at central unit. So, process in which we can find out presence and absence of PU is called Data fusion.

Data fusion can be done by two ways that are HARD combining and SOFT combining

A. HARD COMBINING

Each node individually decides the presence or absence of primary user in form of '0' and '1' and sends its decision to central unit. Then central unit decides that primary user is present or absent.

B. SOFT COMBINING

Each node does not decide the presence or absence of primary user and it sends whole observation to central unit. Then central unit decides that primary user is present or absent and broadcast its message to all CR users.

IV. HARD COMBINING

As we have discuss earlier in Hard Combining each node(user) sense the presence or absence of PU and send the observation in form of '0' or '1'.

Hard combining can be done by three methods:

- a) OR Method

b) AND method

A. OR METHOD

In OR method if any of the Cognitive radio sense that primary user is present then whole system will decide that Primary user is present. In OR rule based HDC, the final decision of H_1 (Primary user is present) is made when at least one CR user reports H_1 local decision. The Q_f and Q_d is given as

$$Q_f(\lambda) = 1 - (1 - P_f(\lambda))^N$$

$$Q_d(\lambda) = 1 - (1 - P_d(\lambda))^N$$

where N is the number of cooperative CR users.

Q_f is cooperative probability of false alarm.

Q_d is cooperative probability of detection.

P_f is probability of false alarm for single CR.

P_d is probability of detection for single CR.

B. AND METHOD

In AND method if all of the Cognitive radio sense that primary user is present then whole system will decide that Primary user is present.

In AND rule based HDC, the final decision of H_1 is made only when all CR users report H_1 local decision. The Q_f and Q_d is given as

$$Q_f(\lambda) = (P_f(\lambda))^N$$

$$Q_d(\lambda) = (P_d(\lambda))^N$$

V. COMPARISON BETWEEN AND & OR COMBINING

As we have discussed above about the AND & OR rule for hard combining, so now the question which method is the best in both rule for spectrum sensing?

So for the answer of this question we take result for both the combining for same number of CR and samples. After the programming the result in graph form shown in figure 3.

In the graph X axis shows probability of false alarm and Y axis shows the probability of detection.

The Red color line shows the AND combining graph and the Blue color line shows the OR combining graph.

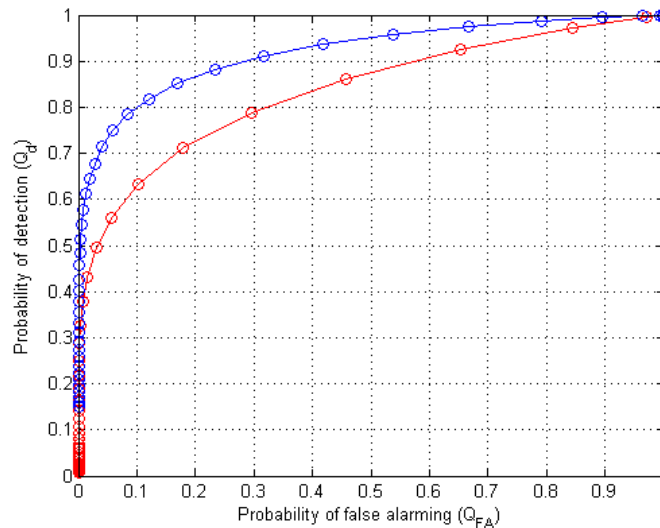


Figure 3: Comparison between AND & OR rule

As in figure 3 we can see that the performance of Blue color graph is better than Red color graph that is the performance of OR combining is better than AND combining.

VI. CONCLUSION

As compare to single cognitive radio communication, cooperative spectrum sensing is better as in cooperative false alarm reduces. In cooperative spectrum, in terms of bandwidth Hard combining is better as in Hard Combining only '0' or '1' is transmitted. But in terms of accuracy, Soft combining is better, as in soft combining whole observation is forwarded to fusion center. And again in hard combining the OR combining is better than the AND combining.

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