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Optimized Spectrum Handoff Delay in Cognitive Radio through Efficient Spectrum Sensing and Proper Decision of Handoff

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Abstract- Cognitive radio is a technology used to improve spectrum utilization by allowing temporary access of unutilized licensed spectrum of primary user (PU) to the secondary user (SU). When the PU appears at the same channel occupied by a SU, the SU has to vacate the channel and find the new channel to resume its transmission. This process of changing a channel is nothing but a spectrum handoff. Spectrum handoff is one of the main challenges in cognitive radio network. In this paper we propose a spectrum handoff based on efficient spectrum sensing and proper handoff decision. The proposed system mainly focuses on the optimized handoff delay. The proposed system uses energy detection method for spectrum sensing and fuzzy logic and neural network for proper handoff decision.

Index Terms- Cognitive radio (CR), Threshold, Sampled frequency, False alarm probability, Detection probability, Modulation type, FLC, ANN,WRAN 802.22

1. INTRODUCTION

Radio frequency spectrum needs to be shared by various upcoming radio services efficiently, optimally and economically. Despite the spectrum scarcity, most of the spectrum is underutilized at a given location. It has been observed that many TV channels remain unused over significant geographical areas.Various spectrum sensing methods are available. The energy detection method is one of the methods available for fast sensing. The implementation of this method is also simple. However, its sensing accuracy depends on selection of threshold level [1][2][3]. Cognitive radio is an intelligent wireless communication system which adaptively reconfigures itself to maximize resource utilization [5]. IEEE 1900 is a standard initiated by IEEE for the CR networks [6]. The IEEE 802.22 Wireless Regional Area Network (WRAN) Working Group is developing a point to multipoint fixed wireless access network standard intended to operate worldwide in the unused segments of the terrestrial TV broadcast bands [4]. Figure 1 shows application Scenario of standard 802.22. 802.22 is a new 802 LAN/MAN standards which aims at constructing WRAN utilizing white spaces(channels that are not already used) in the allocated TV frequency spectrum. The use of the spectrum will be used in an opportunistic way in order not interfere with any TV channel that is transmitting [4]. 802.22 WRAN standard also supports a spectrum sensing mechanism to detect the possible presence of incumbent users such as analog TV, Digital TV, low power licensed users such as wireless microphones [7]. The IEEE802.22 WRAN cell radius is typically from 17 to 33 km from a base station (may extend upto100 km)

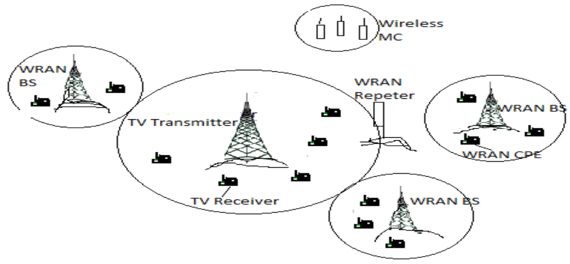


Figure 1 : Scenario IEEE 802.22

[5]. The BS can serve up to 255 customer premises equipment (CPE). The BS uses sectorized or omni-directional antennas. The CPE's are using outdoor directional antennas placed at 10 m above ground level with 14 dB of front to back lobe suppression. The BS as well as CPE sense the spectrum for three primary users, analog television, digital television, and licensed low-power auxiliary devices such as wireless microphones [4]. The probability of detection and the probability of false alarm is 0.9 and 0.1 respectively for all signal types.

SU uses these white spaces, at this time priority is given to PU. So detection of PU is nothing but spectrum sensing. If detection is not proper then unnecessary handoff is required it is wastage of time and power. The rest of the paper is organized as follows. Section 2, explains related work. Section 3, explains proposed system and section 4, explains about results. Section 5 concludes the paper.

2 RELATED WORK

This paper (8) analyzes the energy detector that is commonly used to detect the presence of unknown information-bearing signals. The algorithm simply compares the energy (or power) in a sliding window to a threshold. The analysis allows for arbitrary spectra of information bearing signal and noise processes. It yields two equations that relate five variables/parameters: the probability of false detection, the probability of missing a detection, window length, detection threshold, and signal to noise ratio (SNR). The probability density function of the detection variable is shown to be approximately Gamma distributed. All of the theoretical expressions and approximations are substantiated with simulation results. This paper develops two equations (approximations) that relate two performance measures to three design parameters. That is, they relate the probability of false detection and the probability of missing detection to window length, detection threshold, and signal-to-noise ratio (SNR). While the approximations developed are not exact, they are very useful in determining the window length and the decision threshold.

Paper (9) gives performance of collaborative spectrum sensing using censored energy detection is analyzed. Unlike the conventional energy detector that applies the measurements from the interested band directly to the decision-making process, the censored energy detector selects the measurements at different collaborating users by comparing them with two pre-determined limits before applying them to collaborative spectrum sensing. Both soft decision and hard decision rules are considered. Using the Neyman-Pearson criterion, analytical expressions for the probability of detection are derived and are verified by simulation. A simplified censored energy detector based on the Gamma approximation is also obtained. Using the derived results, it is shown that the censored energy detector outperforms the conventional energy detector when the optimum limits are used in the censoring. The performance gain depends on the decision rule, the operating signal-to-noise ratio and the number of collaborating users.

Paper (10) focuses on spectrum handoffs in a cognitive radio network where secondary (unlicensed) users (i.e. cognitive radios) opportunistically use frequency channels as long as the aggregate interference caused at the primary (licensed) users does not exceed a certain threshold. When harmful interference is caused to a primary user, or when the quality of service perceived by a secondary user is not satisfactory, the secondary user has to initiate a spectrum handoff to quickly vacate the channel it is occupying. The proposal in this paper is a fuzzy-based approach able to make effective spectrum handoff decisions in a context characterized by uncertain, incomplete and heterogeneous information. This paper we propose a fuzzy logic based spectrum handoff algorithm, which can be implemented in a decentralized way, so that SUs can autonomously and automatically make the decision to change its frequency channel. It worth noting that an additional advantage of the proposed approach is its real time capability, which has been proven many times in practical applications in the framework of fuzzy control.

Paper [11] gives, the randomness of the appearance of licensed users, disruptions to both licensed and unlicensed communications are often difficult to prevent, which may lead to low throughput of both licensed and unlicensed communications. In this paper, a proactive spectrum handoff framework for CR ad hoc networks, Prospects, is proposed to address these concerns. In the proposed framework, Channel-Switching (CW) policies and a proactive spectrum handoff protocol is proposed to let unlicensed users vacate a channel before a licensed user utilizes it to avoid unwanted interference. Network coordination schemes for unlicensed users are also incorporated into the spectrum handoff protocol design. Moreover, a distributed channel selection scheme to eliminate collisions among unlicensed users in a multiuser spectrum handoff scenario is proposed.

So we propose a system for spectrum sensing in cognitive radio using frequency method. Proposed system will use energy detection method for detection of signals. It is independent of modulation used for transmission of signal, phase or any other parameter. Fuzzy logic and neural network is used for handoff decision

3 PROPOSED SYSTEM MODEL

A) Efficient Spectrum Sensing:

The energy detection principle measures the energy received in a primary band during an observation interval (ts) and declares the current channel state Si as busy hypothesis (H1). If the measured energy is greater than a properly set predefined threshold or idle hypothesis (H0) otherwise.BW is bandwidth of the signal. Energy of signal compared with threshold; if energy of the signal greater than threshold then signal is present otherwise signal is absent. This detection is proper means detection probability should be maximum. False detection of signal gives unnecessary handoff and wastage of time and power. So we have proposed a sensing confidence i.e. we have divided presence of signal in terms of three category. These are Low, Medium, and High.

B) Fuzzy Logic:

Fuzzy logic builds on traditional logic and extends traditional logic so that fuzzy logic can solve some long standing problems in traditional logic. Problem in the real word quite often turn out to an element of uncertainty either in the parameters which define the problem or in which the problem occurs. Fuzziness means 'vagueness'. Fuzzy set theory is an excellent mathematical tool to handle the uncertainty arising due to vagueness. Fuzzy sets support a flexible sense of membership of elements to a set. Membership function $\mu_A(x)$ is associated with a fuzzy set A such that the function maps every element of the universe of discourse X to the interval [0,1]. Membership functions are a useful and integral part of fuzzy control systems. The membership function values need not always be described by discrete values. Different shapes of membership function exist. The shapes could be triangular, trapezoidal, curved.

Fuzzy control

Fuzzy controllers are very simple conceptually. They consist of an input stage, a processing stage, and an output stage. The input stage maps sensor or other inputs, such as switches, thumbwheels, and so on, to the appropriate membership functions and truth values. The processing stage invokes each appropriate rule and generates a result for each, then combines the results of the rules. Finally, the output stage converts the combined result back into a specific control output value. The most common shape of membership functions is triangular. We have considered triangular membership function for handoff decision. For decision of handoff we have considered parameters, Presence of primary (P1), bit rate(P2) and received signal strength (P3) of SU. So our fuzzy controller will work as follows.

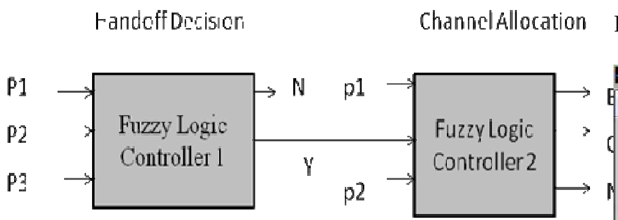


Figure 2: working two FLCs

We have defined 27 fuzzy rules for FLC1, as the output of FLC1 is 'N' there is no necessity for handoff transmission of data transfer on the same channel. If output of FLC1 is 'Y' then handoff is required. Channel allocation is performed by FLC2.

Handoff Cases

A) Handoff condition is 'Y'

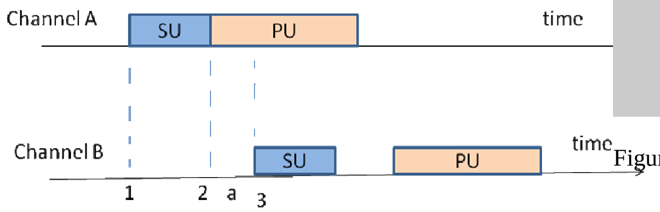


Figure 3:Hd=Y

- 1- SU prepares backup channel
- 2- SU predicts PU A arrival then pauses transmission
- a- Handoff latency
- 3-SU resumes transmission

B) Handoff condition is 'N'

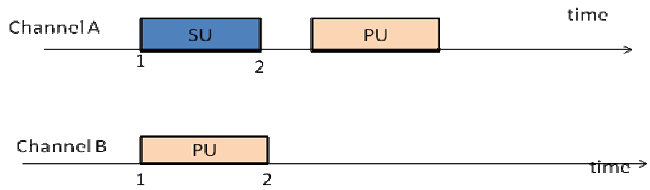


Figure 4: Hd=N

- 1- SU starts transmission
- 2- SU completes transmission
- 3- PU starts transmission with channel B so no need for handoff

4 Simulation Results

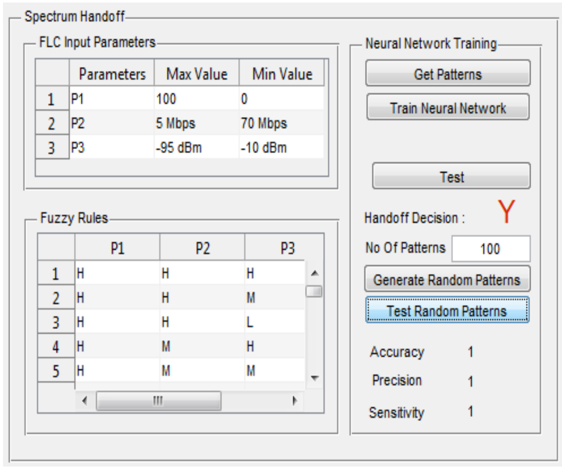
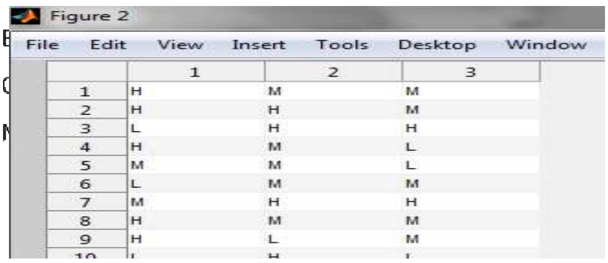
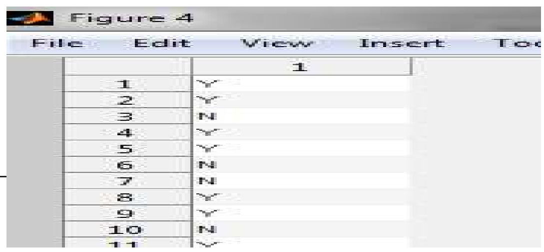


Figure 5: system GUI (graphical user interface)



	1	2	3
1	H	M	M
2	H	H	M
3	L	H	H
4	H	M	L
5	M	M	L
6	L	M	M
7	M	H	H
8	H	M	M
9	H	L	M

Figure 6: Generated Fuzzy Rules



	1
1	Y
2	Y
3	N
4	Y
5	Y
6	N
7	N
8	Y
9	Y
10	N

Figure 7: output of FLC1

Figure 5, 6, 7 gives overall system GUI, FLC generated rules, decision given by neural network respectively.

5. CONCLUSION

In frequency domain analysis we get detection for number of users as per threshold formula. We get detection probability 98%. So properly selected P1 acts as a input to FLC1. Unnecessary spectrum handoffs are eliminated. Proactive handoff strategy is used, so handoff latency is low. All provisions have already made so no necessicity of times negotiation, authentication, key exchange. So handoff latency is reduced.

Our future work will be implement this coding on a cognitive bed.

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