Energy Efficient Techniques in Cognitive Radio Networks

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Abstract – A cognitive radio framework is a system which grants cognitive user to utilized empty bands. Licensed user (primary user) and cognitive radio users (secondary users) may exist together in a spectrum band, provided that secondary users work without meddling with primary user's communication. Secondary users can identify an primary user's activity in a band employing different signal processing techniques. A necessity in the cognitive radios is the absence of information about the primary signal and channel gain statistics at the secondary users. The effect of obstruction can be diminished by employing cognitive radio method that highlights in spectrum detecting and broadcasting information just on clear channels, the presentation of spectrum detecting secures extra vitality use. Spectrum sensing based energy detection is exhibited in this paper. Cognitive users distinguish the nearness of such free bands and energy detection is exceedingly viewed as eventual method for this spectrum detecting undertaking. An iterative spectrum sensing algorithm is utilized as a part of this paper. It is used to reduced the energy wastage and save the energy in multichannel scenario. Energy detection which does not need earlier data of primary signal and which has low complication.

Index Terms – Cognitive Radio, Energy detection, Iterative spectrum sensing algorithm, Spectrum sensing.

1. INTRODUCTION

The initial step of CR is to distinguish free spectrum. Spectrum detecting is the most vital assignment for cognitive radio organization. Different estimations of spectrum use retain vacant assets in recurrence, code, time and space [6].

A cognitive radio [1, 10] is a radio whose control forms allow the radio to use situational learning and clever handling to independently adjust towards some objective. Intelligence is the ability to gain and apply learning, particularly, toward an intentional objective. A cognitive radio watches the accessible spectral bands, captures their data, and distinguishes the spectrum holes. Cognitive radio innovation empowers radio systems to utilize spectrum in totally new and refined systems. CR has two important characteristic concepts [3]: cognitive capability and Reconfigurability. Cognitive ability [7] is utilized to recognize the unused spectrum at a particular time or area. Reconfigurability empowers the cognitive radio to be modified progressively as per the radio condition [8], [2]. In this paper, Energy detection [5] is discussed. Energy detection which is simple to implement and much lower intricacy contrasted with the other two plans than matched filter detection and cyclostationary detection.

The rest of the paper is formed as follows: In section II, System model is discussed. In section III, Pseudocode is discussed. In Section IV, we present the simulation results and discussion. In Section V, we conclude our work.

2. SYSTEM MODEL

A CR can cleverly identify whether any portion of the spectrum is being utilized, and can incidentally utilize it without intrusive with the communications of different users.

Spectrum sensing based energy detection system is utilized as a part of this paper. A noteworthy test in cognitive radio is that the cognitive users need to perceive the nearness of primary users in a authorized spectrum and abandon the recurrence band as quick as accessible if the relating authorized radio loom to prevent intervention to authorized users. This plan is known as spectrum detecting.

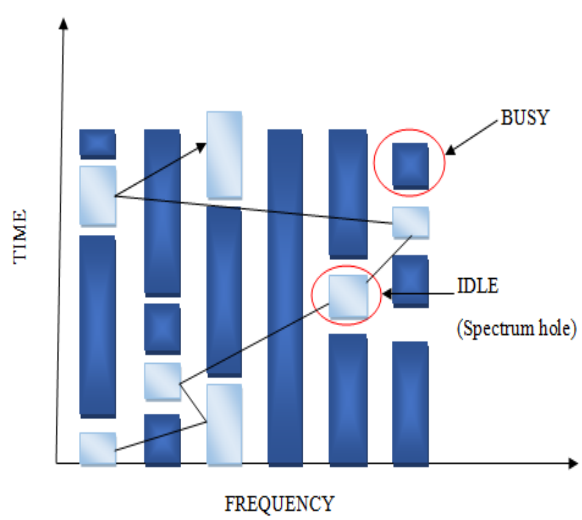

Figure 1 Spectrum hole

Iterative spectrum detecting algorithm is utilized. Energy detection which is easiest detecting procedure and fastly detects the idle state channel. In Energy detection, the primary user is detected in view of detected energy.

The Idle state channel which represents the spectrum abandoned by primary user. The busy state channel which represents the spectrum employed by the primary user. In single channel scenario, some packet drop and causing interference. To avoid that, Iterative spectrum sensing based energy detection is used to detect the idle state channel in multichannel scenario and to reduced the energy wastage and save the energy as shown in Figure 1.

The intervention can be limited and to enhance the communication throughput in multi channel scenario.

2.1. System State

The Overall system state is determined as sampling period T_s.

$$Y_l\,[L+1] = A \,.\, Y_l\,[L]+W_l\,[L] \tag{1}$$

where A is a constant matrix and Y{l} is input.

The vacant and occupied times of the channel are characterized as,

$$\rho=\frac{E[t_B]}{E[t_I]} \tag{2}$$

The probabilities of idle and busy state channels are characterized as,

$$P_{Id} = \frac{1}{1+\rho},\ \ P_{Bu} = \frac{\rho}{1+\rho} \tag{3}$$

Before transmitting a packet, Energy detection based spectrum sensing verify the system condition and then transmitting the packet just when the channel is in unoccupied state.

The detecting strategy continues as long as time of τ , during which the signals got from the channel and afterward chooses either the system is in empty or in occupied state. Between the channel detecting techniques, *energy detection* is a standout amongst the well known procedures.

In Energy detection, generally the detecting results might be incorrect. e.g., the detecting strategy may erroneously report vacant channel when it genuinely involved. Give S_c a chance to be the detecting result (with ‘0’ represents empty channel and ‘1’ represents occupied channel).

$$P_d\,(\text{Channel idle}) = (1 - \epsilon_d)\,\sqrt{\tau W} \tag{4}$$

$$P_f\,(\text{Channel busy}) = (1 - \epsilon_f)\,\sqrt{\tau W} \tag{5}$$

where W represents the channel bandwidth.

The successful packet transmission rate is represented as,

$$\beta=(n^* P_d) / 1+ \rho \tag{6}$$

2.2. Design Methodology

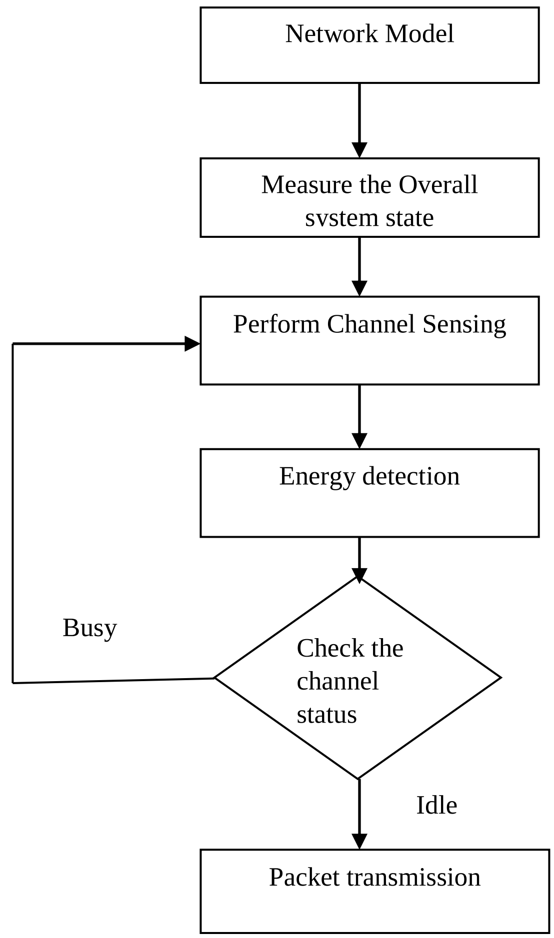

Figure 2 Flow chart Description

The flow chart Description is shown in Figure 2. To begin with a network model and to measure the overall system state. Then to perform channel sensing by Energy detection. An Energy detection which is used to indicate the the nearness or vacancy of authorized users signal in a band. Then to check the channel status.

If the system is in empty state then to broadcast the packet. A broadcasting will be failed, i.e., some packet will be drop, when the system is in occupied state. An Iterative spectrum sensing algorithm which is repetition of process to sense the idle state channel in multichannel scenario and then transmit the packet without packet loss to reduced the energy wastage and save the energy.

3. PSEUDOCODE FOR PROPOSED SYSTEM

Initialize: T_s=1, l=1, q_1=50, q_2=50, γ=0.7

Step 1: To measure the system state.

for l = 1: q_1

initialize Y_l {L}, W_l {L}

update Y_l [L+1]

if $L \neq 1$

compute $S_l\{l\}= E[Y_L\{L\} – Y_L\{L-1\} . Y_L\{L\} – Y_L\{L-1\}]^T$

end

Step 2: To define the channel model.

The average idle and busy periods channel is calculated by update ρ

Step 3: The probabilities of idle and busy state channels is calculated by P_{Id} and P_{Bu}.

Step 4: Perform channel sensing by Energy detection.

update S_c by calculating P_d and P_f

Then packet transmission is performed by β

end

Step 5: Calculate the sensing time on each channel in multichannel scenario.

Assume iteration=300, The average idle and busy rates channels are assumed by,

α_i =5, β_i =30, γ=0.94.

for i=1:m

$P_{tx}(i)=1-(1-P_{tx})$

end

Step 6: Calculate the sensing time under Iterative spectrum sensing algorithm (ISSA) when samples at initial step n=1,4,5.

Step 7: Performance comparison of all three ISSA is obtained.

Step 8: Finally, the energy consumption will be obtained.

end

4. SIMULATION RESULTS AND DISCUSSIONS

MATLAB [4] is utilized for the simulation setup. The rundown of parameters taken from [9] for simulation are shown in TABLE 1.

The Sensing time in multichannel situation are appeared in Figure 3. From this outcome, the channel sensing at τ_1(ms) is 6 ms and τ_2(ms) is 4 ms.

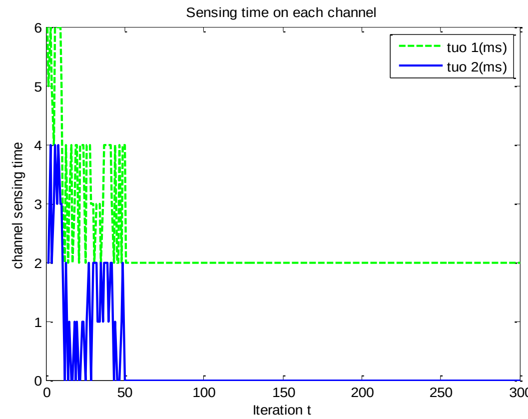

Figure 3 Sensing time in multichannel scenario

TABLE 1

SUMMARY OF PARAMETERS

NOTATION	EXPLANATION
Y_l {L}	Input system state at beginning of step L
W_l {L}	Random noise which is generated between packet transmission
S{l}	Covariance prediction (estimation performance)
T_S	Sensor's sampling period
t_S	Transmission time of each measurement packet
τ (tuo)	Channel sensing time
P_B , P_I	Probabilities of idle and busy state channels
P_d , P_f	correct and false detection probabilities of channel
γ (gamma)	Packet transmission rate
η	Sensing accuracy

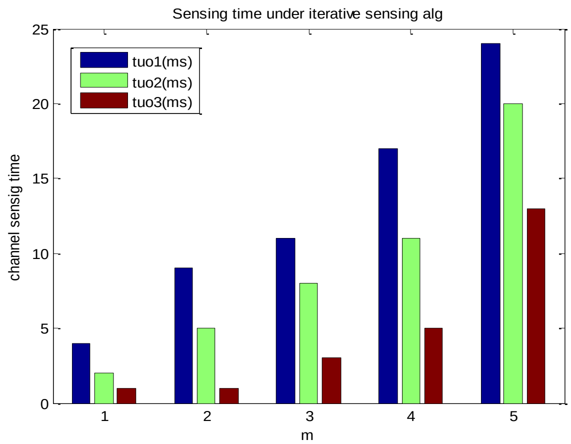

Figure 4 Sensing time under ISSA of fixed n

The detecting time under ISSA when n=1,4,5 are appeared in Figure 4,5,6. The number of licensed channels which is represented by m. From this outcome, by comparing with channel sensing time at τ (1ms), the channel sensing time at τ (2ms) and τ (3ms) which performs less sensing time.

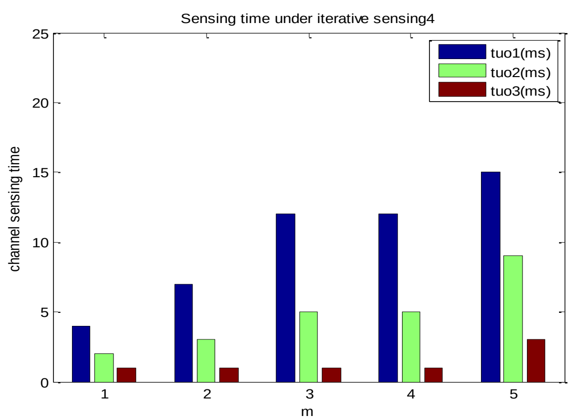

Figure 5 Sensing time under ISSA when n=4

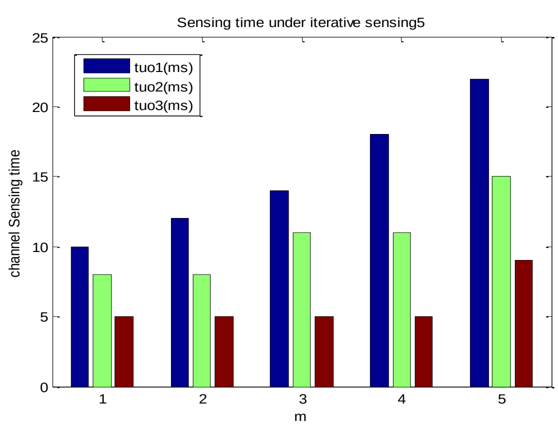

Figure 6 Sensing time under ISSA when n=5

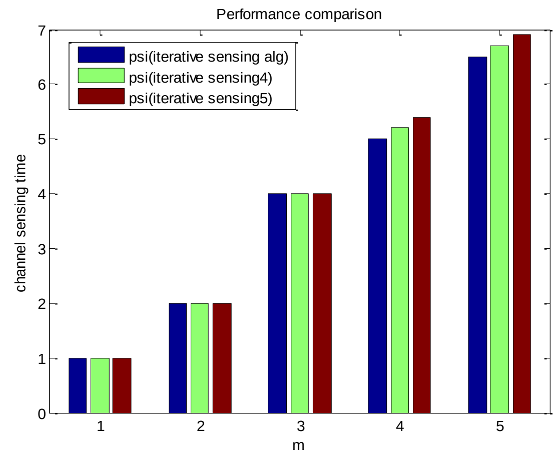

Figure 7 Performance comparison

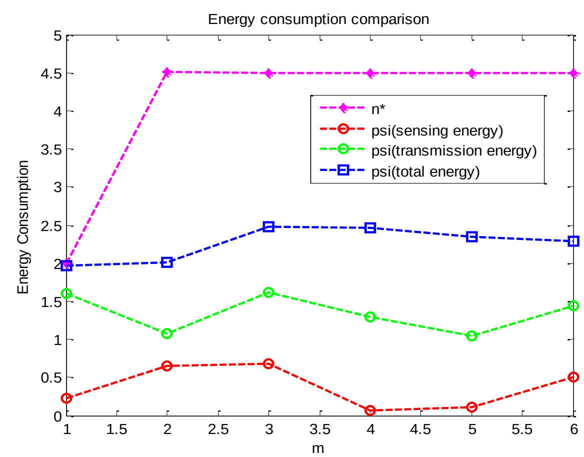

Figure 8 Energy consumption comparison

The Performance of Iterative Spectrum Sensing Algorithm (ISSA) when n=1, n=4 and n=5 are shown in Figure 7. By comparing the performance of each sampling step at n=4 and n=5 with initial step n=1, the channel sensing time for sensing the idle state channels at n=4 and n=5 which almost achieves the same performance and to enhance the performance.

Figure 8 which demonstrates the energy consumption comparison. The average transmission energy for transmitting the packet and sensing energy for sensing the idle state channels will be reduced by comparing with total energy of normal spectrum sensing. Under $m \geq 3$ the n^* is obtained idle within a shorter duration of time and to reduced the energy wastage.

5. CONCLUSION

In this paper, Energy detection based spectrum detecting is utilized. An iterative spectrum detecting algorithm is utilized to detect the idle state channel in multichannel situation and then to transmit the packet without packet loss. The performance comparison under each sampling step n=1, n=4 and n=5 are demonstrated. By comparing the performance with sampling step at n=1, Simulation results which shown that the sampling step at n=4 and n=5 which is almost achieves the same performance for sensing the idle state channel. By comparing with normal spectrum sensing total energy, the transmission energy for transmitting the packet and sensing energy for sensing the idle state channels will be minimized.

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