HYBRID ENERGY HARVESTING SCHEME FOR COGNITIVE RADIO NETWORK

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Abstract— *Cognitive radio networks are becoming increasingly popular these days because of their propensity to tackle spectrum shortage problem so efficiently through dynamic spectrum access. The cognitive radios are battery operated devices and require continuous spectrum monitoring for the opportunistic use of the spectrum. Thus, the performance of such radios is limited by the battery life. To overcome this bottleneck, a hybrid energy harvesting scheme is proposed in this paper. The proposed scheme harvest energy from RF energy from PU as well as SU on detecting their presence and absence from the channel. The proposed algorithm compares the harvested energy with desired transmission power. If the harvested energy is less than desired transmission power, external energy source is used to meet the deficit. The numerical simulated results are presented and compared with the conventional scheme to validate the proposed scheme.*

Keywords— *Cognitive radio network, Energy harvesting.*

I. INTRODUCTION

The increasing popularity of wireless applications and anytime, anywhere internet connectivity has increased the demand of radio spectrum exponentially from past few years[1], [2]. However, the exiting spectrum access policies in use have left no spectrum to deploy new applications and to enhance the existing ones. A recent FCC report has suggested that existing spectrum scarcity problem is mainly due to the inefficient use of the spectrum rather than the actual shortage of the spectrum[3]–[6]. The researchers worldwide have suggested many alternatives to this problem and it has been concluded that existing spectrum crunch problem can be handled well through dynamic spectrum access based technologies such as cognitive radio. The cognitive capability and reconfigurability features distinguish this radio from other wireless radios. It constantly monitors its surrounding RF environment for licensed user presence in a channel. On detecting the primary user in a channel it transmits the data otherwise adapt its transmission parameters such that no interference may offered to them[7]. To do so, sensing is very crucial aspect of cognitive radios that requires continuous power source. Thus the energy efficient operation is most desirable feature for such radios. Recently, the focus of the research is being shifted towards the green communication such that desired power requirements are meet through energy harvesting from RF and Non-RF sources to meet the power requirements for transmission as well as for the proper functioning of on board circuitry[8].

II. LITERATURE SURVEY

In [9], a hybrid underlay-overlay cognitive radio with energy harvesting is proposed that harvest energy from the primary user's signal as well as from the other ambient sources. The secondary user either operates in one of the two transmission modes; overlay and underlay in order to maximize the throughput. In [10], prediction based cooperative spectrum sensing scheme is proposed for energy harvesting cognitive radio (CR) network. A CR harvests from non-RF resources if both the decisions (decision of prediction and decision of spectrum sensing) do not match or if both the decisions match in favor of the absence of PU. On contrary, it harvests from RF resources while both the decisions match in favor of thepresence of PU. In [11], consider a radio frequency energy harvesting cognitive radio network in which a secondary user (SU) can opportunistically access channel to transmit packets or harvest radio frequency energy when the channel is idle or occupied by a primary user. The channel occupancy state and the channel fading state are both modeled as finite state Markov chains. At the beginning of each time slot, the SU should determine whether to harvest energy for future use or sense the primary channel to acquire the current channel occupancy state. It then needs to select an appropriate transmission power to execute the packet transmission or harvest energy if the channel is detected to be idle or busy, respectively. This sequential decision-making,done to maximize the SU's expected throughput, requires to design a joint spectrum sensing and transmission power control policy based on the amount of stored energy, the retransmission index, and the belief on the channel state. In [12], The hybrid overlay-underlay scheme allows the secondary users to access the spectrum even when the primary signal is detected. We are the first to partition the unit area into three parts for secondary users: Overlay mode area, underlay mode area, and harvesting zone. Then, we propose a metric to classify the CRN into the spectrum-limited state and the energy-limited state,and accordingly maximize the throughput through the monotonicity analysis of throughput and collision probability.

In [13], focuses on the issue of cooperative spectrum sensing (CSS) in a mobile energy-harvesting cognitive radio network (EH-CRN), where secondary transmitters (STs) are powered by the radio-frequency (RF) signal emitted from primary transmissions. Only the STs with sufficient energy participate in CSS, and send their local sensing decisions to a fusion center (FC), which makes a final decision on the state of the spectrum by a general k-out-of-M(k) fusion rule. The target of this article is to develop an optimal CSS strategy in terms of final decision threshold k that maximizes the expected achievable throughput of the EH-CRN, subject to a collision constraint. In [14], an optimal policy is presented to maximize the secondary user's (SU's) throughput in an energy harvesting cognitive radio network with multiple SUs and single primary user (PU). The SU can access the PU's channel in a hybrid interweave/underlay channel access mode using time division multiple access (TDMA) technique. This hybrid access mode combines the benefits of interweave channel access mode of accessing the PU's channel opportunistically with hightransmission power to gain high throughput and that of the underlay channel access mode of transmission at any time regardless of the PU's activity with controlled power.

Motivated from studies above, in this paper a hybrid energy harvesting scheme is proposed. The paper is organised in following manner: the basics of cognitive radio and need of energy harvesting for such radios is explained in Section 1. Section 2 overviews the most recent works in this field. The proposed system model of energy harvesting cognitive radio networks and proposed algorithm is described in Section 3. In Section 4, simulated results are presented along with description followed by conclusion in Section 4.

III. Proposed System Model

We have considered a scenario in which PU_Tx is transmitting information to PU_Rx whereas the SU_Tx is looking for transmission opportunities to transmit the data to SU_Rx. The setup has also a DF relay node (SR)and 2 external ambient RF signals. The CR transmitter transmits in PU band on detecting PU absence from the channel. The secondary relay SR isassisting the SU_Tx to send it data to SU_Rx. It is assumed that the SU_Tx node consists of energy harvesting circuitry to harvest the energy from another SU, PU and external RF signal when required. We assumed that the location of external RF sources israndom as shown in Figure 1.

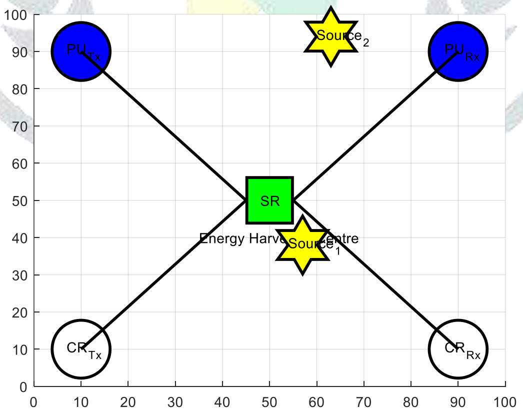


Fig. 1: Experimental set up

It is assumed that SU_Tx is equipped with the energy detector that constantly monitors the channel and compares the received energy signal with predefined threshold values to detect the presence/absence of PU from the targeted licensed channel. The SU_Txis also equipped with the circuitry to harvest the energy from RF signal either from PU/SU/ external Non-RF source. The proposed scheme is harvesting the energy in two scenarios based on the sensing outcomes if PU is present or absent from the channel. Unlike the conventional approach, the proposed scheme check the energy demand's fulfillment in both cases whether PU is present or not. On detecting the harvested energy is less than the power requirement ffor the successful transmission of the data, the harvester circuit start harvesting energy from external source. Thus, the harvestor model can be presented as given in (1)

$$E_{Hoverall} = \begin{cases} \alpha Tr E_{HCR} & If\ PUPresent, andEnergyDemandSatisfy \\ \alpha Tr(E_{HCR} + E_{HPR}) IfPU\ \&\ SU\ Present, andEnergyDemandSatisfy & \\ E_{HES} & IfEnergyDemandDoNotSatisfy \end{cases} \quad (1)$$

Where αTr is time period for which harvester circuit works, $E_{HCR}$and $E_{HPR}$are the energy harvested from PU and SU and $E_{HES}$is energy harvested from external source. The E_{HES} is given by (2)

$$E_{HES} = \tau P_u (\frac{G_u G_i \lambda_u^\alpha}{4\pi d_{i,u}^\alpha} \quad (2)$$

where G_u and G_i are antenna gains, P is transmitted power, d is distance ranging from 1-100m and λ is wavelength of the signal, α is harvesting efficiency which is considered as 30% in this work. The proposed algorithm flow diagram is as shown in Figure 2.

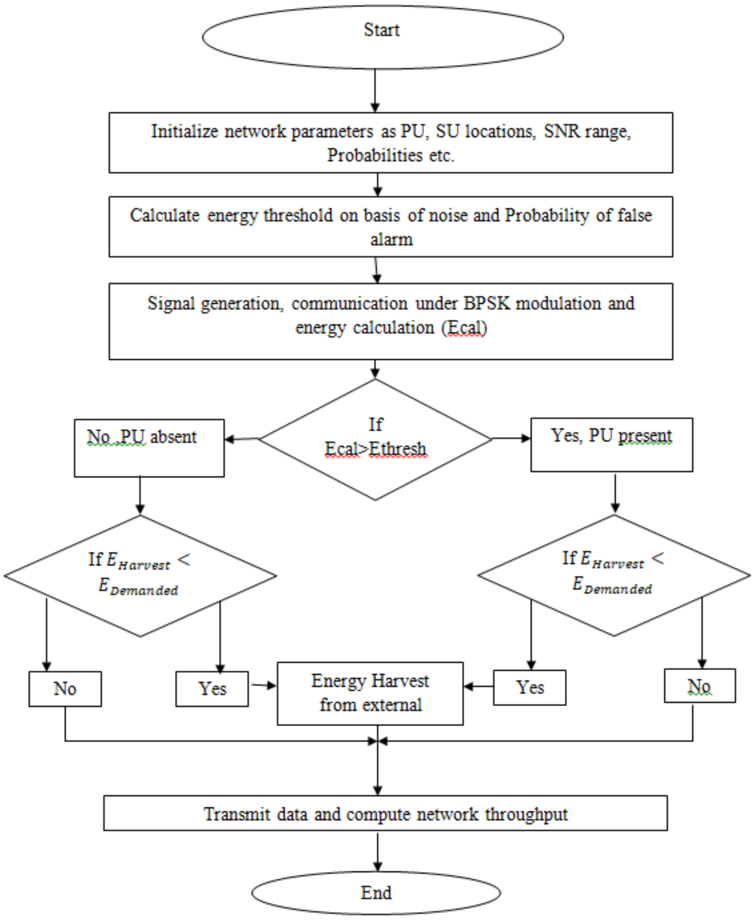


Fig. 2: Flow Diagram of proposed scheme

IV. RESULTS AND DISCUSSIONS

This section gives the results obtained after the simulation of the proposed model. The proposed model is simulated in MATLAB software. Theresults of the model are analyzed in terms of network throughput, energy harvested.Figure 3 represents the network throughput by varying the SNR in dBs for 3 different values of α. It is found thatfor given value of harvesting parameter, the network throughput of increases as the values of SNR are increasing.

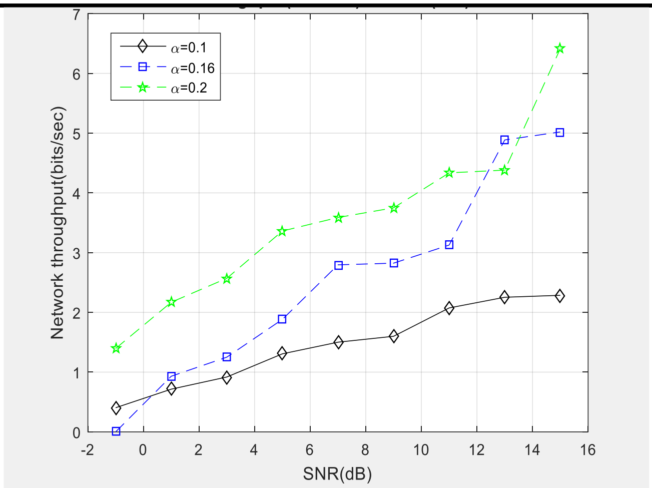
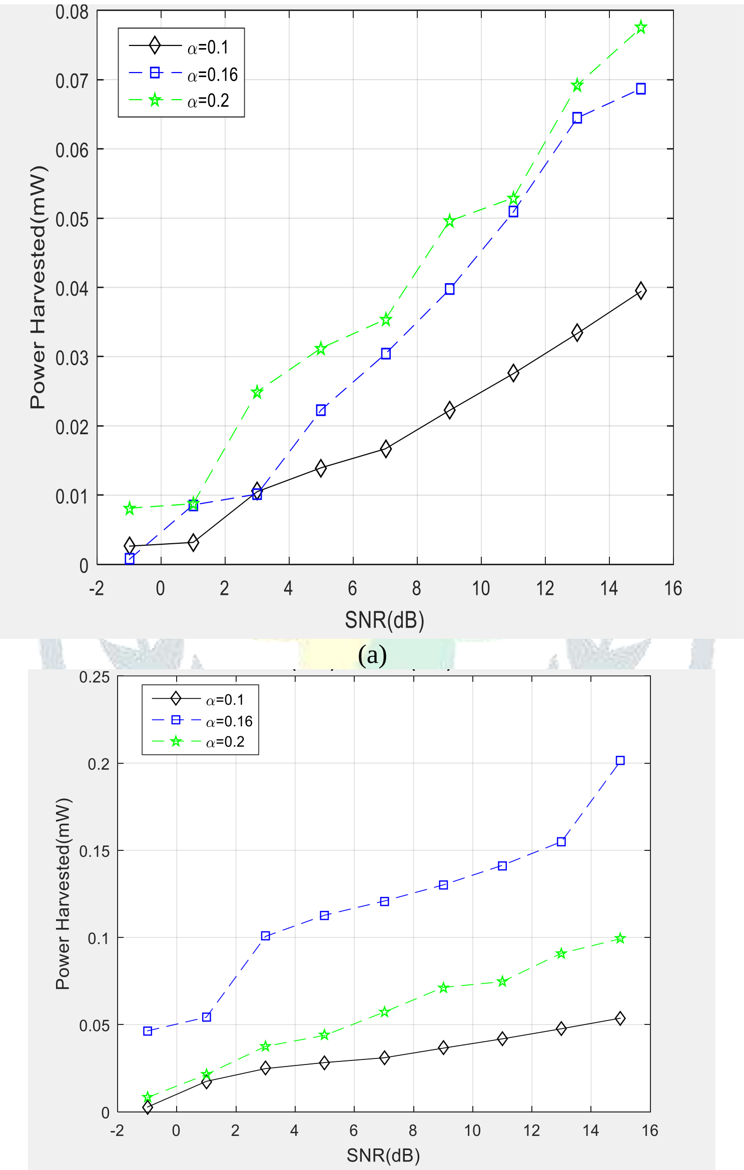


Fig. 3 : Throughput versus Signal-to-Noise-Ratio



(a)

(b)

Fig. 4: Power harvested versus SNR for different α(a) Conventional Scheme (b) Proposed Scheme

Figure 4(a) and 4(B) show the power harvested by the conventional system when no external power source is present and proposed scheme when external power source is used. The value of α is kept same for the comparison. It is clear from the graph that proposed scheme is able to harvest more power as compare to the conventional scheme for the same value of α and SNR.

V. CONCLUSION

In this paper, the energy harvesting cognitive radio system is proposed that exploit hybrid means of harvesting energy from RF as well as Non-RF sources. It has been observed that proposed scheme outperforms the conventional scheme and enhance system throughput and harvest more power as compare to the conventional system. The simulated results are presented to validate the efficacy of the proposed system in terms of Throughput and power harvested.

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