AN OPTIMAL MODEL FOR ENERGY EFFICIENCY SPECTRUM SENSING IN COGNITIVE RADIO NETWORKS

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***Abstract*— Cognitive Radio Sensor Network (CRSN), which incorporates the ability of cognitive radio in wireless sensor networks. Sensor nodes generally operate on batteries and therefore have strict energy restrictions. As a result, energy efficiency is also a very critical problem in the CRSN. This document focuses on energy consumption due to spectrum detection. We also present an interval time strategy of adaptive spectrum detection, in which secondary users can adjust the following spectrum detection time interval based on the results of detection of the current spectrum (i.e. channel status).) and also analyze the probability of false alarm. To find an optimal spectrum detection time interval, the user's operating model is introduced. Next, establish a mathematical model based on the Markov model**

Keywords-component; spectrum sensing, cognitive radio, energy consumption

I. INTRODUCTION

Cognitive radio (RC) is a form of wireless communication.In which the transmitter and receiver can intelligently detect which communication channels are in use and which are not, and move instantly over empty channels to avoid busy ones. This optimizes the use of the available radiofrequency (RF) spectrum and minimizes interference with other users. In its most basic form, CR is a hybrid technology involving radio-defined software (SDR) applied to diffuse-spectrum communications [1]. The possible functions of cognitive radio include the ability of a transceiver to determine its geographical location, identify and authorize its users, encrypt or decode signals, detect neighboring wireless devices in operation and adjust output power and modulation characteristics . There are two main types of cognitive radio, complete cognitive radio and spectrum-sensitive cognitive radio. The complete cognitive radio takes into account all the parameters that a node or a wireless network can know. Spectrum-based cognitive radio is used to detect channels in the radiofrequency spectrum. Spectrum detection is the process by which it is able to determine the free spectrum, the channel parameter of the licensed user, the ability to measure, detect and know the parameter of the radio characteristics and reliably detect the presence of the licensed user without causing interference with the user's license rights. This is known as spectrum detection. Spectrum detection is a very important function of cognitive radio. For efficient use of the radio spectrum, spectrum detection has proposed a different methodology for spectrum detection.

II.SYSTEM MODEL

A. Cognitive Radio Network Architecture

Consider a CRSN, in which sensors with cognitive capabilities work with the ISM frequency channel. Furthermore, we assume that the main users are the TV bands and the secondary user includes the transmitter ($SUtx$) and the receiver ($SUrx$). SUs can access frequency bands when they detect frequency bands not used by processing units; on the contrary, the SU work with the ISM frequency channel.

B. Channel State

A Markov chain model [2] is applied to model the status of each channel. The channel is referred to as Rn (t). The status of the channel varies between inactive and busy.

$$R_n(t) \in \{1(\text{idle}),0(\text{busy})\} \quad (1)$$

C^n_{01} and C^n_{11} are the probability of channel n to transmit busy state to idle state.

$$C^n_{01} = \Pr\{ C^n(t)=1 \mid C^n(t-1)=0 \} \quad (2)$$
$$C^n_{01} = \Pr\{ C^n(t)=1 \mid C^n(t-1)=1 \} \quad (3)$$

Fig.1 shows the transition model of the channel state

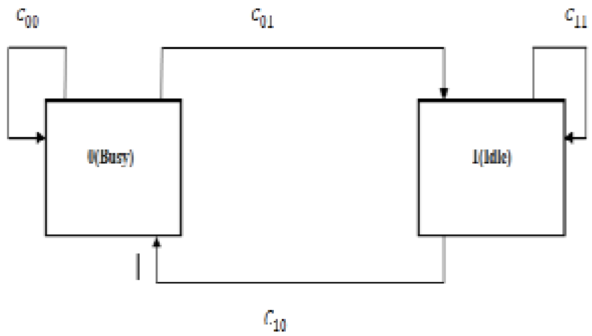

Fig 1 Channel state transition model

C. Operating Model

In our model, a mechanism for controlling access to a decentralized medium with a time frame is adopted. Each time interval can be divided into three main sub-intervals. At the beginning of each time interval, the detection period τs is reserved for identification of the available channel (inactive channel). As far as the detection result is concerned, an SU decides which channel must operate in the transfer switching period. If the channel is already used by an SU in the previous slot identified as an available channel, SU does not change the operating frequency and continues its transmission. Otherwise, the SU determines a new channel that must be defined as a hole in the spectrum in the spectrum detection period [2].

$$W_c(t+1) = \begin{cases} C_{11} & r(t) = c, S_{a(t)}(t) = 1 \\ C_{01} & r(t) = c, S_{a(t)}(t) = 0 \\ wcC_{11} + (1 - wc(t))C_{01} & a(t) \neq c \end{cases} \quad (4)$$

III.ENERGY CONSUMPTION ANALYSIS OF SYSTEM

A. Model for Energy consumption

The dissipation of energy by a sensor node [2] can be attributed to the transmission and reception of data. When a transmitter transmits a message unit to a receiver and its distance is indicated by d, the transmitting and receiving power of the antenna is indicated as gt and gr respectively, so that the energy consumption in the transmitter can be calculated as

$$E_t = E_{r,min} \frac{(4\Pi d)^{\theta}}{g_t g_r \propto^2} f^2 \quad (5)$$

B. Energy Consumption of SU

In our system model, as mentioned above, SUs are probably in two states: no spectrum detection and spectrum detection.

C. The Energy Consumption of SU Node without Spectrum Sensing

If the SU have sufficient spectrum resources to transmit the data, they do not need to detect the spectrum. In this case, the energy consumption of CRSN as a common WSN occurs in the SU transmission phase, the SU reception phase and the transmission of data with the ISM frequency channel phase [3]. Therefore, we can obtain that the total energy consumption of the transmission of the κ bit data can be expressed as

$$E_1 = k(E_{sutx} + E_{ism}) + kE_{sutx} \quad (6)$$

where EISM is the 1-bit data energy consumption transmitted by the ISM channel. ESUtx and ESUrx indicate the power consumption of the transmitter and SU receiver when 1-bit data is transferred between them.

D. The Energy Consumption of SU Node with Spectrum Sensing

If the SU does not have sufficient spectrum resources, they must perform a spectrum detection and have the opportunity to use the inactive channel without Pus [3-5]. In this case, the transmission of data between the SU transmitter and the SU receiver includes detection phase, decision phase, switching phase, transmission phase and reception phase. If a channel is occupied by detection, the SUs do not need to change the current ISM frequency channel to another channel. In this case, by comparing cases without spectrum detection, more energy is consumed in spectrum detection and decision making. Therefore, the power consumption of bit k packet transmission can be expressed as

$$E_{busy} = E_{sp} + E_d + k(E_{sutx} + E_{ism}) + kE_{surx} \quad (7)$$

$$E_{idle} = E_{sp} + E_d + E_h + k(E_{sutx} + E_{sc}) + kE_{surx} \quad (8)$$

IV.SIMULATION

In this section, we run MATLAB simulations to find optimal next spectrum interval based on current spectrum results. In all simulations, we assume the parameters C_{01} = 0.5, P_{10} = 0.7, E_b = 1pJ/bit, d = 60m, r = 3, f = 200MHz, fISM = 2.5GHz, κ = 1000 bit, E_{SUtx} = 50nJ/bit, ESUrx = 50 nJ/bit, Eh = 1mJ, and Esc = 20mJ.

Fig.1 shows the energy consumption at busy state and Fig.2 shows the energy consumption at idle state and Fig.3 shows the probability of false alarm

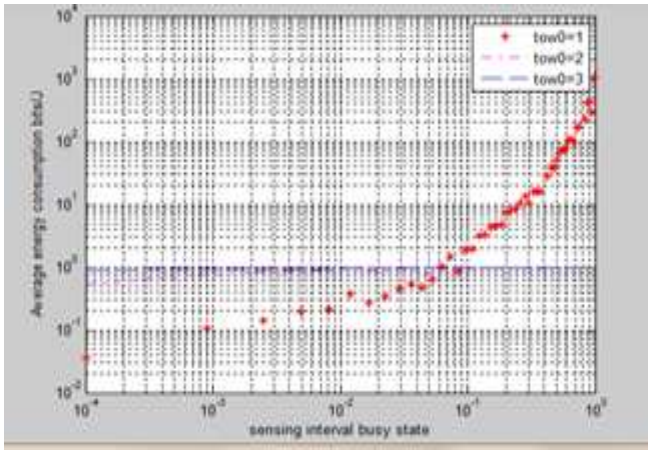

Fig.1 Energy consumption at busy state

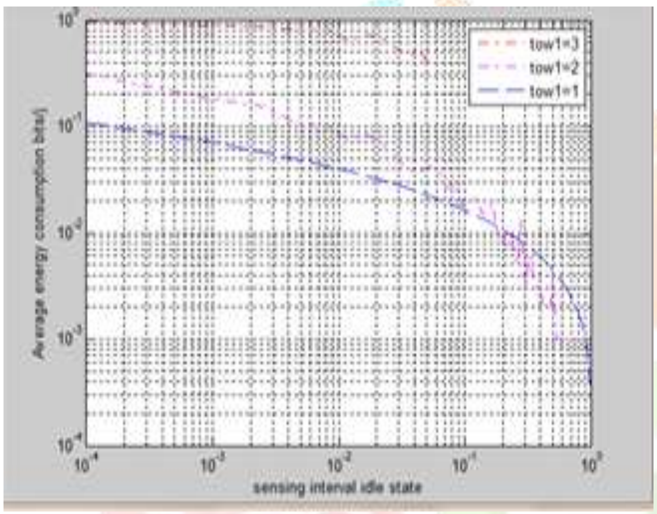

Fig.2 Energy consumption at idle state

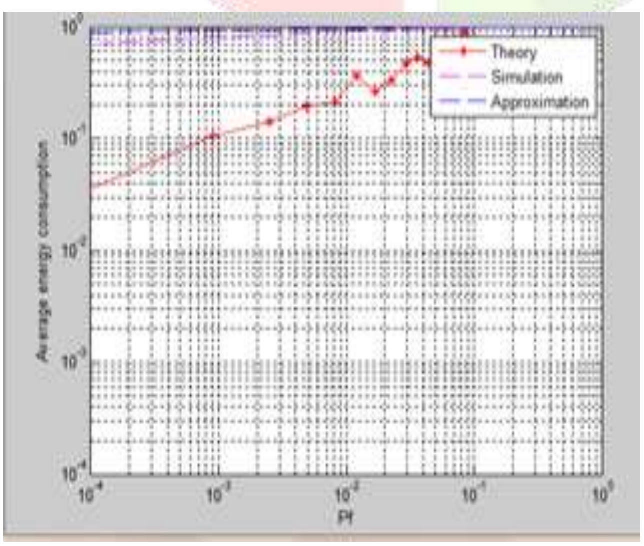

Fig.3 Probability of false alarm

II. CONCULSION

The proposed system is a study that uses the markov model with state prediction for the detection of the spectrum in crsn. there is an optimal range of spectrum detection that reduces total energy consumption. the results of the simulation show that, due to the non-fixed detection time interval, the forecasting scheme can reduce energy consumption. this suggests that the user's operating model is used to achieve an optimal spectrum detection time interval. it can alleviate energy consumption to improve the energy efficiency of CRSN.

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