Research on Spectrum Detection Technology in Cognitive Radio

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Abstract. The shortage of spectrum resources has hindered the development of the new wireless multimedia technology. Cognitive radio (CR) technology can successfully deal with the growing demand and scarcity of the wireless spectrum. Through this technology the unlicensed users can use the underutilized spectrum without any harmful interference to the licensed users. The spectrum sensing problem is one of the most challenging issues in cognitive radio systems to detect the available frequency bands. This paper introduces the spectrum sensing technology of cognitive radio and summarizes the result of simulation experiment based on GNU Radio and hardware platform.

Keywords: Cognitive radio · Spectrum sensing · GNU Radio
Hardware platform

1 Introduction

In recent years, wireless technology has entered a prosperous period of a rapid development. The increasing of wireless user and the emerging wireless multimedia applications are leading to an insatiable demand for radio spectrum. But the shortage of spectrum resources has hindered the development of them. So people put forward the initial hypothesis of CR technology. CR is formally defined by FCC as a radio that can change its transmitter parameters based on interaction with the environment in which it operates.

This paper reviews the research status of the simulation experiment of spectrum sensing technology of cognitive radio technology and GNU Radio hardware platform based on the development and more about ideas and put forward a new measurement method is helpful. Section 2 of this paper introduces the spectrum detection technology. In Sect. 3, we have described the simulation experiment and the results of the spectrum detection technology based on GNU Radio in the hardware platform. Then Sect. 4 summaries prospect of the spectrum detection technology of CR.

2 Spectrum Detection

In CR systems, when unlicensed users use the band allocated to licensed users for communication should not interfere with the communication of licensed users. So spectrum detection is one of the key technologies for CR system to detect the spectrum

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environment efficiently and reliably. Generally, spectrum sensing technology can be roughly divided into transmitter detection, cooperative detection and interference detection. Transmitter detection techniques used to identify licensed users by detect the weak signal from the licensed users' transmitter. In general, detection problem is analyzed as a binary hypothesis model, defined as (1):

$$x(t) = \begin{cases} n(t) & H_0 \\ hs(t) + n(t) & H_1 \end{cases} \tag{1}$$

where x(t) is the signal received by CR during observation window T, n(t) represents the additive white Gaussian noise (AWGN) with mean 0 and variance σ2, s(t) represents the transmitted signal from primary user which is to be detected and h is the channel gain. This is a classic binary signal detection problem in which CR has to decide between two hypotheses, H0 and H1. H0 corresponds to the absence of primary signal in scanned frequency band while H1 indicates that the spectrum is occupied.

3 Simulation of Hardware Platform Based on Energy Detection

3.1 Energy Detection

Energy detection is the common way for the detection of unknown primary signals in spectrum sensing for its low computational and implementation complexities. Energy detection judges the energy accumulation in a certain frequency band. If the detected energy is higher than the threshold, it is considered that there is the licensed users' signal. If the threshold is lower than the threshold, it is considered that there is only the noise. The principle of energy detection is that the energy of the signal plus noise must be greater than the energy of the existence of the noise. In addition, it is more generic as receivers do not need any knowledge on the primary users' signal [1]. It is the optimal detector when the secondary user cannot gather sufficient information about the primary user signal [2]. Here is the formula (2):

$$E\left\{(s(t)+n(t))^2\right\} = E\left\{s^2(t)\right\} + E\left\{n^2(t)\right\} > E\left\{n^2(t)\right\} \tag{2}$$

In this formula the signal and noise are independent of each other, and the noise is zero mean value. According to the time and frequency domain energy detection can be divided into two types. In this paper we use frequency domain energy detector. Frequency domain energy detection model is shown in Fig. 1:

Fig. 1. The modle of frequency domain energy detection.

3.2 GNU Radio and Hardware Platform

GNU Radio is an open source software radio project launched by Blossom Eric. It is a tool that can serve the users around the world to study and create a software defined radio system. When connecting the RF hardware, the composition of Radio GNU is easy to form a software radio software platform, which is used to carry out the simulation experiment of sending and receiving data.

3.3 Experiment Simulation

We use Hack RF ONE as the experimental platform whose frequency range is 10 MHz–6 GHz. In the frequency range of the receiver, the energy detection can be carried out for any frequency band. TVWS is our measurement band. By measuring the occupancy of this frequency band and analyzing the usage of the frequency band, we can get the simulation results. In the simulation experiment the first thing is setting the center frequency and sampling bandwidth. We set the sensing range 698–806 MHz and 2 MHz as the sampling bandwidth. FFT is 256. The hardware platform will collect and save the signal data. By stepping into the tuning, we can get a wide range of signal spectrum data. Finally, using these data, we draw the corresponding spectrum. Figure 2 is the spectrum sensing data graph under simulation environment. Figure 3 is the spectrum occupancy map in this frequency band.

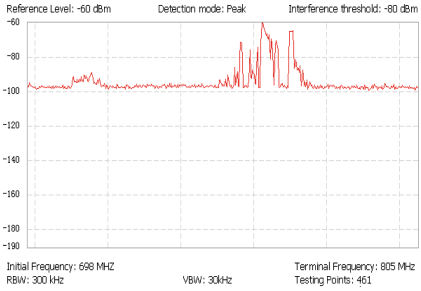

Fig. 2. Spectrum sensing data graph

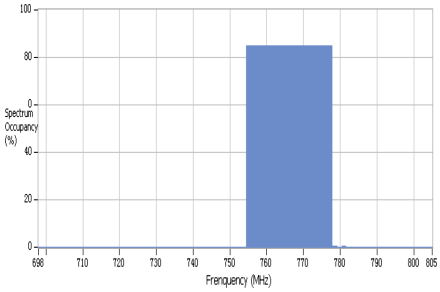

Fig. 3. Spectrum occupancy map

We can clearly see that the occupancy rate of 755–780 MHz band is higher. The result is similar with the spectrum analyzer. It can be known that the simulation of hardware platform based on energy detection can accurately detect the main user signal. And the complexity is low, the accuracy is high. In summary, after spectrum sensing, we can have a better understanding of the use of the current spectrum, and then through the opportunity spectrum access, improving the use efficiency of the spectrum.

4 Conclusion

Cognitive radio technology is the key to solve the shortage of spectrum resources effective method, spectrum detection technology as one of the key technologies of cognitive radio, is the basis of theory research of cognitive radio technology, is a kind of cognitive radio to the premise of practical application. In this paper, the simulation experiment is carried out by GNU Radio and hardware platform. We can come to the conclusion that the prospect of CR is very attractive, but it is not mature at present. In the future, we should do a deeper research on the theory of spectrum sensing algorithm which focused more on implementation-friendly, low-complexity sensing algorithms that are robust enough to provide required sensing performance with demanded reliability in minimum time.

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