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Spectrum Sensing in Cognitive Radio

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Abstract— During the last few decades, the severe shortage of radio spectrum has been the main motivation always used by researchers in the field of wireless communications. It has been believed that this shortage is mainly due to the physical scarcity of radio spectrum and to the rapid spread of diverse devices with wireless-interaction capability, such as mobile phones, laptop computers, home appliances, wireless tags, etc. Traditional and common approaches to solve this problem have been to increase the number of bits that can be transmitted per unit time and frequency, resulting in high capacity within a given frequency bandwidth. To this end, considerable research effort and fund have been spent to develop advanced wireless access technologies, and a lot of research is still ongoing all over the world. However, a recent report published by the federal communication commission (FCC) in US has shown a surprising finding, which highlights a different cause of the shortage of frequency resource: "In many bands, spectrum access is a more significant problem than physical scarcity of spectrum, in large part due to legacy command-and-control regulation that limits the ability of potential spectrum users to obtain such access". Thus, the large part of the licensed spectrum is not utilized most of the time and space, and the frequency spectrum is actually abundant. Cognitive radio has been proposed as a means to achieve such dynamics. A cognitive radio senses the spectral environment over a wide frequency band and exploits this information to opportunistically provide wireless links that can best meet the demand of the user, but also of its radio environments. The cognitive-radio devices have two important functionalities: spectrum sensing and adaptation.

Key words: Spectrum Sensing, Cognitive Radio

I. INTRODUCTION

Cognitive radio (CR) is an intelligent wireless communication system that is aware of its surrounding environment, learns from the environment and adapts its internal states to statistical variations in the incoming RF stimuli by making corresponding changes in certain operating parameters in real time. The primary objectives of the cognitive radio are to provide highly reliable communications whenever and wherever needed and to utilize the radio spectrum efficiently. The key issues in the cognitive radio are awareness, intelligence, learning, adaptivity, reliability, and efficiency.

The term cognitive radio was first suggested by Mitola. He defines the cognitive radio as a radio driven by a large store of a priori knowledge, searching out by reasoning ways to deliver the service the users want. The cognitive radio is reconfigurable and built on the software-defined radio (SDR). The software-defined radio (SDR) denotes a class of reprogrammable or reconfigurable radios, meaning that the same piece of hardware can perform different functions at different times. In this project, we are going to use a energy detection technique to sense a vacant spectrum. It is easiest method for detection of unknown signals. It measures the energy in the received waveform over an observation time window.

II. CLASSIFICATION OF SPECTRUM SENSING TECHNIQUES

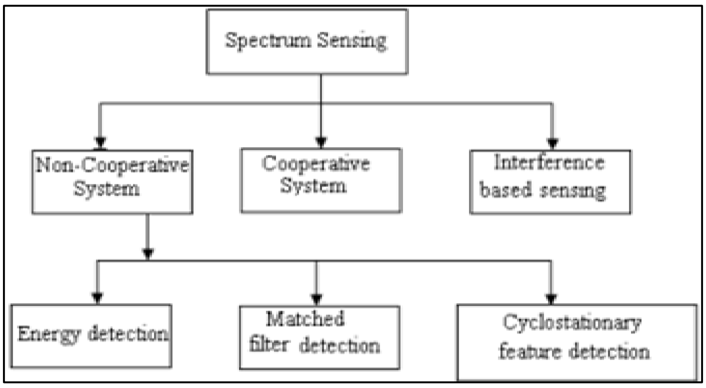

Fig. 1: Classification of spectrum sensing techniques

Figure shows the detailed classification of spectrum Sensing techniques. They are broadly classified into three main types, transmitter detection or non-cooperative sensing, cooperative sensing and interference based sensing. Transmitter detection technique is further classified into energy detection, matched filter detection and cyclostationary feature detection.

Primary Transmitter Detection-Energy Detection It is a non-coherent detection method that detects the primary signal based on the sensed energy. Due to its simplicity and no requirement on a priori knowledge of primary user signal, energy detection (ED) is the most popular sensing technique in cooperative sensing.

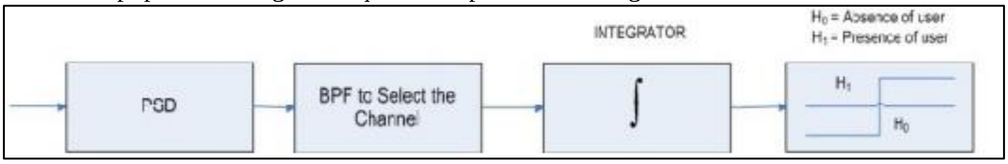

Fig. 2: Energy detector block diagram.

The block diagram for the energy detection technique is shown in the Figure. In this method, signal is passed through band pass filter of the bandwidth W and is integrated over time interval. The output from the integrator block is then compared to a predefined threshold. This comparison is used to discover the existence of absence of the primary user. The threshold value can set to be fixed or variable based on the channel conditions. The ED is said to be the Blind signal detector because it ignores the structure of the signal. It estimates the presence of the signal by comparing the energy received with a known threshold ν derived from the statistics of the noise. Analytically, signal detection can be reduced to a simple identification problem, formalized as a hypothesis test. However ED is always accompanied by a number of Disadvantages, sensing time taken to achieve a given probability of detection may be high detection performance is subject to the uncertainty of noise power. ED cannot be used to distinguish primary signals from the CR user signals. As a result CR users need to be tightly synchronized and refrained from the transmissions during an interval called Quiet Period in cooperative sensing. ED cannot be used to detect spread spectrum signals.

III. BLOCK DIAGRAM

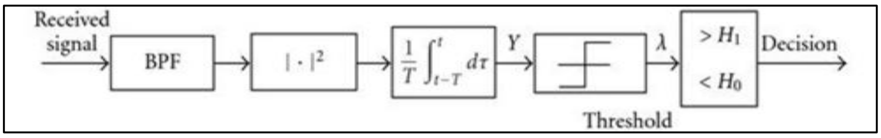

Fig. 3: Block diagram of energy detection.

IV. BLOCK DIAGRAM DESCRIPTION

The input signal y(t) is filtered with a bandpass filter (BPF) in order to limit the noise and to select the bandwidth of interest. The noise in the output of the filter has a band-limited, flat spectral density.

Next, the figure there is the energy detector consisting of a squaring device and a finite time integrator. The output signal V from the integrator is.

$$V = \frac{1}{T}\int_{t-T}^{t} |y(\tau)|^2 \, d\tau .$$

This output signal V is compared to the threshold η in order to decide whether a signal is present or not.

The threshold η is set according to statistical properties of the output V when only noise is present. The energy detector is also often referred to as a quadratic detector.

If the value of the output V is greater than the threshold, it means the spectrum is busy.

And if the value of the output V is less than the threshold, it means the spectrum is available or vacant for secondary users.

V. PROJECT IMPLEMENTATION

The implementation simplicity of the energy detector makes it favourable candidate for spectrum sensing task. However, the performance of the energy detector is highly susceptible to noise level uncertainty. We are building this project by using two software's mainly Matlab and Netsim.

MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. A proprietary programming language developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, Fortran and Python.

Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing capabilities. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded systems.

The MATLAB application is built around the MATLAB scripting language. Common usage of the MATLAB application involves using the Command Window as an interactive mathematical shell or executing text files containing MATLAB code.

NetSim is a popular network simulation and network emulation tool used for network design & planning, defense applications and network R & D. Various technologies such as Cognitive Radio, Wireless Sensor Networks, Wireless LAN, Wi Max, TCP, IP, etc. are covered in NetSim.

NetSim comes with an in-built development environment, which serves as the interface between User's code and NetSim's protocol libraries and simulation kernel. Protocol libraries are available as open C code for user modification. De-bugging custom code during simulation is an advanced feature: i.e. a simulation can be started and then at user determined breakpoints in the code, users can perform single-step, step-in, step over etc. This can be carried out at various levels (depending on where the user code links) including at a per-packet interval.

Using NetSim modeling & simulation services are provided in a variety of networking technologies and protocols including MANET, Wi-Fi, Wi-Max, IP, MPLS, WSN, QoS, VoIP etc. This can help avoid the time consuming process of programming, customization and configuration commercial simulators to meet customer specific needs.

VI. ADVANTAGES

A. Overcome Radio Spectrum Scarcity

By sensing spectrum utilization (irrespective of channel allocation), cognitive radios can broadcast on unused radio spectrum, while still avoiding interference with the operation of the primary licensee.

B. Avoid Intentional Radio Jamming Scenarios

By sensing channel availability and even predicting the jammer's tactics , cognitive radios can evade jamming by dynamically and preemptively switching to higher quality channels.

C. Switch to Power Saving Protocol

By switching to protocols that trade off lower power consumption for lower bandwidth, cognitive radios conserve power when slower data rates suffice.

D. Improve Satellite Communications

By predicting rain fade and reconfiguring transmitters/receivers for optimum bandwidth, cognitive radios improve communication quality when and where the information is needed most.

E. Improves Quality of Service (QoS)

By sensing environmental and inadvertent man-made radio interferences, cognitive radios can select frequency channels with a higher Signal to Noise Ratio (SNR).

F. Applications

1) Military and Public Security Applications

Conventional WSNs are used in many military and public security applications, such as:

- chemical biological radiological and nuclear (CBRN) attack detection and investigation;
- command control;
- gather the information of battle damage evaluation;
- battlefield surveillance;
- intelligence assistant
- targeting, etc.

In the battlefield or in disputed regions, an adversary may send jamming signals to disturb radio communication channels [34,35]. In such situations, because CR-WSs can handoff frequencies over a wide range, CR-WSNs can use different frequency bands, thereby avoiding the frequency band with a jamming signal. In addition, some military applications require a large bandwidth, minimum channel access and communication delays.

2) Health Care

In a health care system, such as telemedicine, wearable body sensors are being used increasingly. Numerous wireless sensor nodes are placed on patients and acquire critical data for remote monitoring by health care providers. In 2011, the IEEE 802.15 Task Group 6 (BAN) [36] approved a draft of a standard for body area network (BAN) technology. Wireless BAN-assisted health care systems have already been in practice in some remote areas of developing countries, such as in Nepal and India [37,38]. Wireless BAN for healthcare systems is suitable for areas, where the number of health specialists is relatively low.

Medical data is critical, delay and error sensitive. Therefore, the limitation of traditional WSN, as discussed in the previous section confines the potentiality of telemedicine. The QoS may not be achieved at a satisfactory level if the operating spectrum band is crowded in convenient 'telemedicine with BAN'. The use of 'CR wearable body wireless sensors' can mitigate these problems due to bandwidth, jamming and global operability.

VII. CONCLUSION

Proposed project makes the Communicating Spectrum more efficient for now and for future purpose. Here user will get best quality of service. It improve satellite communication, with the help of this network block can be avoided. This is very much useful in military and public security purpose. It also helps in health care sector.

VIII. Future Scope

There is always a chance to improve any system as research and development is an endless process. The following improvements can be done to our project:-

- Mobile Application based on coginitive radio features
- The overhead and optimization in congitive radio function, specially in spectrum sensing and sharing Fem to cells over TV white spaces.
- Cognitive radio in the fifth generation

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