SPECTRUM SENSING IN OFDM USING TRELLIS CODE IN COGNITIVE RADIO SYSTEMS

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Abstract - *The growing demand of wireless applications has put a lot of constraints on the usage of available radio spectrum which is limited and precious resource. However, a fixed spectrum assignment has lead to under utilization of spectrum as a great portion of licensed spectrum is not effectively utilized. Cognitive radio is a promising technology which provides a novel way to improve utilization efficiency of available electromagnetic spectrum. Spectrum sensing helps to detect the spectrum holes providing high spectral resolution capability. Cognitive radios are designed in order to provide highly reliable communication for all users of the network, wherever and whenever needed and to facilitate effective utilization of the radio spectrum. Spectrum sensing aims to determine spectrum availability and the presence of the licensed utilize the unused primary (licensed) bands commonly referred to as white spaces. The proposal is a shows the relationship between the BER and SNR and also the energy detection is noted .*

***Key Words*: Cognitive Radio, Spectrum Sensing, Filter Detection , Trellis Code**

1.INTRODUCTION *(Size 11 , cambria font)*

Cognitive radio is a form of wireless communication where a transceiver can intelligently detect the channels for communication which are in use and which are not in use, and move into unused channels while avoiding occupied ones. This optimizes the use of available radio-frequency spectra while interference is minimized to other users. This is a paradigm for wireless communication where transmission or reception parameters of network or node are changed for communication avoiding interference with licensed or unlicensed users. A spectrum hole is generally a concept of spectrum as non-interfering, considered as multidimensional areas within frequency, time and space. For secondary radio systems, the main challenge is to be able to sensing spectrum hole.when they are within such frequency bands. Cognitive radio is an intelligent wireless communication system that is aware of its surrounding environment and uses the methodology of understanding by building to learn from the environment and adapt its internal states to statistical variations in the incoming radio frequency stimuli by making corresponding changes in certain operating parameters in real time, with two primary objectives in mind: highly reliable communications whenever and wherever needed and efficient utilization of radio spectrum.

1.1 SPECTRUM SENSING

The spectrum sensing function enables the cognitive radio to adapt to its environment by detecting the primary users that are receiving data within the communication range of an CR user. In reality, however, it is difficult for a cognitive radio to have a direct measurement. of a channel between a primary transmitter detection based on local observations of CR users. In the spectrum has been classified into three types by estimating the incoming RF stimuli, thus, black spaces, grey spaces and white spaces. Black spaces are occupied by high power local interferer some of the time and unlicensed users should avoid those spaces at that time. Grey spaces are partially occupied by low power interferers but they are still candidates for secondary use. White spaces are free RF interferers except for ambient noise made up of natural and artificial forms of noise e.g. thermal noise, transient reflection and impulsive noise. White spaces are obvious 2 candidates for secondary use. With development in cellular radio and personal communications, subscribers have grown manifold. To accommodate the growth of subscribers, additional bandwidth is required but the availability of Electromagnetic spectrum is limited and there is severe competition for the available bandwidth.

Telecommunication regulatory bodies allocate fixed bandwidths depending on different technical standards, regulatory requirements and applications. The bandwidth allocation is different for different countries and it depends on the geographical conditions of the country. A fixed set of bandwidth is reserved for Military applications which are set apart from commercial use. It is hence not possible for the telecommunication regulatory bodies to continually change/migrate the allocated bandwidth for adding new standards in the existing spectrum. It is observed that even after efficient allocation of bandwidth by the telecommunication regulatory body, the spectrum is used inefficiently. The Figure1.1 illustrates the occupancy of the spectrum, it is seen that the spectrum is not prudently used and there are void spaces or holes in the spectrum. The reasons for the under utilization of the spectrum are The occupancy of the spectrum is high during the day time and less during the night time.

The presence of guard bands in the spectrum to prevent adjacent channel interference. The current project is not targeted to locating guard bands. Guard bands reduce the sensitivity to spectral leakage in multicarrier communication.

Spectrum holes are not stable and they migrate with frequency and time as shown in the Figure1.2.The spectrum sensing algorithm should be fast enough to rapidly detect the moving holes in the spectrum in real time. Spectrum sensing is also computational expensive and requires special hardware to implement. Furthermore in the case of Low SNR scenario the noise power affects the operation of the spectrum
The spectrum sensing algorithm used must be sensitive enough to distinguish between the signal power and the noise power. The main objective of this paper is to simulate Energy Detection using MATLAB for the purpose of spectrum sensing in cognitive radio and to plot Receiver Operating Characteristics (ROC).

2. SPECTRUM SENSING TECHNIQUES

Classification of Spectrum sensing techniques

- Energy detection
- Matched filter detection
- Cyclo stationary Feature detection
- Interference-based detection

2.1 MATCHED FILTER DETECTION

A matched filter (MF) is a linear filter designed to maximize the output signal to noise ratio for a given input signal. When secondary user has a priori knowledge of primary user signal, matched filter detection is applied. Matched filter operation is equivalent to correlation in which the unknown signal is convolved with the filter whose impulse response is the mirror and time shifted version of a reference signal. Matched filter detection needs less detection time because it requires only O (1/SNR) samples to meet a given probability of detection constraint. When the information of the primary user signal is known to the cognitive radio user, matched filter detection is optimal detection in stationary gaussian noise.

- However ED is always accompanied by a number of disadvantages
- *(i)* Matched filter detection requires a prior knowledge of every primary signal.
- *(ii)* If the information is not accurate, MF performs poorly.
- *(iii)* MF is that a CR would need a dedicated receiver for every type of primary user.

2.2 CYCLO STATIONARY FEATURE DETCTION

It exploits the periodicity in the received primary signal to identify the presence of primary users (PU). The periodicity is commonly embedded in sinusoidal carriers, pulse trains, spreading code, hopping sequences or cyclic prefixes of the primary signals. Cyclostationary signals exhibit the features of periodic statistics and spectral correlation, which is not found in stationary noise and interference.Thus, cyclostationary feature detection is robust to noise uncertainties and performs better than energy detection in low SNR regions. Although it requires a priori knowledge of the signal characteristics, cyclostationary feature detection is capable of distinguishing the CR transmissions from various types of PU signals. This eliminates the synchronization requirement of energy detection in cooperative sensing. Moreover, CR users may not be required to keep silent during cooperative sensing and thus improving the overall CR throughput. This method has its own shortcomings owing to its high computational complexity and long sensing time.

2.3 INTERFERENCE BASED DETECTION

In general, primary receiver emits the local oscillator (LO) leakage power from its RF front end while receiving the data from primary transmitter. It has been suggested as a method to detect primary user by mounting a low cost sensor node close to a primary user's receiver in order to detect the local oscillator (LO) leakage power emitted by the RF front end of the primary user's receiver which are within the communication range of CR system users. The local sensor then reports the sensed information to the CR users so that they can identify the spectrum occupancy status. It is noted that this method can also be used to identify the spectrum opportunities to operate CR users in spectrum overlay.

2.4 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. 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 derived from the statistics of the noise. Analytically, signal detection can be reduced to a simple identification problem, formalized as a hypothesis test.

3. GENERAL MODEL

In this section, we first present the general model for spectrum sensing, then review the energy detection scheme and analyze the relationship between the probability of detection and the probability of false alarm. Suppose that we are interested in the frequency band with carrier frequency f_c and bandwidth W and the received signal is sampled at sampling frequency f_s. When the primary user is active, the discrete received signal at the secondary user can be represented as

$$y(n) = s(n) + u(n),\ldots(1)$$

which is the output under hypothesis H1. When the primary user is inactive, the received signal is given by

$$y(n) = u(n),\ldots\ldots\ldots (2)$$

and this case is referred to as hypothesis H0. We make the following assumptions.

The noise u(n) is a Gaussian, independent and identically distributed (iiid) random process with mean zero and variance

$$E[|u(n)|^2] = \sigma^2(u)$$

The primary signal s(n) is an iid random process with mean zero and variance

$$E[|s(n)|2] = \sigma s ;$$

The primary signal s(n) is independent of the noise u(n). Denote as the received signal-to-noise ratio (SNR) of the primary user measured at the secondary receiver of interest, under the hypothesis H1.

Two probabilities are of interest for spectrum sensing: probability of detection, which defines, under hypothesis H1, the probability of the algorithm correctly detecting the presence of primary signal; and probability of false alarm, which defines, under hypothesis H0, the probability of the algorithm falsely declaring the presence of primary signal. From the primary user's perspective, the higher the probability of detection, the better protection it receives. From the secondary user's perspective, however, the lower the probability of false alarm, there are more chances for which the secondary users can use the frequency bands when they are available. Obviously, for a good detection algorithm, the probability of detection should be as high as possible while the probability of false alarm should be as low as possible.[7]

3.1 TRANSMISSION AND RECEPTION METHOD

The Orthogonal Frequency Division-Multiplexing (OFDM) is one of the most popular technologies used in broadband wireless communication systems like WiMAX, DVB-T or ADSL. One of the main practical issues of the OFDM is the Peak-to-Average Power Ratio (PAPR) of the transmitted signal. Large signal peaks requires the power amplifiers (PA) to support wide linear dynamic range. causes non-linear distortions leading to an inefficient operation of PA causing intermodulation products resulting unwanted out-of-band power. In order to reduce the PAPR of OFDM signals, many solutions have been proposed and analyzed. The efficiency of these methods can be evaluated considering their characteristics of nonlinearity, amount of processing and size of side information needed to be sent to receiver. This method of encoding digital data on multiple carrier frequencies. OFDM has developed into a popular scheme for wideband digital communication, used in applications such as digital television and audio broadcasting, DSL Internet access, wireless networks, powerline networks, and 4G mobile communications.

OFDM is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels. Each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase-shift keying) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth.

The primary advantage of OFDM over single-carrier schemes is its ability to cope with severe channel conditions (for example, attenuation of high frequencies in a long copper wire, narrowband interference and frequency-selective fading due to multipath) without complex equalization filters. Channel equalization is simplified because OFDM may be viewed as using many slowly modulated narrowband signals rather than one rapidly modulated wideband signal. The low symbol rate makes the use of a guard interval between symbols affordable, making it possible to eliminate intersymbol interference (ISI) and utilize echoes and time-spreading (on analogue TV these are visible as ghosting and blurring, respectively) to achieve a diversity gain, i.e. a signal-to-noise ratio improvement. This mechanism also facilitates the design of single frequency networks (SFNs), where several adjacent transmitters send the same signal simultaneously at the same frequency, as the signals from multiple distant transmitters may be combined constructively, rather than interfering as would typically occur in a traditional single-carrier system.

The orthogonality also allows high spectral efficiency, with a total symbol rate near the Nyquist rate for the equivalent baseband signal (i.e. near half the Nyquist rate for the double-side band physical passband signal). Almost the whole available frequency band can be utilized. OFDM generally has a nearly
'white' spectrum, giving it benign electromagnetic interference properties with respect to other co-channel users

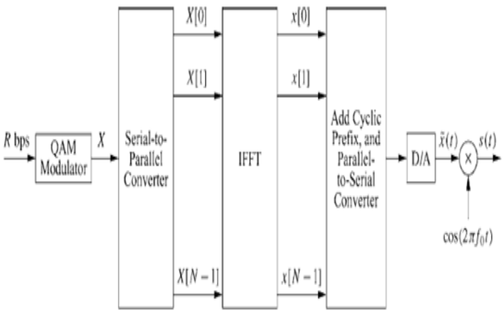

Fig.1 OFDM Transmitter

The receiver picks up the signal r(t), which is then quadrature-mixed down to baseband using cosine and sine waves at the carrier frequency. This also creates signals centered on 2fc, so low-pass filters are used to reject these. The baseband signals are then sampled and digitized using analog-to-digital converters (ADCs), and a forward FFT is used to convert back to the frequency domain. This returns N parallel streams, each of which is converted to a binary stream using an appropriate symbol detector. These streams are then re-combined into a serial stream, s[n], which is an estimate of the original binary stream at the transmitter.

In OFDM, the message bits are grouped in blocks $\{X_n, n=0,1,\ldots,N-1\}$, and modulates in amplitude a set of N subcarriers,$\{f_n, n=0,1,\ldots,N-1\}$. These subcarriers are chosen to be orthogonal, that is $f_n=n\Delta f$, where $\Delta f=1/T$, and T is the OFDM symbol period.

$$x(t)=\frac{1}{\sqrt{N}}\sum_{n=0}^{N-1}X_n e^{j2\pi f_n t}\ .$$

3.2 TRELLIS CODE

The name trellis derives from the fact that a state diagram of the technique closely resembles a trellis lattice. The scheme is basically a convolutional code of rates (r,r+1). Ungerboeck's unique contribution is to apply the parity check for each symbol, instead of the older technique of applying it to the bit stream then modulating the bits. He called the key idea mapping by set partitions. This idea groups symbols in a tree-like structure, then separates them into two limbs of equal size. At each "limb" of the tree, the symbols are further apart.

3.3 ENERGY DETECTION UNDER AWGN CHANNELS

Energy detection is the most popular signal detection method due to its simple circuit in practical implementation. The principle of energy detector is finding the energy of the received signal and compares that with the threshold. In the literature, we come across various algorithms indicating that energy detection can be implemented both in time and also frequency domain using Fast Fourier Transform(FFT).

4. RESULTS AND DISCUSSION:

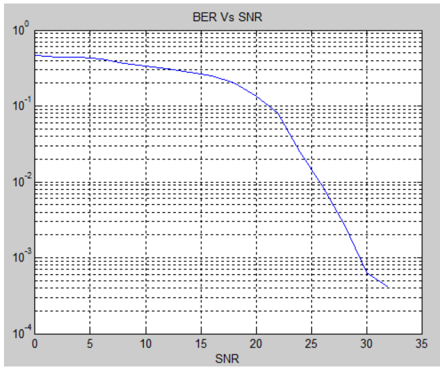

Fig 2 Simulation Result of OFDM

The given below output of the Orthogonal frequency division multiplexing for transmission and reception of signals between primary user and the secondary user.

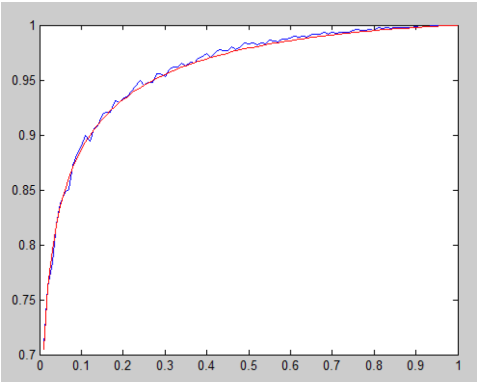

Fig 3 Simulation Results Energy Detection

The given below output of the spectrum sensing by Energy Detection for the detection of spectrum from primary user(Licensed user) to /secondary user (unlicensed user).

CONCLUSION

After executing the program from the obtained graphs we can say that as the energy plot between probability energy detection and probability of false alarm. As from the graph as SNR value reduces more detection of signal crosses the false alarm thereby we can say that we use this technique how effectively we can use the spectrum sensing under noise to detect the signal presence in the spectrum band. Where the false probability is used to indicate the signal presence by getting each point of detection through the signal band of frequencies spectrum.

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