RF Band Detection and Utilization in Wireless Communication

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Abstract- *The purpose of this paper is to provide an overview and summary of the fundamental meaning and concepts of radio-frequency and wireless communication systems. It begins with a 2 summary of the history of wireless communications in general, from the first radio-frequency communication system to current cellular mobile radio systems. It then proceeds with the concept of radio wave propagation, forms of wireless communication systems and techniques, and the basic concept of cellular mobile radio communication. It classifies wireless communications into categories of related technology by grouping related concepts together. With subtopic Spectrum sensing is the key function in implementing cognitive radio, which enables secondary users to identify and utilize vacant spectrum resource allocated to primary users. Recent studies have proposed four major sensing methods, including matched filter, energy, feature, and eigen value-based detectors.. In a constant noise environment, the performance of the proposed detector approaches that of an ideal radiometer. Hence the proposed method has been implemented using sensing technique and different rules are been implemented.*

Keywords* — *Radio, Frequency, Wireless communication, Mobile, Spectrum, Sensing, Detector.

I. INTRODUCTION

Current wireless networks are characterized by a static spectrum allocation policy, where governmental agencies assign wireless spectrum to license holders on a long-term basis for large geographical regions. Recently, because of the increase in spectrum demand, this policy faces spectrum scarcity in particular spectrum bands. In contrast, a large portion of the assigned spectrum is used sporadically, leading to underutilization of a significant amount of spectrum [1]. Hence, dynamic spectrum access techniques were recently proposed to solve these spectrum inefficiency problems. The key enabling technology of dynamic spectrum access techniques is cognitive radio (CR) technology, which provides the capability to share the wireless channel with licensed users in an opportunistic manner. CR networks are envisioned to provide high bandwidth to mobile users via heterogeneous wireless architectures and dynamic spectrum access techniques. This goal can be realized only through dynamic and efficient spectrum management techniques. Cognitive radio (CR) has opened up a new way of sensing and utilizing precious wireless spectrum resources. CR is a dynamically reconfigurable radio that can adapt its operating parameters to the surrounding environment, which has been made feasible by recent advances such as software-defined radio (SDR) and smart antennas. Using such CR devices enables flexible and agile access to the wireless spectrum, which can, in turn, improve efficiency in spectrum utilization significantly. In particular, CR is considered key to resolving the soon-to-occur spectrum scarcity problem. Recent measurement studies have shown that the licensed spectrum bands are severely underutilized at any given time and location [1-2], mainly due to the traditional *command-and-control* type spectrum regulation that has prevailed for decades. Under such a spectrum policy, each spectrum band is assigned to a designated party, which is given an exclusive spectrum usage right.

Given the limitations of the natural frequency spectrum, it becomes obvious that the current static frequency allocation schemes can not accommodate the requirements of an increasing number of higher data rate devices. As a result, innovative techniques that can offer new ways of exploiting the available spectrum are needed. *Cognitive radio* arises to be a tempting solution to the spectral congestion problem by introducing opportunistic usage of the frequency bands that are not heavily occupied by licensed users [1-2]. While there is no agreement on the formal definition of cognitive radio as of now, the concept has evolved recently to include various meanings in several contexts [3]. Other sensing methods are referred when needed as well. Although spectrum sensing is traditionally understood as measuring the spectral content, or measuring the radio frequency energy over the spectrum; when cognitive radio is considered, it is a more general term that involves obtaining the spectrum usage characteristics across multiple dimensions such as time, space, frequency, and code. . It also involves determining what types of signals are occupying the spectrum including the modulation, waveform, bandwidth, carrier frequency, *etc.*. However, this requires more powerful signal analysis techniques with additional computational complexity.

Spectrum sensing is the process of periodically monitoring a specific frequency band aiming to identify presence or absence of primary users. spectrum sensing cognitive radio is use to detect channels in the radio frequency spectrum cognitive radio is an adaptive intelligent radio an network technology that can automatically detect available channel in a wireless spectrum and change transmission parameters in enabling more communication to run con currently and also improve radio operating behavior to avoid the cognition between different frequency band.

II.THEORY

1. Radio Frequency Band

1.1 RF (Radio frequency)

The remarkable success of cellular mobile radio and other wireless technology has fundamentally changed the way people communicate and conduct business. The wireless revolution has led to a new multi-billion-dollar wireless communications industry. Linking service areas, wireless communication has altered the way business is conducted. For example, with a laptop computer, a wireless modem, and a cellular phone, a business consultant can contact his or her office and clients and conduct business while traveling. Field service and sales personnel can access corporate databases to check inventory status, prepare up-to-the-minute price and delivery quotes, modify schedule activities, and fulfill orders directly to the factory while traveling. Company personnel can use two-way paging services to stay in close contact, even when traditional wired communication services are available. Handheld hybrid phonecomputer-fax machines feed information to wireless communication networks, allowing an executive to make decisions while on a leisure outing.

2. Wireless communication

Wireless communication involves the transmission of information over a distance without the help of wires, cables or any other forms of electrical conductors. Wireless communication is a broad term that incorporates all procedures and forms of connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices.

2.1 Features of Wireless Communication

The evolution of wireless technology has brought many advancements with its effective features.
The transmitted distance can be anywhere between a few meters (for example, a television's remote control) and thousands of kilometers (for example, radio communication)
Wireless communication can be used for cellular telephony, wireless access to the internet, wireless home networking, and so on.
Other examples of applications of radio wireless technology include GPS units, garage door openers, wireless computer mice, keyboards and headsets, headphones, radio receivers, satellite television, broadcast television and cordless telephones.

2.2 Wireless: Advantages

Wireless communication involves transfer of information without any physical connection between two or more points. Because of this absence of any 'physical infrastructure', wireless communication has certain advantages. This would often include collapsing distance or space. Wireless communication has several advantages; the most important ones are discussed below: **1]Cost Effectiveness:**Wired communication entails the use of connection wires. In wireless networks, communication does not require elaborate physical infrastructure or maintenance practices. Hence the cost is reduced.
Example: Any company providing wireless communication services does not incur a lot of costs, and as a result, it is able to charge cheaply with regard to its customer fees.

Flexibility:

Wireless communication enables people to communicate regardless of their location. It is not necessary to be in an office or some telephone booth in order to pass and receive messages. Miners in the outback can rely on satellite phones to call their loved ones, and thus, help improve their general welfare by keeping them in touch with the people who mean the most to them.

Convenience:

Wireless communication devices like mobile phones are quite simple and therefore allow anyone to use them, wherever they may be. There is no need to physically connect anything in order to receive or pass messages.

Speed:

Improvements can also be seen in speed. The network connectivity or the accessibility were much improved in accuracy and speed.

Accessibility:

The wireless technology helps easy accessibility as the remote areas where ground lines can't be properly laid, are being easily connected to the network.

Constant connectivity:

Constant connectivity also ensures that people can respond to emergencies relatively quickly.

3. Spectrum sensing

Sensing means to identify free frequency band in the radio environment and plays an important role in CR. The main task of CR is to detect the existence of the primary user by secondary user and to leave the frequency band if the corresponding primary radio emerges in order to prevent interferences to primary users .

Basically spectrum sensing technique is broadly classified into two main types. They are: Direct sensing technique and Indirect sensing technique. Frequency Domain is other name for Direct sensing where signal approach is carried out for estimation. Time domain is another name for Indirect sensing where autocorrelation of signal is used to carry out estimation.

4. Cognitive Radio

Cognitive radio (CR) has opened up a new way of sensing and utilizing precious wireless spectrum resources. CR is a dynamically reconfigurable radio that can adapt its operating parameters to the surrounding environment, which has been made feasible by recent advances such as software-defined radio (SDR) and smart antennas. Using such CR
Devices enabe flexible and agile access to the wireless spectrum, which can, in turn, improve efficiency in spectrum utilization significantly. In particular, CR is considered key to resolving the soon-to-occur spectrum scarcity problem. Recent measurement studies have shown that the licensed spectrum bands are severely underutilized at any given time and location [1, 2], mainly due to the traditional command-and-control type spectrum regulation that has prevailed for decades. Under such a spectrum policy, each spectrum band is assigned to a designated party, which is given an exclusive spectrum usage rightfor a specific type of service and radio device.

IV.METHODOLOGY

SPECTRUM SENSING

Following are the methods of spectrum sensing:
1] Energy Detection.
2] Match Filter Detection.
3] Cyclostationary Detection .
4] Distributed.
5] Centralized.

1. Energy Based detection:-

This is a most common method of spectrum sensing because of low complexity and computational cost. The receivers do not require any prior knowledge on the primary user‟s signal. Energy detection can be done by comparing energy of a received signal in a certain frequency band to properly set decision threshold. If the signal energy is greater than the decision threshold, then the frequency channel is said to be busy else the channel is supposed to be free and could be accessed by the CR users [10]. The block diagram for Energy detection technique is shown in the figure 4. Energy Detector has band pass filter which gives the frequency of interest by limiting the bandwidth of received signal, square law device which squares each term of received signal and a summation device which sums all the square values to compute the energy. In this energy detection, energy of an averaged signal is subjected to two hypothetical test functions.
H0 (PU is absent)
H1 (PU is in operation)
Under H0
X[n] = w[n]; (occurrence of noise only)
Under H1
X[n] = s[n] + w[n]; (occurrence of signal with noise)
Here n = 0,1,2….,N-1,N shows the index of sample, w[n] designate the noise and s[n] is the primary signal to detect.

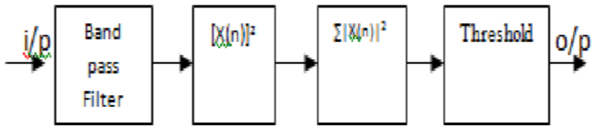

FIG: ENERGY BASED DETECTION

2. Match Filter Detection:-

Match filter is a linear filter used to increase the signal to noise ratio (SNR) for a given input. This method is optimal in the sense it maximizes the SNR, minimizing the decision errors. The basic need of this detection is the prior knowledge on the received signal such as bandwidth, modulating type and order, operating frequency and pulse shaping. Basically work performed is equal to the correlation in which Match filter which is linear filter correlates the signal with time shifted version and analyze the final output of match filter and predetermined threshold will determine the presence of primary user. The block diagram of the Match filter is shown in the figure 5.

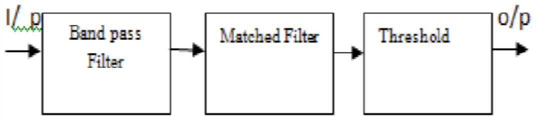

FIG: MATCH FILTER DETECTION

Input is fed through band pass filter which will measure the energy around the related band. The output signal of the BPF is convolved with the match filter whose impulse response is same as the reference signal. The output of match filter is compared with the threshold to detect the presence or absence of primary user.
The operation of the Matched filter is given below:
Y[n] = h [n-k] x[k] Where x is unknown signal convolved with the „h‟, the impulse response of the matched filter that is matched to the reference signal for maximizing SNR.

3.Cyclostationary feature detection:-

This process basically depends on periodicity or statistics of mean or autocorrelation of the signal that vary periodically over time. This periodicity is used in received signal to represent the existence of the primary users [11] [12]. The cyclic correlation factor (SCF) is the key point for detecting the primary user signal. Block diagram of Cyclostationary based detection is shown in the figure 3.1.3.

Modulated signals are in general coupled with cosine carrier, repeating spreading, over-sampling etc., resulting in built-in periodicity. When the signal's mean and auto- correlation exhibit periodicity, i.e., $m_x(t+T)= m_x(t)$, $R_x(t+T,u+T)=R_x(t,u)$, we call this signal a second- order cyclic statistics process[8].
The auto-correlation of signal ( )*xt* is defined as

$$R_x(t,\tau) = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=N}^{N} x(t+\tau/2+nT_0)\,x^*(t-\tau/2+nT_0)$$

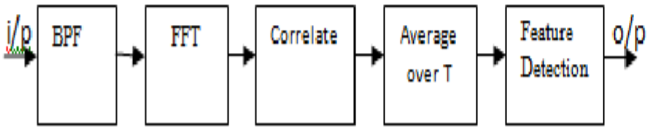

FIG: CYCLOSTATIONARY CYCLE DETECTION

Above fig. shows the block diagram of cyclostationary method of the sensing.
To obtain the average detection performance of this scheme, we simulate 1000 independent runs from SNR 0 dB to -20 dB with 0.01 and calculate the average detection rate. Figures 3-5 compare the observed detection performance of the proposed scheme with that of energy detection with known and unknown noise variance (± 1dB uncertainty) and cyclostationary detection without using FRESH filter.

V.SIGNAL DETECTION

Signal detection theory (SDT; [10, 12]) has provided a simple yet powerful methodology for distinguishing between sensitivity (an observer's ability to discriminate stimuli) and response bias (an observer's standards for producing different behavioral responses) in stimulus discrimination tasks. In tasks where an observer rates his confidence that his stimulus classification was correct, it may also be of interest to characterize how well the observer performs in placing these confidence ratings. For convenience, we can refer to the task of classifying stimuli as the type 1 task, and the task of rating confidence in classification accuracy as the type 2 task [2]. As with the type 1 task, SDT treatments of the type 2 task are concerned with independently characterizing an observer's type 2 sensitivity (how well confidence ratings discriminate between an observer's own correct and incorrect stimulus classifications) and type 2 response bias (the observer's standards for reporting different levels of confidence).

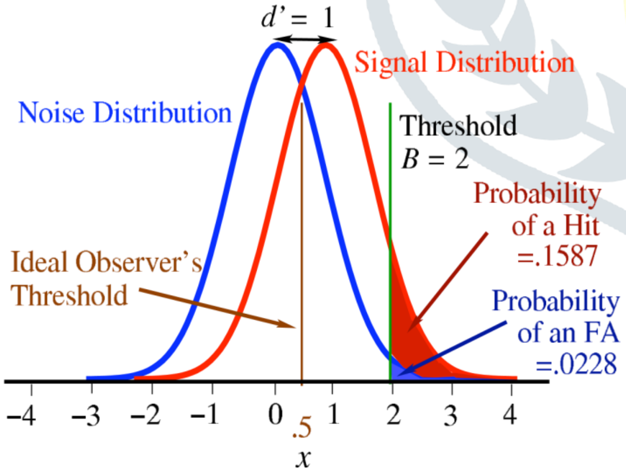

FIG.4.1. SDT MODEL

above, the distribution of the noise is centered at zero (*i.e.*, mean of Figure illustrates the SDT model. The *x*-axis shows the intensity of underlying hidden variable (*e.g.*, familiarity for the face example). As indicated the noise is equal to zero, with a standarddeviationof1. So, the standard deviation of the noise is equivalent to the unit of measurement of *x*. The distribution of the signal is identical to the noise distribution, but it is moved to the right of the noise distribution. The distance between the signal and the noise distributions corresponds to the effect of the signal (this is the quantity that is added to the noise distribution in order to get the signal distribution): this distance is called *d*′. Because the mean of the noise distribution is zero, *d*′ is equal to the mean of the signal distribution.

VI.RESULT AND ANALYSIS

APPROXIMATION IN THE LOW SNR REGIME

We study the approximation of our proposed detector for MPSK modulated primary signals in the low SNR regime. When $x \to 0, \cosh(x) \approx 1 + \frac{x^2}{2}$ *and* $\ln(1+x) \approx x$ we can obtain:

$$\sum_{k=0}^{N-1} ln\left(\sum_{n=0}^{\frac{M}{2}-1} \cosh(v_n(k))\right)$$

Through approximation, the detector structure becomes:

$$T_{L-ABD-1} = \frac{1}{N}\sum_{k=0}^{N-1} |r(k)|^2 \gtrless \frac{N_0}{\gamma}\left(\gamma + \frac{\ln \epsilon}{N}\right)$$

APPROXIMATION IN THE HIGH SNR REGIME

We consider the high SNR regime in this section. When $x \gg 0, cosh(x) \approx \frac{e^x}{2}$ or when $x \ll 0, cosh(x) \approx \frac{e^{-x}}{2}$

The detector structure becomes

$$T_{H-ABD} = \sum_{k=0}^{N-1}\left(ln\left(\sum_{n=0}^{M/2-1} e^{\frac{2}{N_0}\Re[r(k)h^* e^{-j\varphi n(k)}]}\right)\right) \gtrless \gamma + lnM$$

A special case of MPSK signals, we assume a real signal model for BPSK modulated primary signals. The suboptimal BD detector employs the sum of received signal magnitudes to detect the presence of primary signals in the high SNR regime, which indicates that energy detector is not optimal in this regime.

FALSE ALARM PROBABILITY

The false alarm probability is

$$\begin{aligned} P_F &= P\left(T_{\mathrm{L-ABD-1}} > \frac{N_0}{\gamma}\left(\gamma + \frac{\ln \epsilon}{N}\right)|\mathcal{H}_0\right) \\ &= Q\left(\frac{\frac{N_0}{\gamma}(\gamma + \frac{\ln \epsilon}{N}) - \mu}{\sigma}\right) \\ &= Q\left(\frac{\ln \epsilon}{\gamma\sqrt{N}}\right). \end{aligned}$$

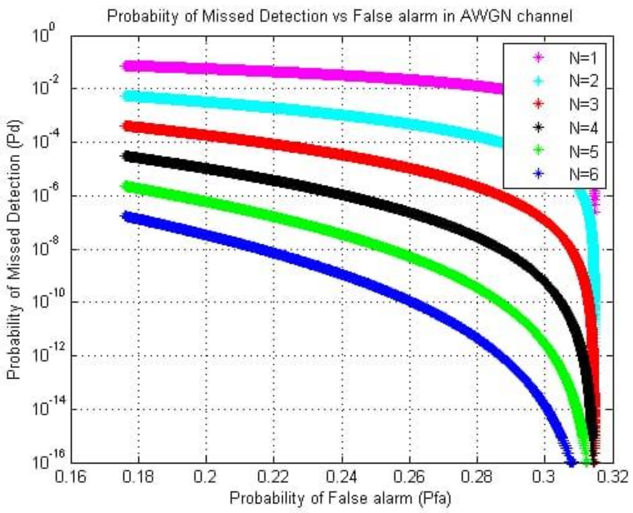

FIG: 6.1

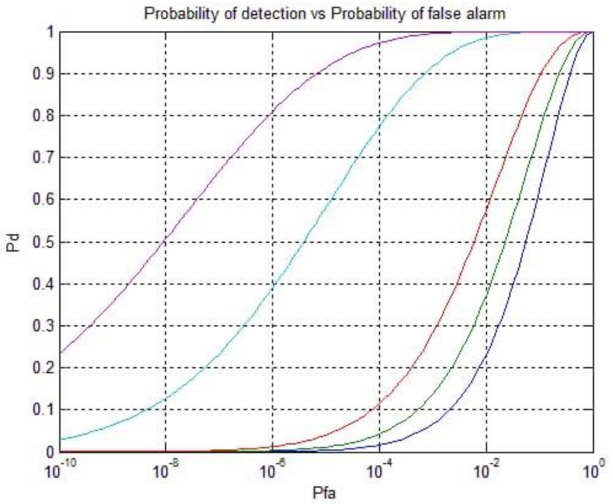

FIG: 6.2

DETECTION PROBABILITY

The probability that the search object will be detected under given conditions if it is in the area search. The probability an object will be detected given all known error and noise source.

$$\begin{aligned} P_D &= P\left(T_{\mathrm{L-ABD-1}} > \frac{N_0}{\gamma}\left(\gamma + \frac{\ln\epsilon}{N}\right)\middle|\mathcal{H}_1\right) \\ &= Q\left(\frac{\frac{N_0}{\gamma}\left(\gamma + \frac{\ln\epsilon}{N}\right) - \mu}{\sigma}\right) \\ &= Q\left(\frac{\ln\epsilon - N\gamma^2}{\gamma\sqrt{N(1+2\gamma)}}\right), \end{aligned}$$

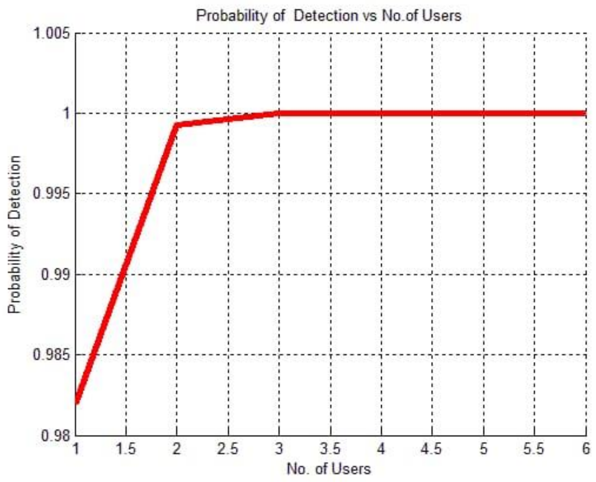

FIG: 6.3

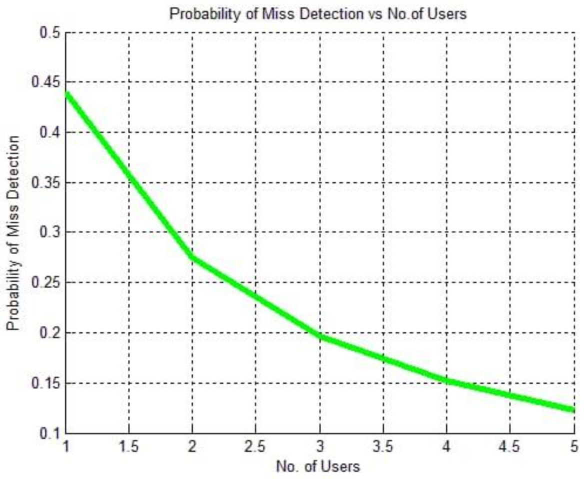

FIG: 6.4

VII.CONCLUSION

This paper present the conceptual model of the spectrum sensing. In that we can try to find the best spectrum sensing method. And propose they dynamic spectrum sensing which improve the effective utilization of RF Band.

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