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Research Article

Spectrum Sensing In Cognitive Radio Network: A Survey

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ABSTRACT

Cognitive radio is emerging technology in wireless communication, the main approach of cognitive radio is to proper utilization of spectrum, it means some time all the allotted bands are not fully utilized ,the unused band can be intelligently utilized by secondary user. In this paper some of the CR techniques are discussed.

Keywords : Cognitive radio, Spectrum sensing

1. INTRODUCTION

In our daily life, gadgets like as TV controllers, PDAs, individual computerized aides (PDA), satellite TV inputs or versatile PCs are supported on remote innovation and still numerous new advancements are rising, which request more range and transmission capacity for quicker development. The static spectrum allotment strategies cause underutilization of spectrum assigned to primary user(PU), hence requesting dynamic allotment of spectrum rather than static.

As of late there have been creating interests in intellectual radio, anywhere optional artful radio endeavors entrepreneurially range left-overs, or supposed "White spaces", by methods for information on the earth and comprehension capacity, and adjusts their radio boundaries appropriately The up and coming IEEE 802.11af norm (well-known as “super-WiFi” or “Power over Ethernet”) depends on cognitive radio (CR), using the transmission capacity inside TV broadcast stations.

CR utilizes the use of band by permitting to the subordinate user when the PU is in inactive state. The subordinate users are needed to check the presence of PU with a high possibilities of discovery then the empty the location otherwise decrease the transmitting power. For IEEE 802.1l af norm, time to clear band laterprimary user’s discovery is 2 second along with 90% of likelihood

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of identification then 10% of likelihood of bogus caution at SNR close as small as -20dB alongside geo-area precision of +/- 50m. Detecting a range might be a critical undertaking withiin CR.

Many detection techniques containing the likelihood relation testing(LRT), energy discovery method(ED), matching filter technique(MF), and cyclostationarity discovery method, every one of which has various necessities alongside its focal points or drawbacks. Despite the fact that the LRT has been demonstrated to remain ideal, it remains incredibly hard to use as it needsparticular channel data and conveyance of signal sources and impedance. To utilize the LRT aimed at identification, we should initially distinguish the channel, just as the signal and commotion circulation, which is for all intents and purposes unsolvable

The MF-based technique requires ideal information on the channel reaction after the primary client to the beneficiary and legitimate synchronization (in any case the exhibition will be radically decreased). The energy identification strategy is semi-dazzle location, where information on the noise power is just expected to distinguish a signal. The assortment of receiver operational curves (ROC) is plotted for a few data transmission items for range identification utilizing energy recognition. In the visually impaired consolidated energy utilization strategy, which utilizes the spatial connection of the got signal dependent on energy location, is investigated on an autonomous and indistinguishably disseminated signal source, which is a FM regulated radio sign utilized in free TV Channels with a functioning recurrence band working - Less than 200 kHz and multipath blurring channels..

A trial study to catch range in the 2.4 GHz0ISM band over the 85 MHz band utilizing energy identification for sinusoidal media and the QPSK sensor is at present being assessed. A similar reference esteem gauges the base perceptible signal level, which is dictated by the vulnerability of the receiver noise. The cyclostation discovery measure requires knowing the cyclic recurrence of the essential client, which may not be practical for some, range reuse applications. Moreover, this strategy places unnecessary requests on analog to digital (A/D) converters and sign handling abilities.

In reference, another calculation for range discovery is proposed which depends on the covariance of the got signal and is alluded to as the Covariance-Absolute-Value (CAV). CAV is a visually impaired discovery strategy, utilizes space-time signal relationship to distinguish signals that don't need information on signal impedance and force. The covariance of signal and commotion is generally extraordinary, which can be utilized to distinguish PU.

In, the performance of ED and CAV was assessed by the Advanced Television Systems Committee (ATSC) (used in the US and South Korea) using a 6 MHz bandwidth for narrowband signals from wireless microphones by analyzing several antennas. In, ROC bend for the remote receiver signal is investigated for the outside condition with the Rician channel, and the extra identification likelihood () comparative with the leveling factor is analyzed for the remote microphone signal.

Additionally, in d versus various estimations of SNR’s are read for ATSC indication with single and numerous radio wires which is closed by the impact of time variation channel on the identification of ATSC signal. Be that as it may, inside the ROC bend and hence the impact of time-variation Rayleigh station utilizing ED and CAV range detecting calculations on discovery

of ATSC sign has not stayed examined. Extra CAV techniques for the DVB-T customary for the 8 MHz band were not assessed.

Meanwhile cognitive radio is another innovation, the capacity with respect to the range affectability calculation must be investigated under various channel blurring conditions.

In today's wireless communication proper spectrum utilization is the prime consideration. The frequency spectrum is not used properly by all the licensed user maximum time spectrum will be unused, the unused spectrum can be used intelligently by cognitive radio method.

CR is the intelligent radio network that can detect automatically free unused channels inwireless communication, the frequency spectrum is limited and it is divided into spectrum bands, the frequency bands are allotted to different applications or services like mobile, fixed satellite etc, most of these services required the licensed band for operation, the presently frequency bands are limited and are not easily available so proper utilization of frequency spectrum is required.

In figure.1 its shown that large number of assigned spectrum is not used properly, large portion is under utilized.The proper utilization frequency band is obtained by using the cognitive radio, this method automatically detects the unused frequency bands and allot to the secondary user without effecting the primary users.

In the year 1998 Joseph mitola proposed the concept of the cognitive radio, later in the year 1999 same author published the paper on Cognitive radio, in 2000 same author obtained Ph.D on cognitive radio, from year 2000 to 2020 so many researcher worked and working on cognitive radio.

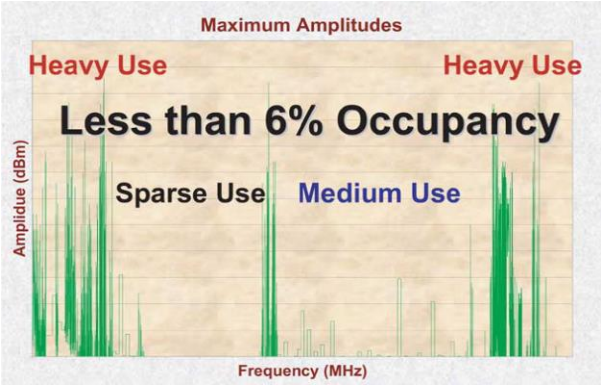

Fig.1 Spectrum usage [5].

Usually in communication network there will be two types of users PU and SU. PU are those who purchased the license to use spectrum. SU can use same spectrum when PU is not accessing the frequency spectrum. The Unused frequency spectrum can be accessed dynamically. The approach of CR can be used to satisfy requirements of mobile communication network by using dynamic resource management [11].

Cognitive radio function

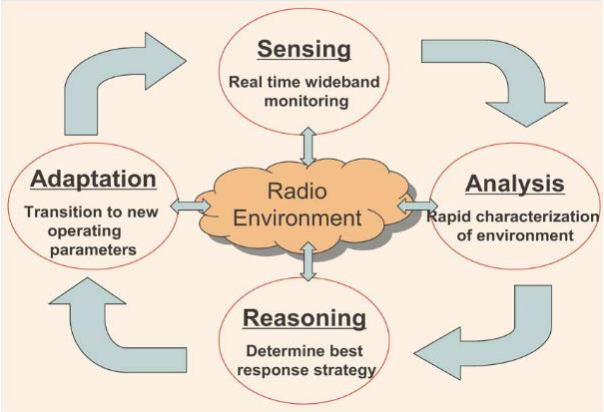

Figure 2. spectrum white space[5]

The duty cycle of CR is shown in figure 2. This consist of discovering of spectrum white space, optimum frequency band selection, spectrum access coordinating with other users and freeing out the freq bands when PU appears.

CR cycle functions:
spectrum sensing and analysis: here part of the freq band that is not used by the PU ,CR can detect the best frequency band
• spectrum management and handoff;
• spectrum allocation and sharing.
CR is one type of intelligent wireless communication method where sender and receiver distinguish the communication channels indigently, which are being used and not used, the user can move into the channels which are unused. This technology enhance and make proper utilization of available radio frequency spectrum.

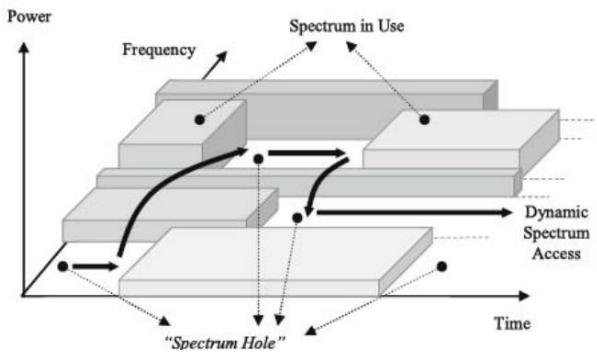

Figure 3. Spectrum hole [9]

Spectrumhole is as well called the white space [10] it is band of frequency allotted to primary users but some specific time band is not utilized by the user. It is the transmission opportunity in spectrum space.

Types of CR

Full CR:

This is also called mitolo radio full CR, in this type every possible parameters are observed by a wireless network is considered .

Spectrum sensing (SS) CR:

In this method radio spectrum freq is considered. In this paper it is discussed about the spectrum sensing methods in CR. The main idea for the CR network is that a SU can use a free band as long as PU required channels, once the primary user (PU) required the channel then secondary user (SU) must release the channels immediately and select alternative band.

The problem of the SS can be formulated by 2 hypothesis.

$$r(t)=\begin{cases} n(t) & H0 \\ s(t)+n(t) & H1 \end{cases}$$

where received signal r(t) secondary user , Transmitted signal s(t), primary user observed at secondary user & n(t) is the noise.
There are many methods of spectrum sensing.

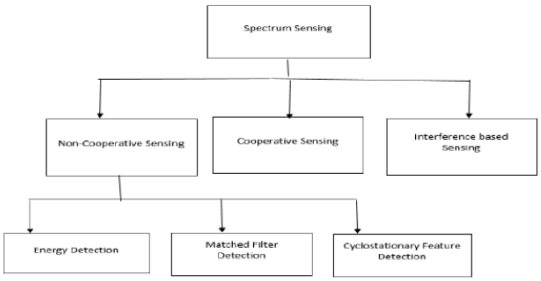

Figure 4: types of CR Sensing methods

Non-cooperative sensing:
In this type of method, CR users detect the PU presence of signal, here CR doesnot have prior knowledge of PU signals so it will differentiate the noise and signal.

Non Cooperative Sensing:
In this CR user have the prior knowledge about the signals, most popular methods are:

1. Energy detector (ED).
2. Matched filter (MF)
3. Cyclostationary detector (CD)
4. Covariance absolute value method.etc

Energy detector:

The ED technique is favorite detection technique, it thinks about the energy of the got waveform over a predefined time through an edge acquired in place of a given P_fa cutoff to choose whether essential signaloccurs otherwise not. For a givendata transmission of signal, a pre-channel must be applied by the transfer speed of the sign, in this method sensing device does not need any prior knowledge about the PU signals. In energy detection method it compares the energy of the received signal over the specified time along with threshold. Threshold is decided from noise energy & its precision (accuracy) is key of ED performance, if energy of received signal is higherthen threshold H1 hypothesis is validated & PU is present, otherwise H0 hypothesis is validated.

The below figure shows the block diagram of ED.This is the noncoherent detection technique which detects the primary signal in wireless communication on bases of energy sensed [1].

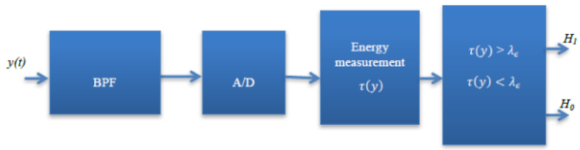

Figure 5 ED technique

Signal is received through antenna, signal is filtered by BPF for selection of channel, analog signal is converted in to discrete through A/D (analog to digital) convertor, output is squared & N sample average is obtained and test statistic is compared with threshold.

The decision formula for energy detector is [3][4]

TED== $\frac{1}{N}\sum_{n=0}^{N-1} \quad (|y(n)|))^2$

Where N is no. of samples , TED is matched with the threshold value to decide either signal is present or not, if TED is greater then threshold value, the signal is assumed to be present otherwise signal is assumed be absent.

Advantages:

- ✔ It simple and easy to implement
- ✔ In this method it is not demand the prior information about the primary signals

Disadvantages:

- ✔ Falsealarm is high
- ✔ It cannot distinguish the PU from other signal source

Matched filter

Another best spectrum sensing method in AWGN environment is the matched filter , it is the liner filter which boosts SNR in presence of additive noise. It needed prior information about PU signal , operation is same as correlation. In this received signal & filter responses are convolved which is reference signals time shifted version. When not known signal is compared with known signal, if both signals are similar then it assumed that PU is present in spectrum. If signals are not similar then it is assumed that spectrum is free & available for SU.

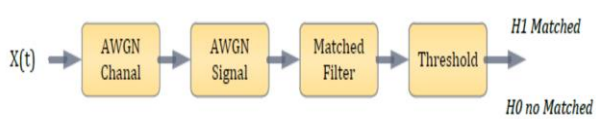

Figure 6 Matched filter Detection

In this type of method SU has a priori knowledge of PU signal,

The advantages

- ✔ More robust to noise
- ✔ Better signal detection
- ✔ It required very small amount of samples to achieve better detection

Disadvantage:

- ✔ It require prior knowledge about primary signals
- ✔ It is highly complex

Cyclostationary Detection

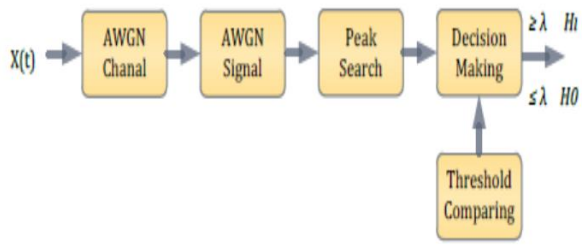

Figure 7 Cyclostationary Feature Detection

It is also called cyclostationary feature detection (CFD) this method considered the periodic redundancy into signal by modulation and sampling.

The CFD is effective where noise level is uncertain. Its because of AWGN channel spectral correlation function is zero by virtue of stationary properties. PU signals presence or absence can determined by property of stationeries. CFD output is compared with predefined threshold value to analyze PU signal presence or absences.

It make use of periodicity in received signal of primary to determine the presence of PU signals.

Advantages:

- ✔ It is more robust against noise
- ✔ Its detection is better in low SNR
- ✔ It can easily distinguish different types primary systems and transmissions

Disadvantages:

- ✔ Specific features must be with primary signals
- ✔ It require need to to introduced.

Is stationary [54],

Sensing methods Comparison

A wave form based sensing method is most robust then other sensing method, its because of coherent processing.

ED has the limited performance when common assumption can not hold. Noise can not be same and variance of noise may not be known, some other problem with ED is bases band filter effect[6].

Type of Detection	Advantages	Disadvantages
Energy Detection (ED)	It does not require prior knowledge information. Computational cost is less	Performance is lower when SNR is low.

		Its difficult to differentiate the users sharing the same channel
Matched Filter Detection	More robust to noise. Better Signal Detection. It required very small amount of samples to achieve better detection	It require prior knowledge about signals. It is highly complex
Cyclostationary Detection	It is more robust against noise Its detection is better in low SNR It can easily distinguish different types primary systems and transmissions	Specific features must be with primary signals It require need to to introduced. Is stationary

Cyclostationary sensing methos is worse then the energy detector when noise is stationary [5], however, in presence of co channel interference noise will becomes non stationary, hence Energy detector sensing method fails while CD based sensing methods are not effected [8], on other hand CD sensing method may lost fully because of channel fading [3], Some tradeoff must be considered while selecting the sensing method, primary user characteristics are the main factor while

Selecting sensing method.A basic comparison is shown in the figure, wave form based sensing method is most robust then other sensing method, its because of coherent processing. ED has the limited performance when common assumption can not hold. Noise can not be same and variance of noise may not be known, some other problem with ED is bases band filter effect[3].

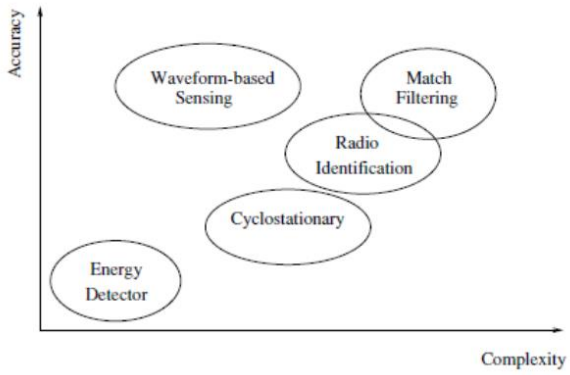

Figure. 8 different sensing methods.

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