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Efficient Spectrum Sensing Using Discrete Wavelet Packet Transform Energy Detection in Cognitive Radio

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Abstract

The detection based on wavelet technique is commonly used in image processing in those applications which involve edge detection. In this approach proposed by Tian and Giannakis, wavelets were made use of for the detection of edges in the Power Spectral Density of wide-band channel for spectrum sensing. The edges in power spectral density serve as the demarcation separating the various spectrum holes or white spaces, hence it helps to detect the vacant bands. On the basis of this information, an attempt has been made by using this wavelet based detection technique for sensing the spectrum in Cognitive Radio system and Comparatative Simulation Performance Analysis of Wavelet based Energy Detection has been described.

Keywords: Spectrum Sensing, Discrete Wavelet Packet Transform, Energy Detection, Cognitive Radio.

1.0 INTRODUCTION

Cognitive Radio is a comparatively new technology in which problems like underutilization of spectrum and spectrum scarcity is solved based on the revolutionary ideas. Cognitive Radio allows group of users to identify and access to available spectrum resources for their optimum use. Latest study reveals that major portion of the spectrum which is allocated as per FCC remains underutilized. On the contrary, the growing number of wireless multimedia applications lead to a spectrum shortage. Cognitive Radio has been seen as an apt technology for solving the imbalance between scarce spectrum and underutilized spectrum. Under Cognitive Radio environment, the sensing of the spectrum is done in order to trace the unused spectrum segments from target spectrum pool to use those segments in a fair optimal manner such that there should be no unwanted interference to the licensed primary user [1].The aim of the Cognitive Radio technology is to provide the maximum efficiency of spectrum to increase its utility by using dynamic spectrum access techniques. The key to enabling the maximum spectrum efficiency is to provide the capacity to share the wireless rf propagation channel with primary licensed users in the most efficient way and this goal can be achieved by spectrum management techniques that are dynamic and efficient. Cognitive radio is a fully programmable wireless device which can sense its environment and adapt the channel access methods, transmission waveforms, spectrum utilization and networking protocols in a dynamic manner as desired for a good network with application performance [2].The interesting feature of cognitive radio technology is the one in which the handsets would use underutilized spectrum automatically. Smartness of a radio is when it utilizes the available service from local accessible wireless computer based networks, and also that it interacts with network of protocols preferred on priority, without any problem of finding out the appropriate network for audio- video or data [3]. Moreover, frequencies selection and utilization minimizes interference with other already existing radio systems. For optimizing the usage of resources, the future generation networks need smart devices like Cognitive Radio to be capable of modelling the to model the location, networks, users in a larger environment. Various CR capabilities, which make it extra-ordinary from other radios. On the basis of the monitored set of these parameter values, Cognitive Radio can change or adjust itself according to appropriate frequency bands, interfaces and protocols [4].A CR can sense the wider bandwidth, detect the spectrum holes and use these holes for communication whenever required subject to condition that it does not create any interfere to the Primary User. The air interface for Cognitive Radio is dependent on four aspects [5].

1. Spectrum Sensing
2. Spectrum Management
3. Spectrum Sharing
4. Spectrum Mobility

This paper comprises of two Sections A, B. Section A has its focus on the Fast Spectrum Sensing using wavelet based Energy Detection for Cognitive Radio, using 1-level discrete wavelet packet transform function. Flowchart for the algorithm used for implementing the proposed scheme is discussed. Section B holds the Simulation Results using MATLAB Code where these simulated results are observed and interpreted in detail.

1.1.IEEE802.22WRANSENSINGARCHITECHTURE

Djaka Kesumanegara in his study in 2009 [6] mentioned two way sensing architecture as shown in Figure 1.The procedure is the architecture is performed in two basic steps. Use a wide-band antenna,wideband RF-front end and coarse energy detection scheme which is performed firstly to select the channel which is unoccupied, and then examine one of the channels by the Fine/Feature sensing to judge the incoming signal type and detect weak signals.

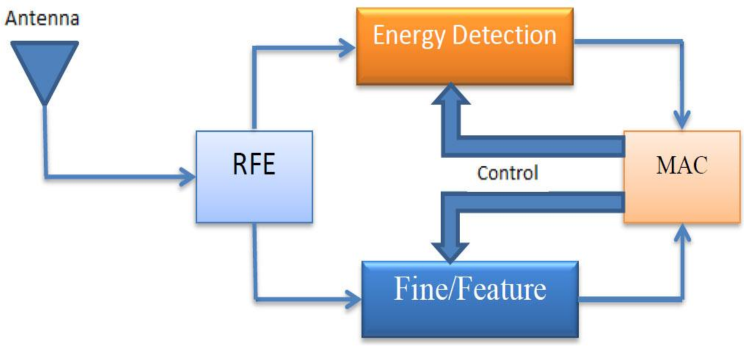

Figure.1 Two stage sensing Architecture [6]

1.2 ENERGY DETECTION

Energy Detection in 802.22 WRAN system using following two methods:

i. *Measurement of Received Signal Strength (RSSI):* It selects the unoccupied channels using received signal strength by converting the energy in an interested band to the input signal strength.

ii. *Multi-Resolution based Spectrum Sensing (MRSS):* in this it senses the band of interest in the analog domain using a wavelet transform using the features of Fourier Transform technique.

The energy detection schemes are performed in the wide band and need to compare the results with a specific threshold, faster sensing and determination of the threshold are vital parameters of the energy detection scheme[6-7].

1.3 FINE/FEATURE SENSING

The signal feature sensing detection and cyclostationary feature detection have been proposed in the sensing stage. The common disadvantage of this scheme is that, prior information about the features of possible incoming signal should be known.The energy detection scheme which can be used in IEEE 802.22 system has to sense the radio spectrum in a faster way by determining the threshold level. Djaka Kesumanegara in 2009 [6] discussed the energy detector for IEEE 802.22 WRAN using discrete wavelet packet transform for 3 Primary Users (PU) to alleviate these problems. In this study discrete wavelet packet transform for 5 Primary User (PU) has been discussed.

1.4 WAVELET BASED ENERGY DETECTOR

This technique is commonly used in image processing where applications which involve edge detection. In this approach, the wavelets were used for detecting the edges in Power Spectral Density of wideband channel for spectrum sensing. The edges in power spectral density are the boundary between spectrum holes hence it helps to find vacant bands [8]. Based on this information this wavelet based detection is used for Spectrum Sensing in Cognitive Radio systems.

1.4.1 POWER MEASUREMENT USING WAVELET

If the received signal, *r(t)*, is a periodic signal *T* then, the power signal is computed by

$$P = \frac{1}{T}\int_0^T r^2(t)dt \qquad (5.1)$$

r(t) is represented as

$$r(t) = \sum_k Cj0, k\emptyset, k(t)(t) + \sum_{j>j0}\sum_k dj, k\varphi, k(t) \qquad (5.2)$$

where '*Cjo, k'* and '*dj, k'* are scaling coefficients and wavelet coefficient respectively. So,the power of the received signal can be easily computed using the orthogonal wavelet and scaling functions properties

$$P = \frac{1}{T}\int_0^T r^2(t)dt \qquad (5.3)$$

$$= \frac{1}{T}\left[\int_0^T \left\{\sum_k Cjo, k\emptyset, k(t)(t) + \sum_{j>j0}\sum_k dj, k\varphi, k(t)\right\} \overset{2}{\rightarrow}\right]$$

$$= \frac{1}{T}\left[\sum_k Cj0^2, k + \sum_{j>j0}\sum_k dj, k\right] \qquad (5.4)$$

It means that the power of each sub band can be calculated using scaling and wavelet coefficients[9-10].

1.4.2 THE COMPLEXITY OF WAVELET ANALYSIS

Analysis of the number of mathematical operations, considering just multiplication, shows the complexity of the schemes. In discrete wavelet transform, there is *log2 N* level decomposition and only output of filter(low pass) goes through the next operation. Hence, the complexity can be calculated as

$$Complexity \quad = 2LN + 2\frac{LN}{2} + \cdots + \frac{2LN}{2^{(\log_2 N-1)}} \qquad (5.5)$$

$$= 2LN\,(2^0 + 2^1 + \cdots + 2^{(\log_2 N-1)}$$

where L is the length of high-pass and low-pass filters, if L<<N the complexity reaches 0(N). In discrete wavelet packet transform, the outputs of high pass filter go through the next operation[7].

1.5 PROPOSED APPROACH

In this section, how the proposed scheme senses primary (or licensed) users, using Frequency band of 1600 KHz and which is divided in 16 sub channels of bandwidth 100 KHz each. 5 Primary Users (PU) are taken and 1, Customer Premised Equipment (CPE) as shown in Figure 2 and whole procedure is examined for Discrete Wavelet Packet based Energy Detection meant for Spectrum Sensing in Cognitive Radio [11].

1.5.1 SIMULATION ENVIRONMENT

As shown in Figure 2, the environment for simulation is vertical sharing.There exist 5 primary users and 1, Customer Premise Equipment which can sense the interested frequency band (or scanning range) for the unlicensed secondary user. If we assume that each primary user signal is a sinusoid, then the received signal at the CPE is represented by

$$r(t) = a1\sin(2\pi f1t) + a2\sin(2\pi f2t) + a3(sin2\pi f3t) + a4(sin2\pi f4t) + a5(sin2\pi f5t) \quad (5.8)$$

Here '*aj*' and '*fj*' denote attenuation factor and centre frequency of each primary user signal , and *n(t)* is AWGN with zero mean variance. We assume that each primary user uses different channel, the interested frequency band, *Bi*, is 1600 KHz as there are 16 channels in the frequency band, Bi.

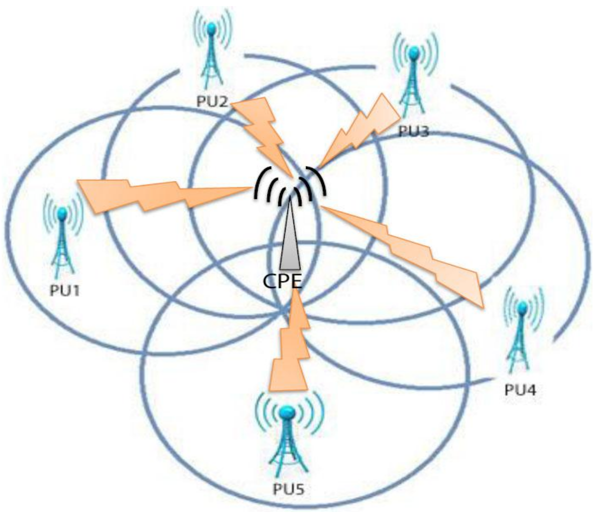

Figure 2 Simulation Environment Scenario[11]

1.5.2 FLOWCHART FOR PROPOSED APPROACH

The discrete wavelet packet transform can separate given frequency band into low frequency and high-frequency sub band. As mentioned before the wavelet based energy detector is designed based on this fact and it maintains the two stage sensing architecture. It is assumed that *Bi* and *Bc* are the interested frequency band (or scanning range) and the bandwidth of each channel respectively and the ratio of *Bi* and *Bc* is a power of 2. The procedure of the idea, wavelet based energy detector, is shown in Figure 3.

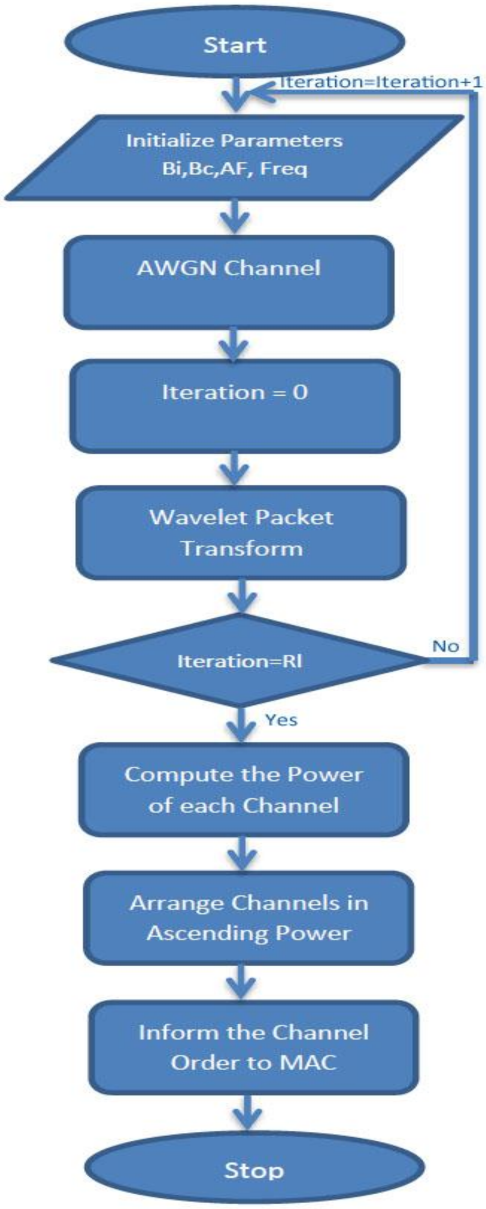

Figure 3 The flow process of Wavelet based Energy Detector[9-10].

The brief explanation of the flow chart for the proposed Wavelet based Energy Detection used for calculating the simulated resulted in MATLAB is given below:

1. Initialize the parameters Bi (Interesting frequency Band), Bc (channel Bandwidth), AF (Attenuation Factor), and Centre Freq. for Primary Users.
2. Passing the combined signal over the AWGN Channel.
3. Initialize the iteration parameter to 0.
4. 1-level Discrete Wavelet Packet Transform is Performed.
5. The iteration parameter is compared with *RI*. *RI* denotes required iteration number of wavelet packet transform and is calculated by log2 (*Bi*). If the iteration parameter equals to RI, it goes to the next step. If not, the 1-level discrete wavelet packet transform is performed again with increasing iteration parameter by 1.
6. Then the power of each channel is computed using wpdec toolbox.
7. Sorting of channels in the ascending order is further done on the basis of power of each channel.
8. The order of sorted channel index is informed to MAC to process the second sensing stage .i.e. fine/feature sensing.

1.5.3 SIMULATION AND RESULTS

Simulation is done using MATLAB R2011b (7.13). In the above simulation environment, there are 16 channels in Bi, B, is 100 KHz and 4-level discrete wavelet packet decompositions is performed. Power of the Channel is computed and sorted the indexes to channels in ascending order. The "db20" wavelet is used in the simulation. Assuming that each Primary User (PU) uses different channel, 5 PU's are considered in this case, Frequency Band is 1600 KHz and there are 16 channels in frequency band, the received signal at CPE is represented by the equation. Signal is passed through AWGN channel with SNR = -15db.

$$r(t) = a1\sin(2\pi f1t) + a2\sin(2\pi f2t) + a3(sin2\pi f3t) + a4(sin2\pi f4t) + a5(sin2\pi f5t)$$

(B.1)**Attenuation Coefficients**

Table 1 shows the parameter being used in the Matlab Simulation code where f1, f2, f3, f4 represents the centre frequency for PU1,PU2,PU3,PU4 respectively whereas the centre frequency for PU5 is changed and plotted so as in order to notice the different in power for each channel. The wavelet packet transform is performed in the received signal to generate the Fig 4 and it is seen that how the change in centre of frequency in f5, varies the power in each Sub-channel.

Table 1 Parameters for Simulation

Attenuation Factor	Value	Frequency	Value KHz	Frequency	Value KHz	Frequency	Value KHz
a1	0.05	f1	100	f1	100 KHz	f1	100 KHz
a2	0.025	f2	400	f2	400 KHz	f2	400 KHz
a3	0.0125	f3	700	f3	700 KHz	f3	700 KHz
a4	0.0062	f4	1100	f4	1100 KHz	f4	1100 KHz
a5	0.0031	f5(Blue)	600	f5(Green)	900 KHz	f5	1350 KHz

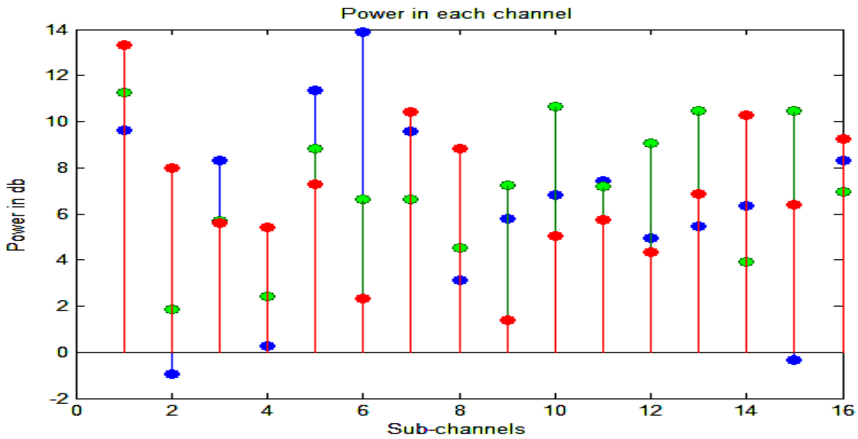

Figure 4. Power in each Channel for f5=600 KHz, 900 KHz, 1350 KHz.

We can simulate the algorithm above with MATLAB software by using the wpdec toolbox[18]. The tree decomposition showing how the method for Discrete Wavelet Packet Transform works is shown in Figure. 5.

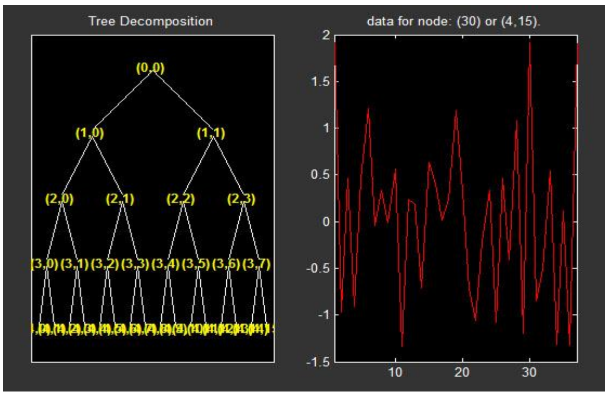

Figure 5. Tree Decomposition Discrete Wavelet Packet Transform.

The wavelet packet method is a generalization of wavelet decomposition where wavelet packet atoms are waveforms indexed by three natural interpreted parameters: position,scale as in wavelet decomposition, and frequency[12].

The simulation is performed considering three cases which are with different centre frequency for Primary Users (PU's) and varying *SNR* values.

CASE 1: Five Primary Users (PU's) with following centre frequency and AWGN SNR at 20db. Table 2 shows the parameters used in CASE 1.

Table 2 Parameters for CASE 1.

Attenuation Coefficient

Attenuation Factor	Value
a1	0.05
a2	0.025
a3	0.0125
a4	0.0062
a5	0.0031

PU Centre Freq.

Frequency	Value
f1	100 KHz
f2	400 KHz
f3	700 KHz
f4	1100 KHz
f5	1500 KHz

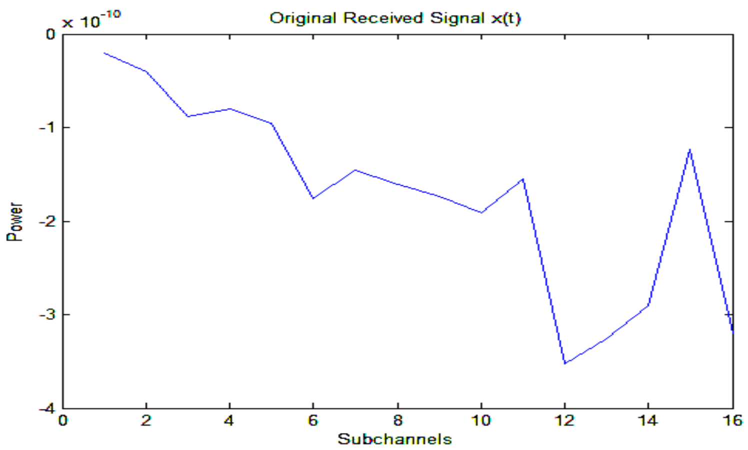

Figure 6. Input Signal *x(t)* to AWGN channel.

Figure 6 shows the original received signal *x(t)* at the input to AWGN channel. Since the centre frequencies from PU1 to PU5 are 100, 400, 700, 1100 and 1500 KHz, it can be noted that the powers of channel 1, 4, 7, 11,15 are higher than other channels. The output from the channel is the input signal *x(t)* and noise, which in this case is passed through AWGN channel with SNR = 20db. The signal which is received at the output of the so mentioned AWGN channel is shown in Figure 7.

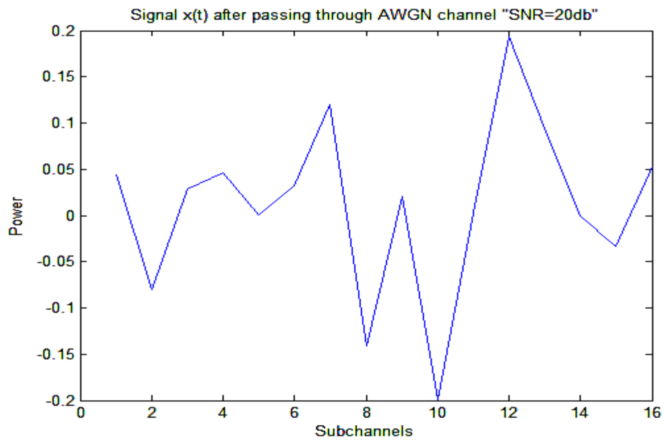

Figure.7 Output signal from AWGN channel, SNR=20db.

Here in Figure 7, showing the output signal (*x(t)* + noise, generated by AWGN of SNR=20db) shows that centre frequencies for PU's at 100, 400, 700, 1100 and 1500 KHz, has larger power in channel 1, 4, 7, 11 and 15 than other channels but due to noise, distortion has being introduced thereby shifting the centre freq. for PU4 from 11^{th} to 12^{th} channel and PU5 from 15^{th} to 16^{th} channel.

By applying the simulation using the 1-Level the Discrete Wavelet Packet Transform in MATLAB, using WPDEC toolbox, which is one-dimensional wavelet packet analysis function in which coefficient vector is also splitted in two parts using same approach as in approximation vector splitting,.Power in 16 channels varies for each channel as shown Figure 8.

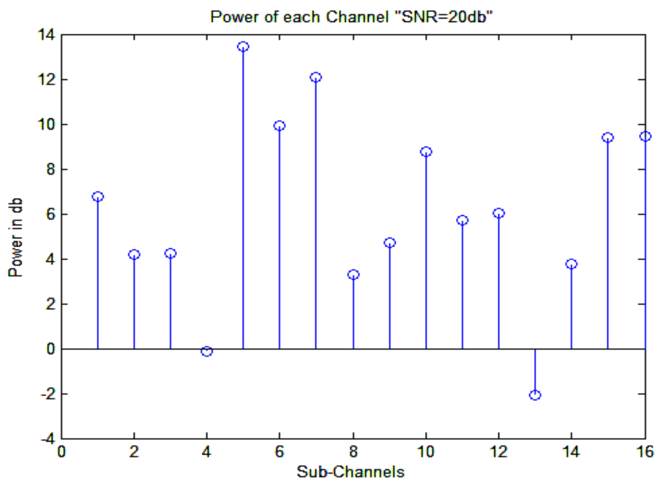

Figure 8: Computed Power in each channel using wpdec function.

From the above Figure 5B.5 is can be observed clear that channel 13 has the lowest power of -2db, meanwhile channel 5 has the highest power of approx. 14dB, which means that there's high probability that channel 13 is not used while channel 5 is most likely to be used. So assigning channel 13 to Secondary Users reduces the risk of interference with Primary User therefore channel 13 is given the highest priority for assigning it to the secondary user and channel 5 at the end.Therefore ,the next step is the sorting the channel is the ascending order of power in db. Figure 9 shows then sorted channel in ascending order as per the power in its respective channel.

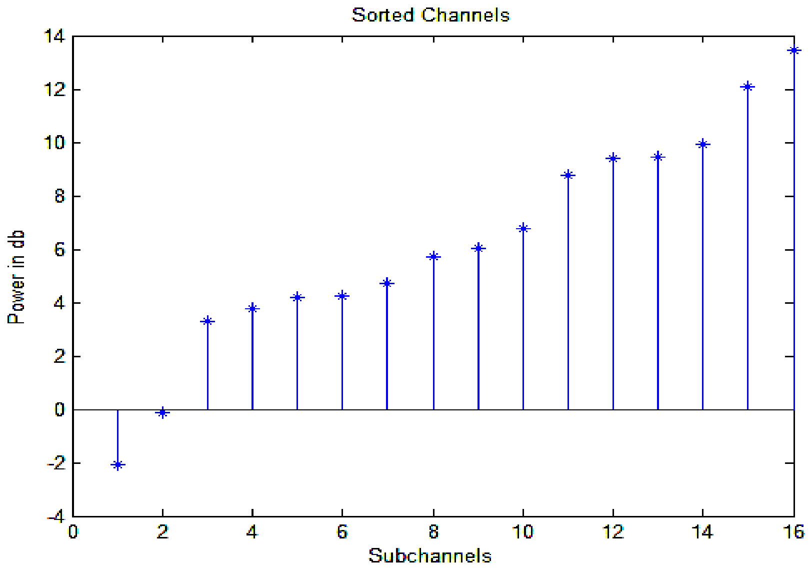

Figure 9. Sorted channel for f1=100 KHz, f2=400 KHz, f3=700 KHz, f4=1100 KHz, f5=1500 KHz and SNR=20db**.**

As mentioned earlier, Figure 5 B.5 that the lowest power of -2db in obtained for channel 13 and highest of about 14db for channel 5. The channel with lowest power is assigned 1st index and channel with highest is indexed in the end which can clearly be noticed from the Figure 9 having -2db power in the 1st channel and approx. 14db power in the 16th channel. The final outputs along with sorted channel indexes, are then further sent to MAC for Spectrum Sharing to make Cognitive Radio Network functional. Thus making it possible for the proposed scheme to select the unoccupied channel without confirming whether spectrum is used or not.

CASE 2: In this case the Centre Frequency of all the Five Primary Users (PU's) are changed,to the following values keeping constant the SNR value i.e. at SNR=20db and attenuation coefficients. Table.3 shows the parameters used in the CASE 2.

Table 3. Parameters for CASE 2.

Attenuation Coefficient PU Centre Freq.

Attenuation Factor	Value	Frequency	Value
		f1	50 KHz
a1	0.05	f2	250 KHz
a2	0.025	f3	550 KHz
a3	0.0125	f4	950 KHz
a4	0.0062	f5	1300 KHz
a5	0.0031		

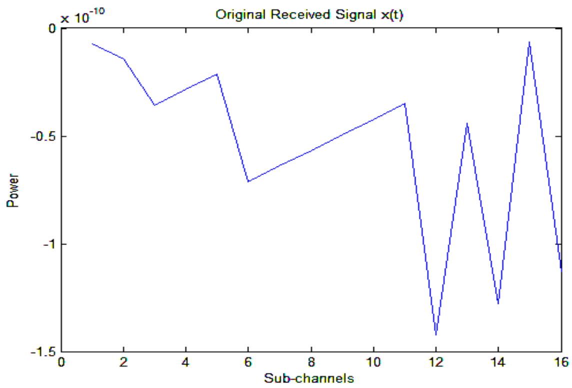

Figure 10. Input Signal *x(t)* to AWGN channel.

Figure 10 shows the original received signal *x(t)* at the input to AWGN channel. Since the centre frequencies for PU1 to PU5 are 50, 250, 550, 950 and 1300 KHz respectively, it can be noted that the powers of channel 1, 3, 6, 10, 13 are higher than other channels.The output from the channel is the input signal *x(t)* and noise, which in this case is passed through AWGN channel with SNR = 20db. The signal which is received at the output of the so mentioned AWGN channel is shown in Figure 11.

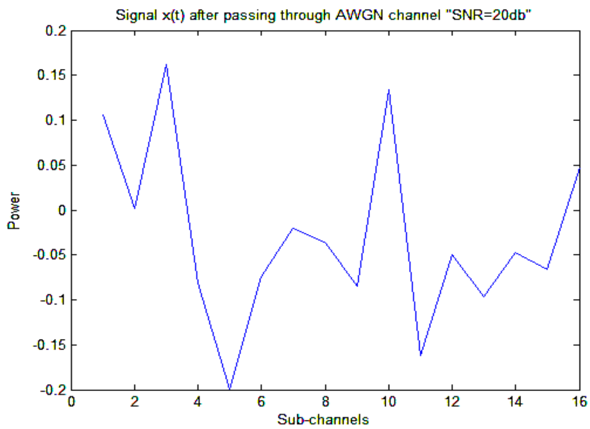

Figure 11. Output signal from AWGN channel, SNR=20db.

Here to in the Figure 11, showing the output signal (*x(t)* + noise, generated by AWGN of SNR=20db) shows that centre frequencies for PU's at 50, 250, 550, 950 and 1300 KHz, has larger power in channel 1, 3, 6, 10 and 13 than other channels but due to noise, distortion has being introduced thereby shifting the centre freq. for PU3 from 6th to 7th channel and PU5 from 13th to 14th channel.By applying the simulation using the 1-Level the Discrete Wavelet Packet Transform in MATLAB, using WPDEC toolbox, which is one-dimensional wavelet packet analysis function in which coefficient vector is also decomposed into two parts using the same approach as in approximation vector splitting, offering richest analysis. Power in 16 channels varies for each channel as shown Figure 12.

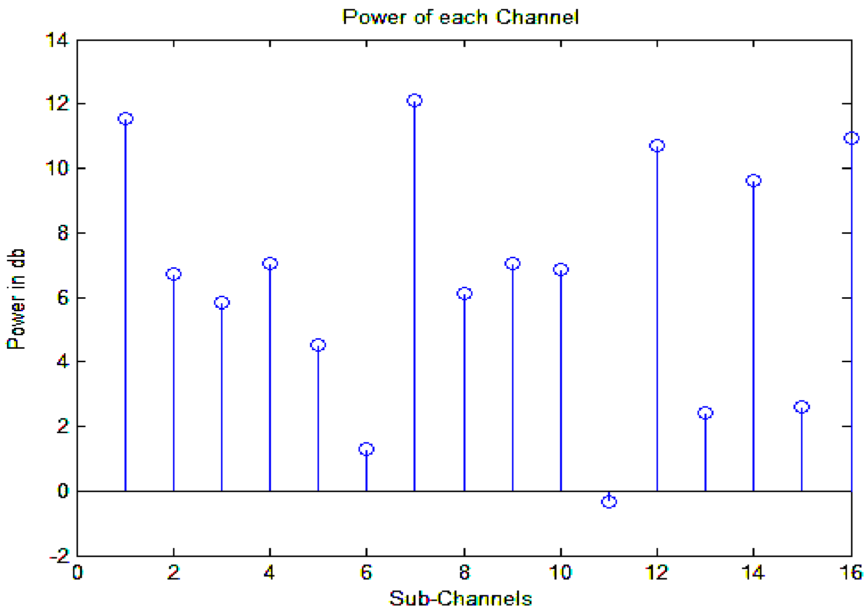

Figure 12. Computed Power in each channel using wpdec function.

From the Figure 12 it is observed that channel 11 has the lowest power of -0.8db, meanwhile channel 7 has the highest power of approx. 12dB, which means that there's high probability that channel 11 is not used while channel 7 is most likely to be used. So assigning channel 11 to Secondary Users reduces the risk of interference with Primary User therefore channel 11 is given the highest priority for assigning it to the secondary user and channel 7 at the end. Therefore the next step is the sorting the channel is the ascending order of power in db. Figure 13 shows then sorted channel in ascending order as per the power in its respective channel.

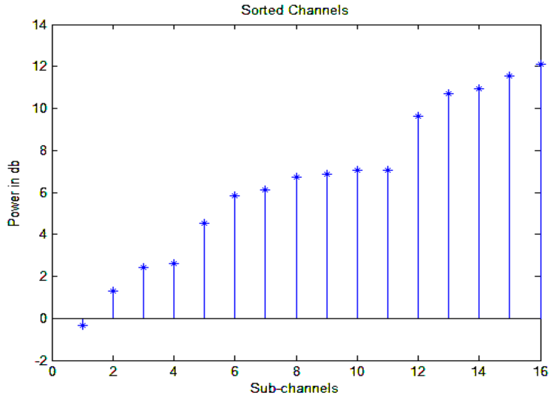

Figure 13. Sorted channel for f1=50 KHz, f2=250 KHz, f3=550 KHz, f4=950 KHz, f5=1300 KHz and SNR=20db.

As mentioned earlier Figure 12 that the lowest power of -0.8db in obtained for channel 11 and highest of about 12db for channel 7. The channel with lowest power is assigned 1st index and channel with highest is indexed in the end which can clearly be noticed from the Figure 13 having -0.8db power in the 1st channel and approx. 12db power in the 16th channel.The final outputs for both the cases, sorted channel indexes, are then further sent to the MAC for Spectrum Sharing to make Cognitive Radio Network functional.Thus making it possible for the proposed scheme to select the unoccupied channel without confirming whether the spectrum is used or not.

CASE 3: In this case the Centre Frequency of all the Five Primary Users (PU's) are kept synoptically with the centre frequencies considered in CASE 1 but SNR is varied from 0 – 15 with the difference of 5db in between. Attenuation coefficients has been kept as statistical constant in all the three CASES. Table.4 shows the parameters used in CASE3.

Table.4: Parameters for CASE 3.

Attenuation Factor	Value
a1	0.05
a2	0.025
a3	0.0125
a4	0.0062
a5	0.0031

Attenuation Coefficients

Frequency	Value KHz
f1	100 KHz
f2	400 KHz
f3	700 KHz
f4	1100 KHz
f5	1500 KHz

PU Centre Freq.

Channels	SNR Value
AWGN1	0db
AWGN2	5db
AWGN3	10db
AWGN4	15db

Channel SNR values

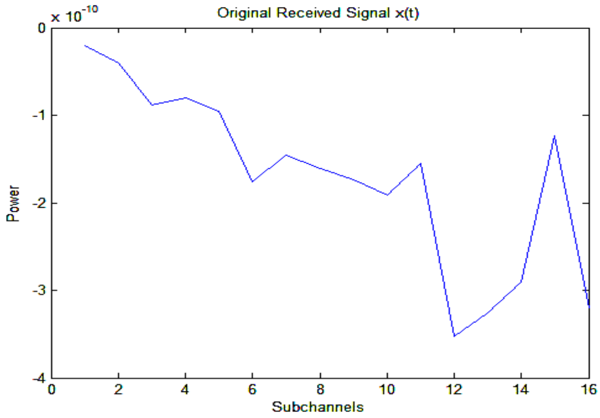

Figure 14. Input Signal *x(t)* to AWGN channel.

Figure 14 shows the original received signal *x(t)* at the input to AWGN channel. Since the centre frequencies for PU1 to PU5 are 100, 400, 700, 1100 and 1500 KHz respectively, it can be noted that the powers of channel 1, 4, 7, 11 and 15 are larger than other channels.The output from the channel is the input signal *x(t)* and noise, which in this case is passed through 4 different AWGN channels individually with SNR = 0db, 5db, 10db, 15db respectively. The received signals at the output of the so mentioned 4 different AWGN channels are shown as subplots in Figure 15.

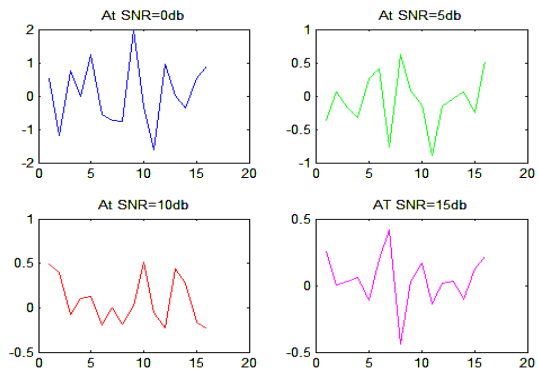

Figure 15. Output signals from AWGN channels at SNR=0db, SNR=5db, SNR=10db, SNR=15db.

Figure 15, shows the effect of noise on the signal which is introduced by the environment channel in which it is working. In this simulation, noise introduced by AWGN channels at SNR=0db,5db, 10db,15db are discussed. From the Figure 15 its can be seen quite clearly that the signal is more distorted for the SNR 0db and 5db as compared to the signal at SNR 10db and 15db. As centre frequencies for SNR=0db is received correctly for only one PU i.e. PU1 at 100 KHz. For SNR=5db only two PU's are received correctly i.e. PU3 at 400 and 700 KHz. For SNR=10db three PU's are received correctly i.e. PU1 at 100, PU2 at 400 and PU3 at 700. For SNR=15db four PU's are received correctly i.e. PU1 at 100, PU2 at 400, PU3 at 700 and PU5 at 1500

KHz. Simulation results are obtained using the 1-Level the DWPT in MATLAB, using WPDEC toolbox. Power in 16 channels varies for each channel as shown Figure 16.

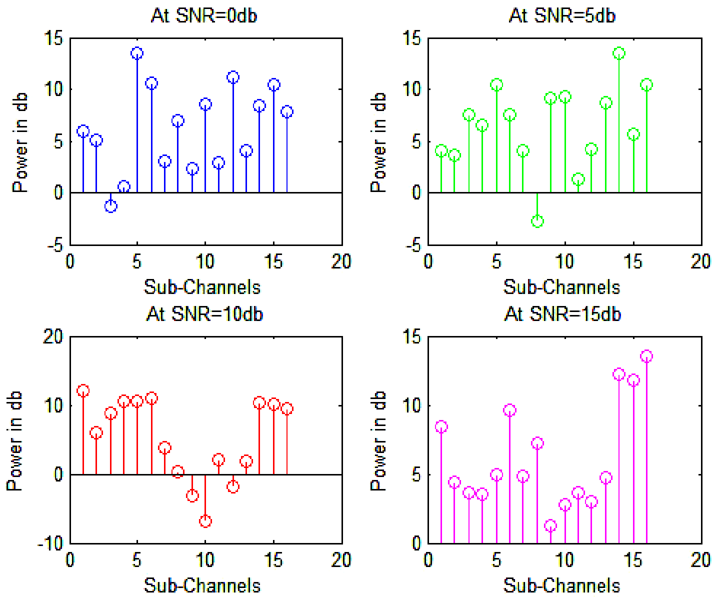

Figure 16. Computed Power using wpdec function at SNR=0db, SNR=5db, SNR=10db, SNR=15db.

Table 5. Simulated Power for CASE 3.

At SNR 15db	Channel	Power db
Lowest Power	9	1db
Highest Power	16	13db

At SNR 10db	Channel	Power db
Lowest Power	10	-7db
Highest Power	1	12db

At SNR 0db	Channel	Power db

Lowest Power	3	-2db
Highest Power	5	14db

At SNR 5db	**Channel**	**Power db**
Lowest Power	8	-2.5db
Highest Power	14	14db

Table 5 shows the lowest and highest power obtained using the MATLAB for the above mentioned parameters.The Channels with lowest power have high probability that these channels are not used while channels with highest power are most likely to be used. So assigning lowest power channels to SU's reduces the risk of interference with PU's therefore channels with lowest power are given the highest priority for assigning it to the SU's and channels with highest power, at the end. Here sorting of the channels is the ascending order of power in dB. is done. Figure 17 shows then sorted channel in ascending order as per the power in its respective channels.

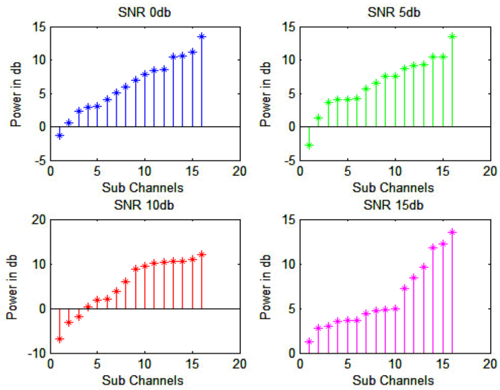

Figure 17. Sorted channels for CASE 3 at SNR=0db, SNR=5db, SNR=10db, SNR=15db.

As mentioned earlier the lowest powers of -2db at SNR=0db, -2.5db at SNR=5db, -7db at SNR =10db and 1db at SNR =15db are obtained for channel 3, 8, 10 and 9 respectively and highest of 14db at SNR=0db, 14db at SNR=5db, 12db at SNR=10db and 13db at SNR=15db for channel 5, 14,1,16.Therefore the channels with lowest power is assigned 1st index and channel with highest is indexed in the end which can clearly be noticed from the Figure 17. The final outputs for both the cases, sorted channel indexes, are then further sent to the MAC for Spectrum Sharing to make Cognitive Radio Network functional. Thus making possible for the proposed scheme select the unoccupied channel without confirming whether spectrums are unused or not and thereby making proposed scheme the Fastest and most efficient Sensing techniques for Cognitive Radio Networks[13-14].

1.6 CONCLUSION

A driving force of future network architectures are the mobile users, who want to access information resources while moving, or whether travelling on a vehicle. Wireless technology is necessary to support the mobile user and adaptive use of radio spectrum is an important aspect of developing future network architectures. Wavelet based energy detection unriddle this problem. Fast spectrum sensing algorithm based on the discrete wavelet packet transform focusing on the coarse detection as this proposed algorithm reduces complexity and makes spectrum sensing faster, making the proposed scheme select the unoccupied channel without confirming whether the spectrum is used or not. Thus the proposed scheme comes out as the fastest and most efficient Sensing techniques for Cognitive Radio Networks. The proposed scheme can be an alternative energy detector of two stage spectrum sensing in IEEE 802.22 WRAN. As unoccupied channels is selected, without confirming whether channels are used or not, which is accomplished by sorting the channels in the ascending order based on the power of each channel.As it obvious that the channel with lowest power has the high probability of being an unoccupied channel. As it performs the discrete wavelet packet transform not to the final level but to the RI level and its complexity changes respectively. The present study has its impact on the design and development of multicarrier based cognitive radio systems under radio frequency communication environment[19-22].

1.7 IMPACT OF STUDY

The Study on Comparative Performance Analysis of Spectrum Sensing Techniques used in Cognitive Radio under different Strategic Conditions using Simulation Environment will have the following Impact.The present study is helpful in Radio Environment which is opportunistic, adaptive, and intelligent under different strategic conditions which will provide base for Maximum Capacity Utilization and increasing Probability of Detection and decreasing Probability of False alarm as moving from Non-Cooperative to Cooperative Sensing under different conditions. Moreover, this study will provide useful information in implementing the Fast Spectrum Sensing Technique using Discrete Wavelet Packet Transform (DWPT).In fact, through analysis and computer simulation will be useful in developing prototype. The overall design of Intelligent Wireless Communication System will get affected under constraints of improved congestion, interference avoidance, better spectral management[15-18].

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