Comparison of Spectrum Sensing Methods for Multicarrier Signals under Various Channels in Cognitive Radio

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Abstract— **In order to solve the scarcity of the spectrum. Cognitive radio is used.CR, built on a software defined radio. The common spectrum sensing techniques are Energy detection, Matched filter detection, Cyclostationary Feature detection. OFDM signals are widely used in various application like WIFI, WIMAX, ZIGBEE etc. Spectrum sensing of OFDM signals is performed using the three detection techniques under various channel conditions such as the AWGN channel and Rayleigh fading channel. The results interpreted from ROC curves of the detectors shows that the performance of the Cyclostationary feature detector is better than the other detectors under low SNR conditions, because of its noise rejection capability. In addition, spectrum sensing of 5G signal known as FBMC (Filter Bank Multicarrier Signal) is performed using Cylcostationary Feature Detection.**

Keywords— Cognitive Radio, Spectrum Sensing, Ofdm, Fbmc,Energy Detector, Matched Filter, Cyclostationary Feature Detector

I.INTRODUCTION

The need for higher data rates is increasing. It is obvious that current spectrum allocation cannot cover all demands of spectrum. Most of the licensed radio-wave spectral bands were underutilized in time and space domain resulting in unused white spaces in time frequency at any particular location. Fixed spectrum allocation policies do not allow for reusing of the rarely used spectrum allocated to licensed users by unlicensed users. In order to solve the scarcity of spectrum, Fedaral Communication Commission has introduced Cognitive Radio (CR). Cognitive radio, built on a software defined radio .An intelligent wireless communication system. It provides the promising solution to all these challenges. Cognitive radio has a smart layer which performs the learning of the environment and get better results in unknown and dynamic situations. Spectrum sensing plays a crucial role in the cognitive radio technology to prevent damaging interference to the primary users and quickly spot the white spaces in the spectrum and utilize the opportunity with little Delay . The common spectrum sensing techniques are Energy detection, Matched filter detection , Cyclostationary Feature detection .Energy detection detects the presence of the signal by measuring its energy and comparing the measured energy with a predetermined threshold. Matched filters are commonly used for minimize the noise and maximize the signals. In Cyclostationary Feature detection the cyclic spectral correlation function is the parameter that is used for detecting the primary user signals .Cyclostationary feature detector is used to detect the FBMC signal.

II.LITERATURE SURVEY

S. Haykin, proposed the approach for improving the utilization of precious natural resources: the radio electromagnetic spectrum is a natural resource. A CR has the ability to sense and gather information (such as transmission frequency ,band width ,modulation etc) from the surrounding environment and the ability to swiftly adopt the operational parameter for optimal performance .

T. Yucek and H. Arslan, proposed innovative techniques that can offer new ways of exploiting the available spectrum are needed. A radio that senses its operational electromagnetic environment, it can dynamically and autonomously adjust its radio operating parameter to modify system operation like maximize throughput ,mitigate interference ,facilitate interoperability ,access secondary markets.

H.S Chen and W. Gao , proposed the spectrum sensing algorithm is designed for the primary licensed signals including NTSC analog TV and ATSC digital TV signals .In addition ,an auto correlation –based spectrum sensing algorithm is proposed .The proposed sensors can determine the availability of a TV channel for unlicensed radio transmission when the SNR is as low as -31dB assuming a 5MHz interference alleviation filter is used for sensing ATSC and NTSC signals.

D.Cabric ,A .Tkachenko, and R. W. Broderson, proposed the experimental study that comprehensively evalutes the performance and limitations of three different detection methods proposed for sensing of primary user signals in cognitive radios. Two most prominent digital signal processing techniques include coherent pilot detection that optimally detects known primary user signals and simple non-coherent detection applicable to ant signal type.The pilot detection requires minimum amount of time for sensing but requires perfect synchronization thus it is highly susceptible to frequency.

Hamed Sadeghi,Paeiz Azmi,and Hamid Arezumand,[5]optimal strategies for multi-cycle Cyclostationary detection method,within which the linear combination of multiple independent test statistics corresponding to different cycle frequencies is computed.

III COGNITIVE RADIO

At this moment ,most attention given to the use of CRT(cognitive radio technology) is an opportunistic spectrum access whereby cognitive radios are able to identify "unused " portion of spectrum and share that spectrum without affecting the existing users.CR enable the usage of temporally unused spectrum,The spectrum hole or white space and if a primary user use this band,then the secondary user should move either to another spectrum hole or it may be stay in the same band,altering the modulation scheme to avoid interfering with the primary user.

There are two types of cognitive radio,

i)Full cognitive radio and

ii)Specrtum sensing cognitive radio

Full CR considers all parameters,a wireless node or network can be aware of every possible parameter.

Spectrum sensing CR detects the channels in the radio frequency spectrum and considers radiofrequency spectrum. The requirements of the performances for CRs are:

i)Authentic spectrum hole and detection of primary user

ii)Precise link estimation between nodes

iii)Fast and accurate frequency control

Major Fuctions of CR:

i)Spectrum sensing

ii)Spectrum management

iii)Spectrum mobility

iv)Spectrum sharing

Advantage of Cognitive radio technology

Cognitive radios have ability touse spectrum which is already used by other spectrum user .i.e. they can share the spectrum with other users.So they nee to perform three key activities:

i)Obtain complete knowledge of the radio operational environment and location.

ii)Decide on the gathered information

iii)Act based on the decision(dynamically and autonomously)

IV SPECTRUM SENSING

Spectrum sensing is the ability to sense and be aware of the parameters related to the radio channel characteristics.

Spectrum Sensing Techniques

There are various classical spectrum sensing techniques in literature. Many techniques were developed in order to detect spectrum band .These techniques provide basic concept of spectrum sensing which is further used in various emerging spectrum sensing techniques. To avoid the harmful interference to the primary system.

Classification of spectrum sensing techniques

i)Energy Detection

ii)Matched Filter Detection

iii)Cyclostationary Feature Detection

Energy Detection*:*

Energy detection is the non-coherent method that finds the licensed user signal. It is the simple method in which prior knowledge of the primary or licensed user signal. Easiest sensing technique of non-cooperative sensing in cognitive radio networks. For implementing the energy detector, the received signal x(t) is filtered by a band pass filter (BPF) and it is followed by a square law device. The band pass filter serves to reduce the noise bandwidth. The output of the integrator is the energy of the input to the squaring device over the time interval T .Next, the output signal from the Integrator,was compared with a threshold to decide whether a primary (licensed) user is present or not. Decision regarding the usage of the band will be made by comparing the detection statistic to a threshold. Analytically, determining the sample signal x(t) is reduced to an identification problem, formalized as an hypothesis test H0 and H1.

H0 : y[n] = w[n] (Primary user Absent)
H1: y[n] = s[n]+w[n] (Primary user Present
n=1.......N

Drawbacks of Energy Detection:

1. It requires a longer sensing time to achieve good results

2. It cannot distinguish between noise and primary user.

Matched Filter Detection:

The decision making on whether the signal is present or not can be known if pass the signal through the filter,which will stress the useful signal sig(t) and quash the noise w(t) at the same time. Such a filter which will peak out the signal component at some instant and smoother the noise amplitude at the same time has to be designed.This will give s sharp contradiction between a signal and the noise and if the signal sig(t) is present,the output will come out to have large peak at this instant.If a signal is missing at that instant ,no such peak will occurs.

Cyclostationary Feature Detection:

In the detection technique exploits the periodicity in the received primary signal to identify the presence of primary users (PU) .Due to the periodicity, these cyclostationary signals exhibit the features of periodic statistics and spectral correlation.It is not found in stationary noise and interference.The detection is robust to noise uncertainties and it performs better than energy detection at very 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. In cooperative sensing, this technique is used to eliminates the synchronization requirement of energy detection. During

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 07, July - 2017

cooperative sensing , CR users may not be required to keep silent and thus improving the overall CR throughput. This method has its own shortcomings owing to its high computational complexity and long sensing time. Due to these issues, this detection method is less similar than energy detection in cooperative sensing.

V RESULTS AND DISCUSSION

An extensive set of similations have been conducted to analyse the performance of three spectrum sensing techniques.The result is abtained on the basis of probability of detction under different SNR in different channels which are AWGN and Rayleigh.

Through simulations ,the capability of energy detector applied language MATLAB contains tool for data visualization;serving as a convenient “laboratory” for computations and analysis.Monto carlo(MC) method,which is stochastic technique (based on the use of random numbers)forms the basis of these simulations.The receiver performance is quantified by depicting the receiver operating characteristics(ROC)curves,(PD versus PFA).

The effect of SNR detection performance using an energy detector operating over non-fading (AWGN)channel is carried out.

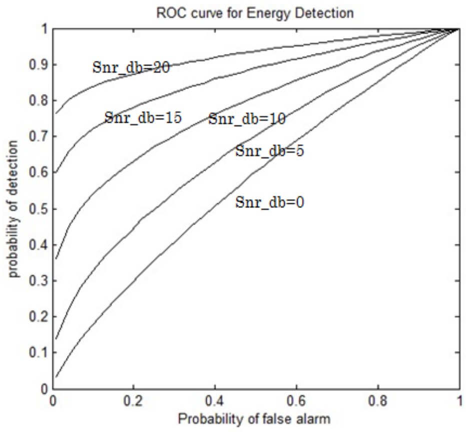

Fig 1. ROC curves for Energy Detection under AWGN channel.

Fig 1.depicts detection performance for a energy detector operating over an AWGN channel. From the figure ,as probability of false alarm increases ,probability of detection increases. It is deducted that detection performance improves with an increase in SNR values.For low values of SNR probability of detection is low.

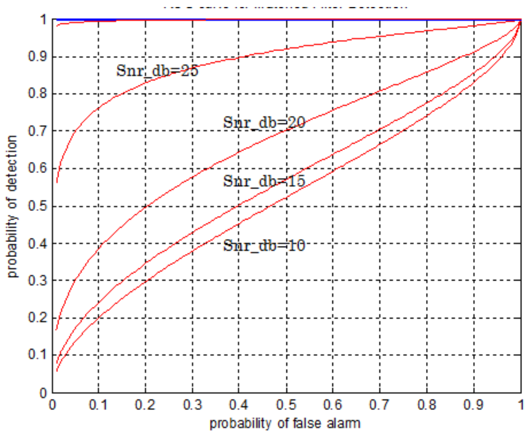

Fig 2 ROC curves for Energy Detection under Rayleigh channel.

Fig 2 depicts the complementary ROC curves over Rayleigh channel .From this plot observed that for low values of SNR probability of detection is low. As the signal power increases the probability of detection increases compared to probability of detection over AWGN channel. It is apparent that energy detection executed over a Rayleigh channel exhibits a tough detection performance, compared to that of AWGN.

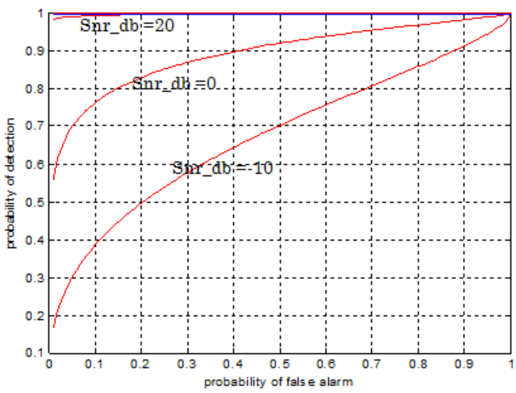

Fig 3 ROC curve for Matched Filter Detection over AWGN channel.

Fig 3. Depicts detection performance for matched filter detector operating over an AWGN channel. In matched filter technique ,probability of detection increases with probability of false alarm for low values of SNR than energy detector.

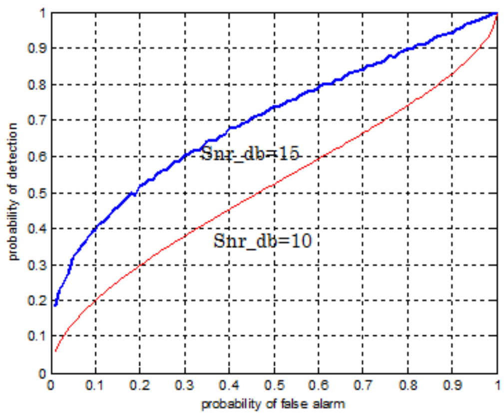

Fig 4. ROC curve for Matched Filter Detection over Rayleigh fading channel.

Fig 4 depicts detection performance for matched filter detector over Rayleigh fading channel.In Rayleigh channel increase in pd is low compared to AWGN channel for the same value of SNR.Under low SNR values,in which the signal is higher than noise,matched filter detection achieves its 80%.

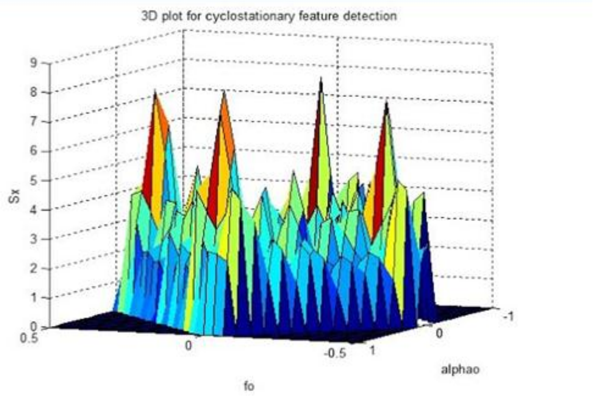

Fig 5 3D plot for cyclostationary feature detection

Fig 5 shows a spectral correlation density plot plotted for three parameter namely cyclic spctrum, frequency and cyclic frequency.It can be clearly observsed that this technique is able to detect the same signal for quite a wide range of frequency as compared as energy detector. One of the features of the signal i.e pilot is used to detect the presence of primary user. In this plot four peaks denotes presence of four primary user.The better performance can be achieved in proposed cyclostationary feature detector compared to the conventional energy detector.

In addition to the Filter Bank Multicarrier(FBMC)which neglects the cyclic prefixis used to detect the presence of primary users.While its basic principle ,dividing frequency spectrum into many narrow sub channels ,may not be now, MC systems have seen wide adaptation in recent years (LTE,WLAN).It is considered as one of the most suitable modulation schemes for 5G mobile. .The implementations of FBMC is similar to the OFDM ,bandwidth efficiency is achieved.

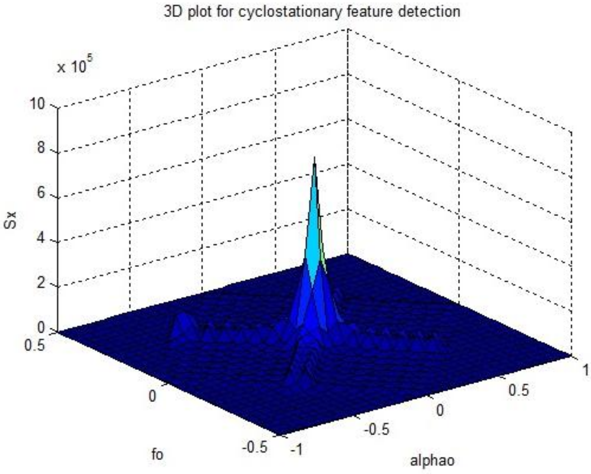

Fig 6 3D plot for Cyclostationary feature detection.

Fig 6 shows a spectral correlation density plot plotted for three parameter namely cyclic spectrum,frequencyand cyclic frequency .The plot shows the presense of primary user at alpha=0,for small range of frequency with cyclic spectrum value=0.5(approx).

Bandwidth efficiency is improved in FBMC compared to Cyclostationary feature detection for OFDM signals, as cyclic prefix is removed.

VI CONCLUSION AND FUTURE WORK

Sensing methods and their simulation results were discussed.Conclude that each method has its strengths and weaknesses. Energy detection is easy to implement and does not require any information about PU signal; however it is not able to distinguish between signal and noise. It has also a high false alarm. Matched filter sensing requires a perfect knowledge of PU signal, which is not practical, but has a good performance under low SNR. The Cyclostationary Feature detection is more robust to uncertain levels of noise and gives much better performance in low SNR regions. Therefore, choosing one of these three sensing techniques depends on the SNR level, noise uncertainty of the transmission channel, and available information about the PU signal. So we conclude that Cyclostationary Feature Detection Technique is the best detection technique and it detect the primary users in the form of peak .In addition, using a better threshold gives better sensing performance. In the future to improve results techniques like wavelet detection or cooperative sensing can be used for spectrum sensing. Some key research challenges in cognitive radio system is on RF Front-end,transceiver and analog to digital and digital to analog interfaces which are still a key bottle neck in cognitive radio system development.

REFERENCES

[1] J. Mitola,, "Cognitive radios: making software radios more personal", IEEE Personal Communications, August 1999 vol. 6, no. 4, pp. 13–18.

[2] Harry Urkowitz, "Energy Detection of Unknown Deterministic Signals",*Proceedings of the IEEE*, vol.55, Apr. 1967.

[3] S.M. Kay, Fundamentals of Statistical Signal Processing: Detection Theory. Englewood Cliffs, NJ:Prentice-Hall, 1998.

[4] W. A. Gardner, *Cyclostationarity in Communications and Signal Processing* ,New Jersey, NY, USA: IEEE Press, 1993.

[5] Z. Quan, S. Cui, V. Poor, and A.H. Sayed, "Collaborative wideband sensing for cognitive radios", IEEE Signal Processing. Mag., Vol. 25, no. 6, 2008, pp. 60-73.

[6] H. Chen, W. Gao, and D. Daut, "Spectrum sensing for OFDM systems employing pilot tones and application to DVB-T OFDM" in Proc. ICC, 2008, pp. 3421-3426.

[7] Salt J.E., Nguyen, H.H., " Performance Prediction for Energy detection of unknown signals", IEEE Transactions on vehicular Technology, Vol.57, Issue. 6, pp. 3900-3904.

[8] Kozal, A.S.B., Merabti, M. and Bouhafs, F. " AnImproved Energy detection scheme for Cognitive Radio Networks in low SNR conditions", IEEE Symposium on Computer and Communications (ISSC), 2012, pp. 684-689.

[9] Cheraghi, P., Yi Ma., Tafazolli, R., " Frequency-Domain Differential Energy Detection based on Extreme Statistics for OFDM Source Sensing", IEEE Vehicular Conference(VTC Spring), 2011, pp. 1-5.

[10] Y. M. Kim, G. Zheng, S. H. Sohn, and J. M. Kim, "An alternative energy detection using sliding window for cognitive radio system," in *Proc. 2008 International Conference on Advanced Communication Technology*, vol. 1, pp. 481–485.

[11] Liangping Ma, Yingxue Li and Demir.A, "Matched filtering assisted energy detection for sensing weak primary user signals", *IEEE International Conference on Acoustics, Speech and Signal Processing(ICASSP)*, 2012, 3149 – 3152.

[12] Sun Hwan Sohn, Ning Han, Jae Moung Kim, Kim Jae Wan "OFDM Signal sensing method based on cyclostationary detection", 2nd International Conference on Cognitive Radio Oriented Wireless Networks and Communications, 2007, pp. 63-68.

[13] Haijian Zhang, Le Ruyet, D., Terre, M., "Signal Detection for OFDM/OQAM System using cyclostationary features", IEEE International Conference on Acoustics, Speech and Signal Processing(ICASSP), 2008, pp. 1-5.

[14] S. Maleki, A. Pandharipande, and G. Leus, "Two-stage spectrum sensing for cognitive radios," in Proc. 2010 IEEE International Conference on Acoustics Speech and Signal Processing, pp. 2946–2949.

[15] Jianping An, Miao Yang, Xiangyuan Bu, "Spectrum sensing for OFDM system based on Cyclostationary Statistical test", 6th International Conference on Wireless Communication Networks and Mobile Computing, 2010, pp.1-4.

[16] Arezumand, H., Azmi, P., Sadeghi, H., "A robust reduced complexity spectrum sensing scheme based on second-order cyclostationarity for OFDM-based primary users", 19th Iranian Conference on Electrical Engineering(ICEE), 2011, pp. 1-5.

[17] Liu, J.G., Xiabin Wang., Nadeau, J., Ho, P., "Blind parameter estimation for OFDM interception receiver with iterative cyclostationary analysis", Military Communication Conference (MILCOM), 2011, pp. 2211-2215.

[18] Axell E., Larsson, E.G., "Multiantenna Spectrum sensing of a second-order cyclostationary signals," 4th IEEE International Workshop on Computational Advances in Multi sensor adaptive processing (CAMSAM), 2011, pp. 329-332.

[19] W. Gardner, "Exploitation of spectral redundancy in cyclostationary signals," *IEEE Signal Process. Mag.*, vol. 8, no. 2, pp. 14–36, Apr. 1991.

[20] B. Sadler and A. Dandawate, "Nonparametric estimation of the cyclic cross spectrum," *Information Theory, IEEE Transactions on*, vol. 44, no. 1, pp. 351–358, 1998.