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Comparative performance evaluation of Spectrum Sensing Techniques for Cognitive Radio in Next Generation Wireless Networks

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Abstract- In recent years there has been an enormous growth in wireless communication devices and wireless users. The availability of the spectrum is most important for fulfillment of the demand. Spectrum is a valuable resource in communication. So to fulfill the demand we either need more spectrums or make efficient use of current available spectrum. But as spectrum resources are limited we need to use them efficiently. It is impossible to use spectrum efficiently with the static spectrum allocation policy. Due to this static policy most of the spectrum remains underutilized. To use spectrum efficiently we need to use dynamic spectrum allocation policy. For future wireless communication cognitive radio is the key in expertise. Spectrum sensing is one of the most important functions in cognitive radio (CR) applications. Cognitive radio technology is used as the problem solution key in wireless networks resulting from the limited available spectrum and the inefficiency in the spectrum usage by exploiting the existing wireless spectrum opportunistically. Sensing of spectrum availability has been identified as a key requirement for dynamic spectrum allocation in cognitive radio networks. it involves the detection of primary user (PU) transmissions on a pre assigned frequency band. Primary user licensed band can be sensed via suitable spectrum sensing methodologies.

This paper presents three basic spectrum sensing techniques of transmitter detection: energy detection, matched filter detection, and cyclostationary feature detection. A proportional scrutiny of all the techniques has been carried out in terms of probability of detection alarm Pd, probability of false alarm Pf and probability of missed detection pm using simulations. As a final point, result shows that at low signal to noise ratio (SNR), cyclostationary feature detection outperforms better than the rest techniques. For simulation matlab software is used.So in this paper authors are presenting the comparative performance analysis of these three techniques.

Key Words: Cognitive Radio System, Pm: Probability of missed detection, Pf: Probability of false alarm, Pd: Probability of detection.

I. INTRODUCTION

In wireless communication, frequency spectrum is a limited resource. Moreover, due to fixed spectrum allocation scheme its utilization is poor making the scarcity more severe. Today's wireless networks are regulated by a fixed spectrum allocation policy, i.e. the spectrum is regulated by governmental agencies and is assigned to license holders or services on a long term basis for large geological regions. In count, a large section of the assigned spectrum is used sporadically as illustrated in Figure 1, where the signal strength distribution over a large portion of the wireless spectrum. The usage of spectrum is determined on certain portions of the spectrum while a significant amount of the spectrum remains unutilized. According to Federal Communications Commission (FCC), temporal and geographical variations in the utilization of the assigned spectrum range from 15% to 85%. Although the fixed spectrum assignment policy generally served well in the past, there is a dramatic increase in the access to the limited spectrum for mobile services in the recent years. This increase is straining the effectiveness of the traditional spectrum policies. The limited available spectrum and the inefficiency in the spectrum usage necessitate a new communication paradigm to exploit the existing wireless spectrum opportunistically. To solve these current spectrum inefficiency problems Dynamic spectrum access is proposed. DARPAs approach on Dynamic Spectrum Access network, the so-called Next Generation (xG) program aims to implement the policy based intelligent radios known as cognitive radios.

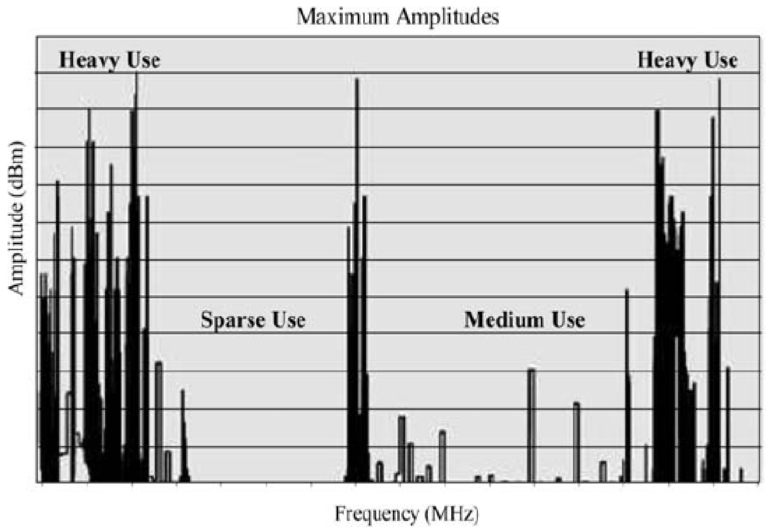

Figure 1. Spectrum Utilization

Next generation (xG) networks for communication, also known as dynamic spectrum access networks (DSANS) as well as cognitive radio networks will provide high bandwidth to mobile users via heterogeneous wireless architectures and dynamic spectrum access techniques. The disorganized usage of the present spectrum can be improved through opportunistic access to the licensed bands without interfering with the on hand users. Next generation networks, however, enforce a number of research challenges due to the broad range of available spectrum as well as diverse quality-of-service (QoS) requirements of applications. These heterogeneities must be handled and captured dynamically as mobile terminals roam between wireless architectures and along the available spectrum pool.

Cognitive Radio is a novel technology that has the potential to deal with the requirement and scarcity of the underutilized radio band. A medication to spectrum scarcity is to improve spectrum utilization by spectrum sensing where the secondary unlicensed users are allowed to access the underutilized licensed bands when the primary licensed users are inactive. Cognitive radio technology provides efficient utilization of electromagnetic radio spectrum. Top layer of Software defined radio provides Cognitive features. Key features provided by cognitive radios are: CR must sense the spectrum and determine spectrum holes and CR must be able to adapt to radio environment i.e. to change signal characteristics like frequency of the signal.

II. SPECTRUM SENSING TECHNIQUES

1) Matched Filter
2) Energy Detection
3) Cyclostationary Feature Detection

2.1 PERFORMANCE ANALYSIS AND SIMULATION RESULTS:

Detection probability (P_d), False alarm probability (P_f) and missed detection **,** Probability ($P_m = 1 - P_d$) are the key measurement metrics that are used to analyze the Performance of spectrum sensing techniques. All simulation was done on MATLAB version 7.10.0 (R2010a).

2.1.1 COMPARATIVE PERFORMANCE ANALYSIS OF ALL METHODS BASED ON PROBABILITY OF DETECTION:

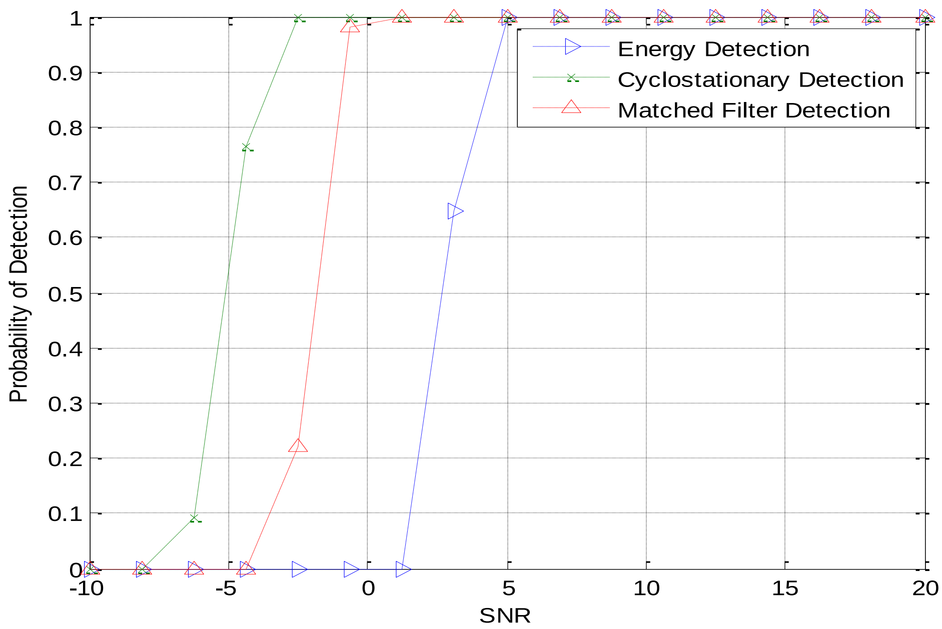

Figure 2. Probability of detection Vs. SNR for Matched filters detection, Energy detection and Cyclostationary feature detection.

Figure 2 shows comparative result of Matched filter detection, energy detection and cyclostationary detection sensing methods on the basis of Probability of detection. For Energy detection method it is clear that the probability of detection is zero for lower values of Signal to Noise Ratio (SNR), it starts increasing from the SNR value 3.125dB. After this value probability of detection is maximum that is one .For Matched filter detection the probability of detection starts increasing from -2.5dB SNR and attains maximum value at 1.25dB SNR. With this it can be concluded that Matched filter detection performs better at low SNR values than Energy detection method. It is clearly seen that the probability of detection (P_d) increases from -6.255 dB SNR and reaches to the maximum value at SNR value of -2.5dB. Comparatively it is observed that the probability of detection is more in Cyclostationary feature detection which is giving more promising results method than the other methods. It means that the primary user detection is better in this method at lower values of SNR.

2.1.2 COMPARATIVE PERFORMANCE ANALYSIS OF ALL METHODS BASED ON PROBABILITY OF MISSED DETECTION:

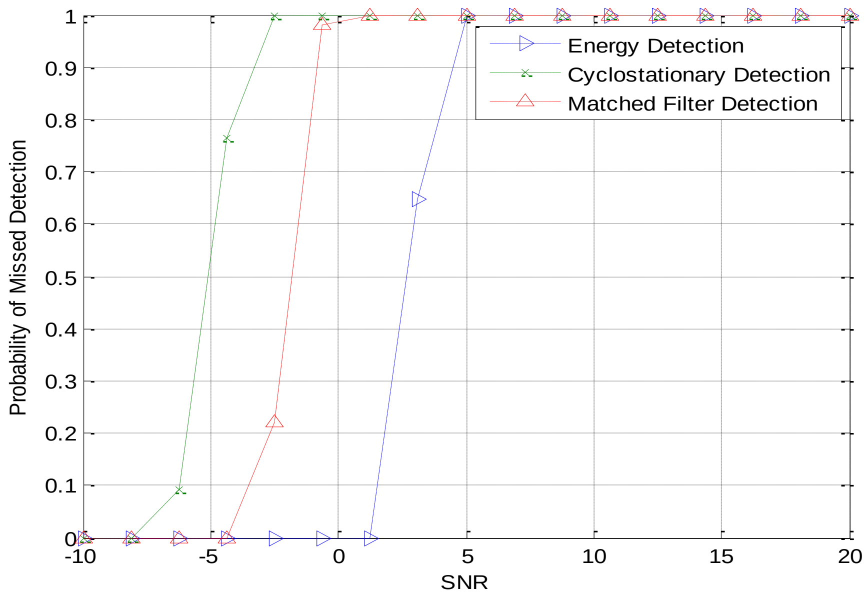

Figure 3. Probability of missed detection Vs. SNR for Matched filters detection, Energy detection and Cyclostationary feature detection.

Figure 3 shows comparative plot of probability of missed detection Vs SNR for all sensing methods .As probability of missed detection is complement of probability of detection, here we are getting complementary plot of probability of detection Vs SNR that means even if signal is present it do not show it. Hence here also cyclostationary feature detection method outperforms the other methods.

2.1.3 COMPARATIVE PERFORMANCE ANALYSIS OF ALL METHODS BASED ON PROBABILITY OF FALSE ALARM:

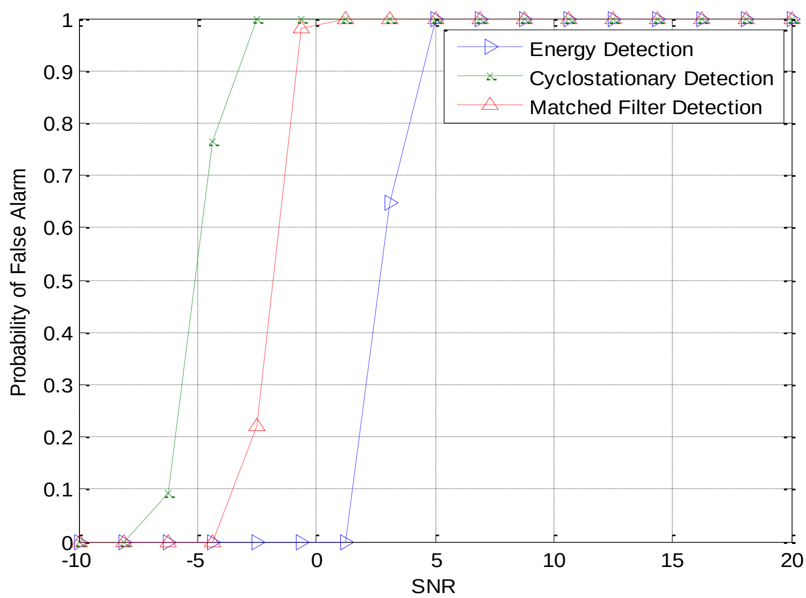

Figure 4. Probability of false alarm Vs. SNR for Matched filters detection, Energy detection and Cyclostationary feature detection.

From the comparative plot of probability of false detection Vs SNR for all sensing methods, for Energy detection method the probability of false alarm is high at low SNR values and after 8.752 dB probability of detection starts decreasing and reduces to zero at SNR value 12.5dB. For Matched filter detection the probability of false alarm starts decreasing from SNR 3.125dB and reaches to zero at 6.752dB SNR. In Cyclostationary feature detection the probability of false alarm (P_f) starts decreasing from SNR value -0.625dB and attains minimum value at 6.875dB SNR. So it can be concluded that the Cyclostationary feature detection method performs better than all the methods as it gives lowest value of false alarm at low SNR values.

III. CONCLUSIONS

In the work presented, authors have compared the performance evaluation of three different spectrum sensing techniques, namely energy detection, matched filter detection, cyclostationary feature detection techniques. Probability of Detection, Probability of Missed Detection and Probability of False alarm with respect to threshold value Gamma are the different performance measurement metrics that are applied to analyze the performance of spectrum sensing techniques.

Based on the analysis it can be concluded that, each sensing technique has its own advantages and disadvantages. As, Matched filter detection improved SNR, but required the prior information of PU for better detection. Energy detection had the advantage that no prior information about the PU is required. But does not perform well at low SNR, there is a minimum SNR required after which it started working. The comparative plot illustrates that the Cyclostationary feature detection method performs better than all the methods as this method clearly distinguish primary and secondary user signals at low signal strength also.

Further from the simulation results it is confirmed that, the Cyclostationary feature detection technique performs better than the other sensing techniques under test. However, its processing time is large and implementation is complex.

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