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Spectrum Sensing Techniques in Cognitive Radio

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***Abstract*- Cognitive radio is emerging wireless technology which offers reallocation and reutilization of the unused spectrum. Not all the network runs with highest load at all the time. Therefore part of spectrum always remains unused. In a multi radio environment cognitive radio allows the user to request for spectrum while roaming from another service provider. In case the service provider has free spectrum, it can reallocate the spectrum to the demanding user. In this work this provides a framework for analyzing spectrum sensing, void user detection, reallocation using two methods namely frequency domain analysis method and QR decomposition method. Simulation results shows that QR decomposition performs better in terms of user accuracy detection under heavy noise but frequency domain method is efficient not only for spectrum analysis but also to implement spectrum reallocation.**

Index Terms: DFF, Extended TSPC (ETSPC), Frequency divider, counters, power delay product, prescaler.

I. INTRODUCTION

Day by day increasing demand of wireless communication has put a lot of impact on radio networks. A lot of limitations have occurred due to this, where the spectrum bands are not strictly utilized. In which some frequency bands are fully present, some are partially present and some are absent. To overcome these problems the cognitive radio is constructed on the wireless communication platforms. Cognitive radio is defined as a wireless communication which intelligently detects the presence or absence of primary user and adapts its environment to the secondary user in the absence of a primary user. Cognitive radio adapts the condition of primary user and makes use of the secondary user (unlicensed user). The cognitive radio consists of four main functions: spectrum sensing, spectrum sharing, spectrum reconfiguration, spectrum mobility. Let see all the functions one by one. Spectrum sensing in cognitive radio is used to detect the presence or absence of primary user, depending on the results of sensing, the secondary users are adapted.

The main function of the spectrum sensing is to find out vacant spectrum and its condition, by continuously sensing the targeted frequency band. Spectrum sensing will detect the spectrum bands without disturbing other licensed users by using a FFT technique and QR decomposition technique. The second main function of the cognitive radio is the spectrum sharing, whose function is to take the decision and assigns a secondary user to that particular band depending on its frequency. In some cases, the presence of primary user is detected, when the secondary user is assigned its spectrum band. At that time, the cognitive radio technology makes the secondary user to leave the secondary user and the primary user is reallocated. This technique in cognitive radio is called as spectrum reallocation or spectrum mobility.

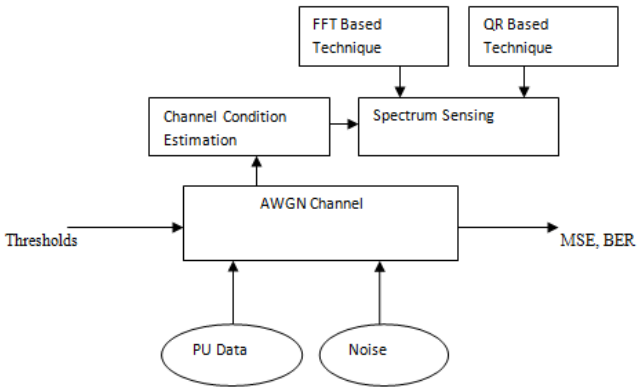

Fig1. General Block Diagram for the Proposed Technique

II.PROPOSED WORK

The Spectrum sensing in Cognitive Radio, detects the utilization of primary user and secondary user, hence determine the spectrum space holes are present or absent. Spectrum sensing can be applied to single user cognitive radio or multiuser cognitive radio. Various Spectrum sensing techniques are being considered in the present system. It is quite clear that every technique depends upon certain thresholding at the result of mathematical or filters operations being performed. The briefly explanation of the spectrum sensing is given below.

In spectrum sensing, the two different methods to detect the primary user are:

1) FFT based technique of spectrum sensing
2) QR decomposition based technique of spectrum sensing

2.1 FFT based technique of spectrum sensing:

The techniques changes the threshold value based on knows training sequence. It is argued that detecting energy in the primary user band is most efficient. Thus FFT of the signal

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reveals not only the frequencies being present in the signal but at the same time the energy content of the bands. As it is quite understandable that the network will always have a partial knowledge about the important spectrum data being transmitted, band of spectrum can be determined from this information. Hence in this work FFT based spectrum sensing model is proposed. The block diagram of FFT based technique is shown below which also compare the results with auto correlation cyclostationary property based technique and proves that FFT based technique is more suitable for the complete frame work of spectrum sensing, allocation and reallocation.

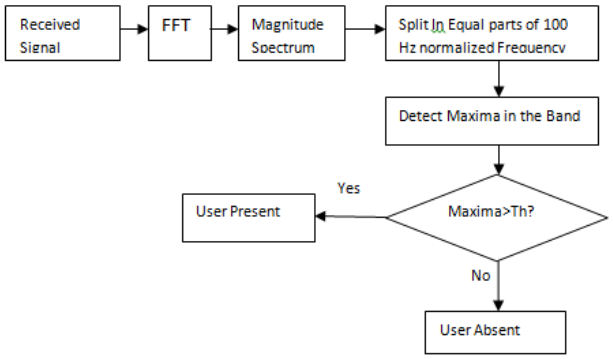

Fig.2. Block diagram of FFT based technique in spectrum sensing.

The block diagram of spectrum sensing based on FFT for multi user is given above in fig 2. When the signal is received in cognitive radio it is made to pass through a FFT, determines the frequency component of the received signal. Now the signal is made to pass through a magnitude spectrum that determines the magnitude of the spectrum, the signal is then passed through a split in equal parts of 100 Hz normalized frequency i.e. 0-100 Hz is the first spitted frequency, 100-200Hz is the second spitted frequency and 200-300Hz is third spitted frequency and so on. After passing through this, the maximum frequency band will be detected, i.e. (if the bands with a maximum frequency say 195 Hz then it will get detected in spitted frequency say in between 100-200Hz). After detecting the maximum frequency band, it is compared with the threshold value. If the frequency band is greater than threshold value then it can be noted that the "primary user" is present, otherwise it is absent. Hence this will allocate the spectrum space holes to the secondary user.

2.1.1 Spectrum Sharing:

Cognitive Radio makes use of the unused spectrum (spectrum space hole) by applying to the secondary user (SU) as primary user remains absent. This property of cognitive radio is called as spectrum sharing where it tries to find the void user in the technique specified above. As the base station does not have access to primary frequency, the base station tries to locate two highest maxima's which are obviously first two user's data. It predicts the guard band based on the difference between the samples of these two frequencies. Now taking guard band as basis the base station will try to locate the free frequency band and emulate that user first through frequency domain and then followed by inverse transform.

2.1.2 Reallocation Detection:

After some time the primary user get detected then the secondary user will get emulated. This method in cognitive radio is called as spectrum mobility or reallocation detection. Where, the Shared Spectrum can be detected simply by observing the received spectrum. It can be seen that from user 1 to user 10 the FFT energy is decreased. However whenever there is any sharing, the attacked spectrum's Energy is greater than its previous one to enable injection. Hence by monitoring the signal level a receiver can detect this spectrum and generate alarm signal.

2.2 QR decomposition based technique:

The QR decomposition is nothing but a matrix. Consider the simple matrix A, its QR decomposition is a matrix decomposition of the form (A=QR), Where 'R' is an upper triangular matrix and 'Q' is an orthogonal matrix. QR decomposition is a basis of Eigen vectors. Depending on this Eigen vectors we determine the presence of primary user.

The block diagram for QR decomposition method is given below in fig 3. It consists of autocorrelation as shown in figure--. Consider if a user is transmitting, in autocorrelation function it will never transmit one bit, it will transmit a number of bits. Whatever the frequency will either 10Hz or 100Hz or 1000Hz, that frequency will be repeated. For example, if a user is transmitting 100 bits then frequency with 100Hz will be repeating 100 numbers of times. Here it does not know what frequency is transmitting and sampling frequency is also unknown.

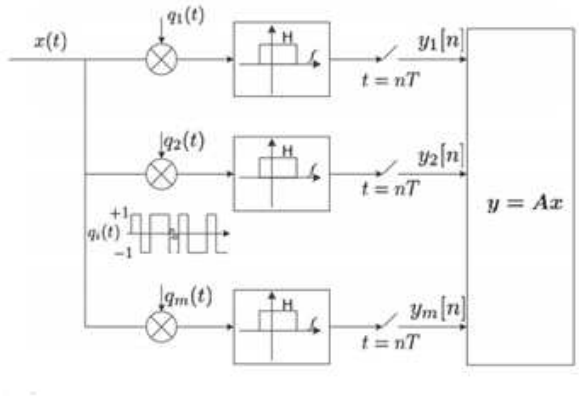

Fig.3. QR decomposition technique

The signal is detected and gives a time delay, after which we are getting two versions: a signal with no delay and a signal with delay. If these two signals are multiplied it will give a result that "when users are present the autocorrelation is high". When users are absent the auto correlation is low. QR decomposition is based on Eigen vectors, as it is said above the Eigen vectors is the diagonal of a autocorrelation matrix, in Eigen vectors when the diagonal of a matrix is '0' it can say that primary user is absent or else primary user is present.

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This is what how the QR decomposition technique is done to detect the presence or absence of user.

III SIMULATION RESULTS

The proposed designs are simulated in MATLAB and the outputs are shown below. Experimental results shows that the proposed FFT based technique not only matches the QR based technique in detection accuracy but at the same time can also be used for efficient spectrum reallocation problem.

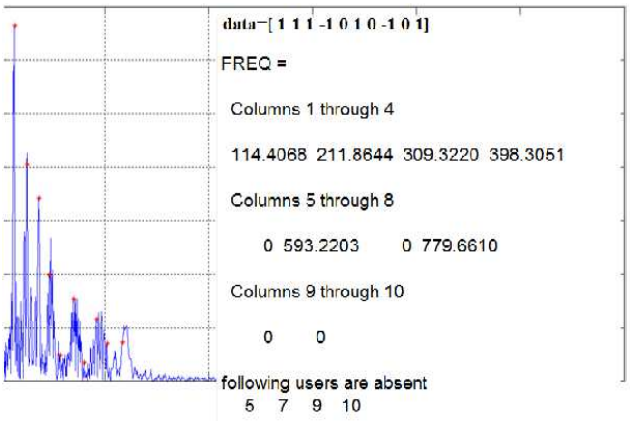

Fig 4: Result of FFT based technique of Spectrum Sensing

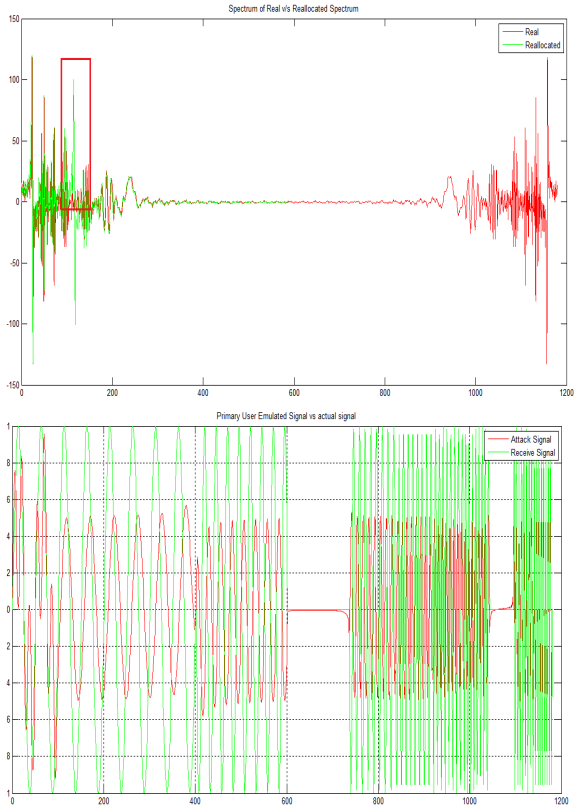

Fig 5: Results of spectrum sharing in cognitive radio

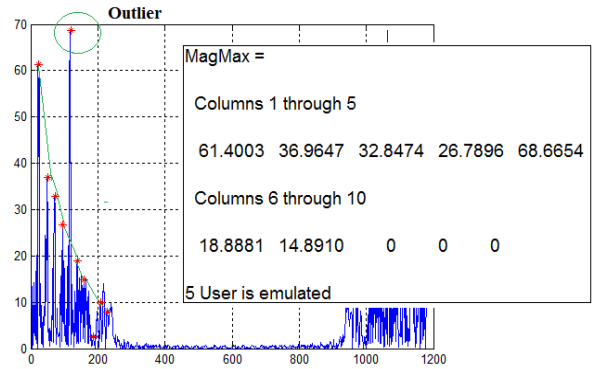

Fig 6: Result of Reallocated detection

Where signal powers are '0'and SNR ratio is 74db.

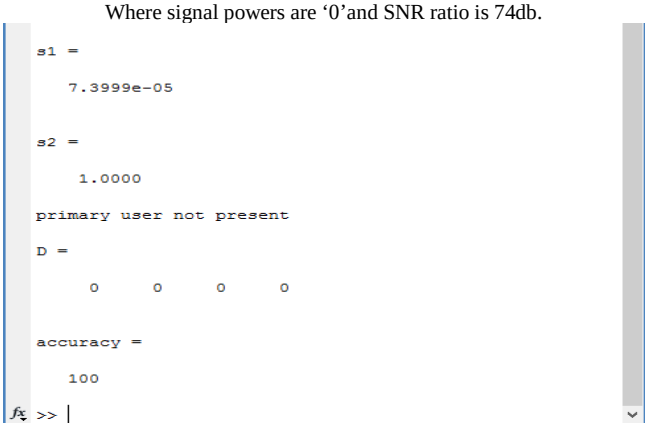

Fig 6: Result for QR decomposition method of spectrum sensing

IV .RESULTS AND COMPARISON

Comparison of QR Decomposition Technique and FFT Technique of Spectrum Sensing.

1.1 SNR V/s Accuracy		
SNR	Detection Accuracy FFT	Detection Accuracy QR
-10	0	60%
0	0	70%
10	50%	80%
1.2 SNR V/s False Alarm		
SNR	False Alarm FFT	False Alarm QR
-10	1	0.4
0	1	0.4
10	0.4	0.2
1.3 SNR V/s False Rejection		
SNR	False Rejection FFT	False Rejection QR
-10	0	0.4
0	0	0.2
10	0	0.2

1.4 Total Void Users v/s Detection accuracy

Void Users	Detection Accuracy FFT	Detection Accuracy QR
1	100%	90%
2	100%	90%
3	100%	100%
4	0	100%
5	0	90%
6	100%	90%
7	0	90%
8	100%	90%
9	0	70%
10	0	60%

V- CONCLUSION

In this paper the Cognitive radio has adjusts the spectrum utilization without disturbing the spectrum of the primary user. Through results and analysis system shows that the proposed FFT based technique not only matches the QR based technique in detection accuracy but at the same time can also be used for efficient spectrum reallocation problem. Different types of spectrum sensing techniques with different multi user access can be used as a future work. Future researchers can also leverage the framework being designed here to adopt and perform simulation under different types of channels like Rayleigh fading or Rician channel.

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