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Study of Cognitive Radio in Indian Communication Network

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Abstract*-In this research paper, we shall study The cognitive radio in modern and next generation wireless communication applications and systems in short range waves in india,OFDM –MIMO combination is mainly used in Cognitive Radio over fading channel , Effective utilization of available electromagnetic radio spectrum in our communication network is the main problem, in this paper we study the Rayleigh fading environment,techniques to reduce BER factor(bit error rate),the advantage of non cooperative communication*

Keywords*-OFDM-MIMO,cognitive radio,non cooperative communication,*

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I. Introduction

The electromagnetic radio spectrum is a powerful source for wireless communication network.many studies on wireless communication network show that there is always vacancy in our electromagnetic radio spectrum.our main problem is to fill the vacancy of electromagnetic radio spectrum. The cognitive radio modification of software-defined radio. Sense the environment ,take decisions, and then give feedback to environment.Many research has proved that OFDM-MIMO System has been proposed as a main candidate for cr's physical layer. Additionaly performance of a wide band spectrum analysis can be supported by Fast Fourier Transform (FFT) in an OFDM receiver. Multitaper spectrum estimation method (MTM) is a non-coherent promising spectrum sensing technique. It has solved many problems of power spectrum estimation .

Table 1 – Frequency Bands Allocated To Various Types Of Radio Services In India According To India'S National Frequency Allocation Plan

i) 0-87.5 MHz	Used for marine and aeronautical navigation, short and medium wave radio, amateur (ham) radio and cordless phones.
ii) 87.5-108 MHz	Used for FM radio broadcasts
iii) 109- 174 MHz	Used for Satellite communication, aeronautical navigation and outdoor broadcast vans
iv) 174-230 MHz	Not allocated.
v) 230—450 MHz	Used for Satellite communication, aeronautical navigation and outdoor broadcast vans
vi) 450- 585. MHz	Not allocated.
vii) 585-698 MHz	Used for TV broadcast
viii) 698-806 MHz	Not allocated.
ix) 806-960 MHz	Used by GSM and CDMA mobile services

x) 960-1710 MHz	Aeronautical and space communication
xi)1710- 1930 MHz	Used for GSM mobile services
xii)1930-2010 MHz	Used by defence forces
xiii)2010-2025 MHz	Not allocated
xiv)2025-2110 MHz	Satellite and Space communications
xv)2110-2300 MHz	Satellite communications and space
xvi) 2300-2400 MHz	Not allocated.
xvii)2400-2483.5 MHz	Used for Wi-Fi and Bluetooth short range services
xviii)2483.5-3300 MHz	Space communications
xix) 3300-3600 MHz	Not Allocated.
xx) 3600-10000 MHz	Space research, radio navigation
xxi) 10000 MHz	Used for Satellite downlink for broadcast and DTH services

II. Cognitive Radio

A basic cognitive cycle comprises of following three basic tasks:

- Spectrum Sensing
- Spectrum Analysis
- Spectrum Decision Making

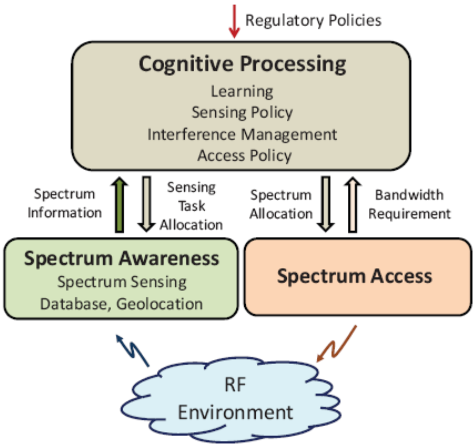

Figure 1 cognitive radio

III. OFDM – MIMO Systems

a. OFDM

OFDM transmits a large number of narrowband carriers, closely spaced in the frequency domain. In order to avoid a large number of modulators and filters at the transmitter and complementary filters and demodulators at the receiver, it is desirable to be able to use modern digital signal processing techniques, such as fast Fourier transform (FFT) .

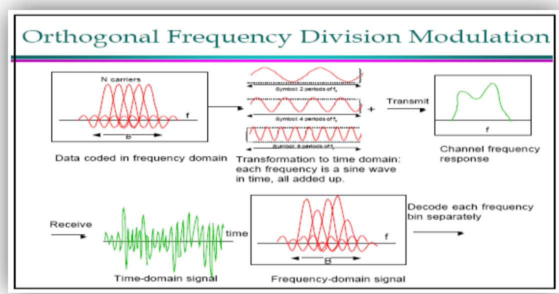

Figure 2 Basics of ofdm

b. MIMO-OFDM

as per paper (6),

OFDM reduces BER performance and ISI with using multiplexing and modulation techniques to get higher data rate over wireless channels, the use of multiple antennas at both ends of the wireless link provide better performance. The MIMO technique does not require any extra transmission power and bandwidth. Therefore, the promising way to increase the spectral efficiency of a system, the combination of MIMO and OFDM is used over fading channels

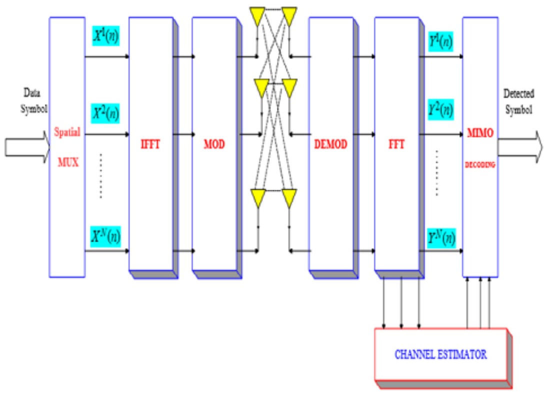

Figure 3MIMO-OFDM system model

The received signal at jth antenna can be expressed as

$$R_j[n,k]=\sum H_{ij}[n,k]X_i[n,k]+W[n,k]$$

Where H is the channel matrix, X is the input signal and W is noise with zero mean and variance.Also bi[n,k] represents the data block ith transmit antenna, nth time slot and kth sub channel index of OFDM. Here i and j denoted the transmitting antennas index and receiving antenna index respectively. The MIMO-OFDM system model with NR receives antennas and NT transmits antennas can be given as:

$$\begin{bmatrix} Z_1 \\ Z_2 \\ \cdots \\ Z_N \end{bmatrix} = \begin{bmatrix} H_{1,1} & H_{1,2} & \cdots & H_{1,NT} \\ H_{2,1} & H_{2,2} & \cdots & H_{2,NT} \\ \cdots & \cdots & \cdots & \cdots \\ H_{N,R-1} & H_{NR,2} & \cdots & H_{NR,NT} \end{bmatrix} \begin{bmatrix} A_1 \\ A_2 \\ \cdots \\ A_{NT} \end{bmatrix} + \begin{bmatrix} M_1 \\ M_2 \\ \cdots \\ M_{NT} \end{bmatrix}$$

IV. Spectrum Sensing

A major challenge in cognitive radio is that the secondary users need to detect the presence of primary users in a licensed spectrum and quit the frequency band as quickly as possible if the corresponding primary radio emerges in order to avoid interference to primary users. This technique is called spectrum sensing. Spectrum sensing and estimation is the first step to implement Cognitive Radio system .We can categorize spectrum sensing techniques into direct method, which is considered as frequency domain approach, where the estimation is carried out directly from signal and indirect method, which is known as time domain approach, where the estimation is performed using autocorrelation of the signal. Another way of categorizing the spectrum sensing and estimation methods is by making group into model based parametric method and period gram based nonparametric method. a. Primary transmitter detection: In this case, the detection of primary users is performed based on the received signal at CR users. This approach includes matched filter (MF) based detection, energy based detection, covariance based detection, waveform based detection, cyclostationary based detection, radio identification based detection and random Hough Transform based detection. b. Cooperative and collaborative detection: In this approach, the primary signals for spectrum opportunities are detected reliably by interacting or cooperating with other users, and the method can be implemented as either centralized access to spectrum coordinated by a spectrum server or distributed approach implied by the spectrum load smoothing algorithm or external detection.

Following Figure shows the detailed classification of spectrum Sensing techniques. They are broadly classified into three main types, transmitter detection or non-cooperative sensing, cooperative sensing and interference based sensing. Transmitter detection technique is further classified into energy detection, matched filter detection and cyclostationary feature detection.

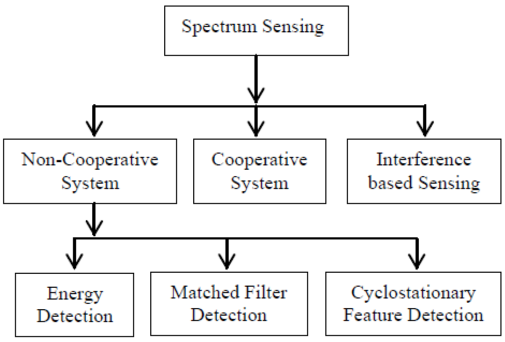

Figure 4classification of spectrum sensing techniques

Non-cooperative Spectrum Sensing Since it is difficult to sense the status of the primary receiver, so to detect the primary user transmission it is necessary to detect the signals sent by the primary transmitter. This kind of spectrum sensing is also called primary transmitter detection.

Energy Detection If CR users have no information about the primary signals then energy detection can be used for spectrum sensing. ED is optimal detector if noise power is known to the CR user .Energy detection is very simple and easy to implement. It is the most popular spectrum sensing technique. In energy detection, the presence of the signal is detected by measuring the signal over an observation time. Advantages: Simple and fewer complexes than other techniques No prior knowledge of the primary signal required Easy to implement

Disadvantages: High sensing time required to achieve the desired probability of detection Using ED, it is not easy to distinguish Primary Signal from noise signal Detection performance is limited by noise uncertainty Spread spectrum signals cannot be detected by ED.

Matched Filter Detection In matched filter detection SNR of the received signal is maximized. The CR user needs to have the prior knowledge of the primary signal transmitted by the primary user. This is the basic requirement for the matched filter detection. Matched filter operation defines a correlation in which unknown signal is convolved with the filter whose impulse response is the mirror and time shifted versions of a reference signal .

Advantages: It needs less detection time. When information of the primary user signal is known to the CR user then Matched Filter Detector is optimal detector in stationary Gaussian noise.

Disadvantages: It needs priori knowledge of the received signal.

Cyclostationary Feature Detection The modulated signals are generally cyclostationary in nature and this kind of feature of these signals can be used in this technique to detect the signal. A cyclostationary signals have the statistical properties that vary periodically with time .This periodicity is used to identify the presence or absence of primary users. Due to the periodicity, these cyclostationary signals exhibit the features of periodic statistics and spectral correlation, which is not found in stationary noise .

Advantages: Robust to noise uncertainties and better performance in low SNR regions. Capable of distinguishing the CR transmissions from various types of PU signals. No synchronization required Improves the overall CR throughput .
Disadvantages: Highly complex method Long sensing time.

V. Methodology

The circuit will be implementations in MATLAB 2013b software, with the main parameters. We generated a random binary signal generate in a serial manner. To analyze a signal in the time domain, we apply IFFT (Inverse Fast Fourier Transform) and convert it from parallel to serial OFDM signal to add a cyclic prefix (CP), which helps avoids interference between OFDM symbols. This signal is then feed through an Additive White Gaussian Noise (AWGN) channel. At the receiver end, the CP is removed and the signal converted from serial to parallel to get the original, with FFT applied to each symbol for analysis in the frequency domain. After demodulation, the signal is cross correlated with that of a time-shifted local oscillator.

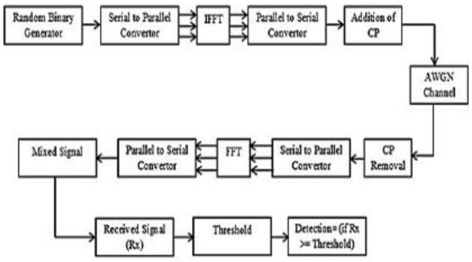

Figure 5 MIMO-OFDM System using Matched Filter Detection Technique

Finally, the received signal is compared to a threshold value (ʎ) following the SNR or determines whether the signal is absent or present; if the received signal is greater than the threshold value, there will be detection, otherwise not:

$$S(t) = n(t)$$

$$S(t) = \{h^*P(t) + n(t)\}$$

where S(t) is the secondary user, P(t) the primary user's transmitted signal, n(t) is AWGN, h the amplitude gain of the channel, H0 = there's no primary user, and H1 = primary user is present.

VI. Example

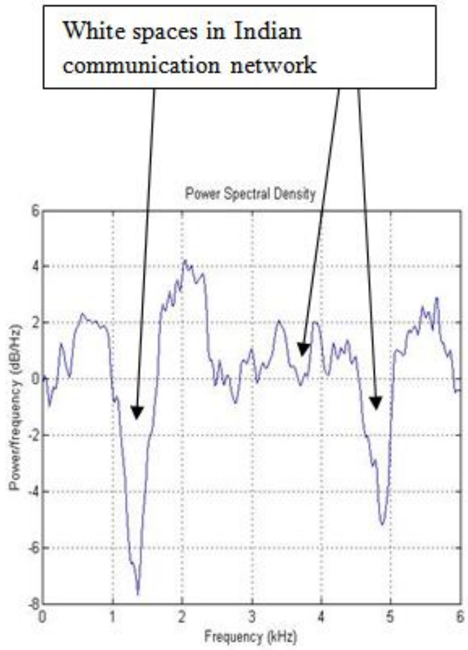

Figure 6 white spaces in indian communication network

VII. Conclusion

A matched filter, also known as optimal linear filter, is a spectrum-sensing method that detects the free portion of the primary user's spectrum and allocates it to secondary users. It derives from cross-correlating an unknown signal with known ones to detect the unknown signal's presence based on its SNR.In matched-filter detection, the dynamic threshold is used to improve the spectrum-sensing efficiency and provide better performance in cases of lower SNR.

We can say that in india there is a large population ,second after china .In same ratio there is a large communication network ,in that network there is large amount of white spaces .so india is a good market of IEEE 802.22 standard based cognitive radio .we can show clearly these results in following figures.

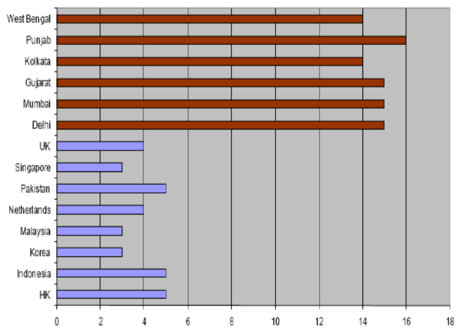

Figure 7 number of cellular operators(Lakhs)with spectrum assigned or promised

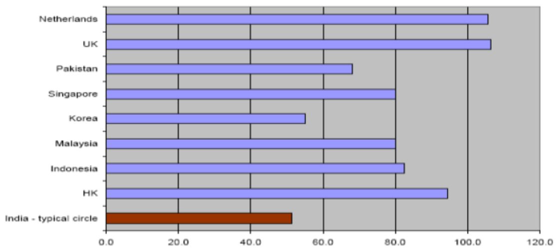

Figure 8 total 2 g spectrum assigned by country(2*mhz)

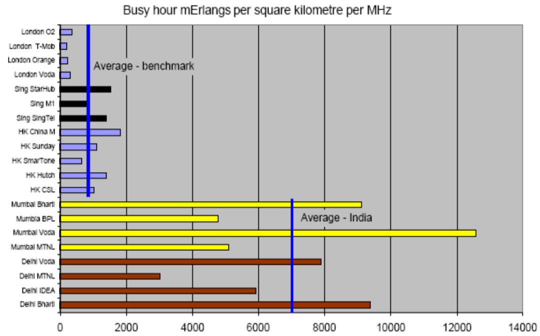

FIGURE 9SPECTRUM EFFICIENCY IN THE CITIES OF INDIA AND OTHER COUNTRIES.

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