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Side Lobe Suppression of OFDM Based Cognitive Radio by Using Genetic Algorithm

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Abstract – The spectrum allocation policies of the Federal Communications Commission (FCC) [1] only allow spectrum access to primary users, it has been proven by various spectrum measurement campaigns that, the current spectrum usage across time and frequency is inefficient. Therefore, in order for the secondary users to access the unused portions of the licensed spectrum, the concept of "spectrum pooling" has been proposed. Efficient pooling of the radio-frequency spectrum is achieved by employing a cognitive radio (CR). A CR could be a multi-band, spectrally agile radio that employs versatile communication techniques. An outstanding candidate for CR which provides us several reasons to use is orthogonal frequency division multiplexing (OFDM) which is a combination of modulation and multiplexing.. The large side lobes resulting from the utilization of OFDM leads to high out-of-band (OOB) radiation that causes interference to the neighbor used frequency spectrum. We are proposing this adaptive optimum suppression technique for side lobe power reduction of CR signals based on a previously proposed method AST, employing a genetic algorithm (GA) approach for optimization purpose. Also we have draw BER vs. SNR after simulation.

Index Terms – Cognitive Radio, OFDM, Out Of Band Radiation, Side lobe Suppression.

1. INTRODUCTION

The need for higher information rates is increasing as results of the transition from voice-only communications to multimedia system kind applications. Given the restrictions of the natural frequency spectrum, it becomes obvious that this static frequency allocation schemes cannot accommodate the wants of associate degree increasing variety of upper rate devices. As a result, innovative techniques which will supply new ways in which of exploiting the offered spectrum square measure required. Psychological feature radio arises to be a tempting resolution to the spectral congestion downside by introducing opportunist usage of the frequency bands that square measure not heavily occupied by commissioned users [1]. Economical pooling of the spectrum is achieved by employing a psychological feature radio that could be a multi-band, spectrally agile radio that employs versatile communication techniques and detects the presence of primary user transmissions over completely different spectral ranges to avoid interference to the commissioned users. According to a report of the U.S. Federal Communications Commission (FCC) [2], there are giant temporal and geographic variations within the utilization of allotted spectrum starting from V-day to eighty fifth. it's then clear that the answer to the spectrum scarceness drawback is dynamically probing for the spectrum "white spaces" and victimization them opportunistically. during this paper, we tend to use the definition of psychological feature radio adopted by Federal Communications Commission (FCC): "Cognitive radio: A radio or system that senses its operational magnetic attraction surroundings and may dynamically and autonomously alter its radio operational parameters to change system operation, such as maximize outturn, mitigate interference, facilitate ability, access secondary markets." [3].

In psychological feature radio word, primary users is outlined because the users United Nations agency have higher priority or heritage rights on the usage of a particular a part of the spectrum. On the opposite hand, secondary users, that have lower priority, exploit this spectrum in such the way that they are doing not cause interference to primary users. Therefore, secondary users have to be compelled to have psychological feature radio capabilities, like sensing the spectrum faithfully to examine whether or not it's being employed by a primary user and to vary the radio parameters to use the unused a part of the spectrum. One approach to share spectrum between primary and secondary spectrum users is timeserving spectrum access (OSA), within which secondary user is allowed to determine and exploit native and instant spectrum white area wherever the prime user isn't gift. Since secondary users may have to transmit over noncontiguous frequency bands, OFDM is a beautiful candidate for modulation in OSA networks.

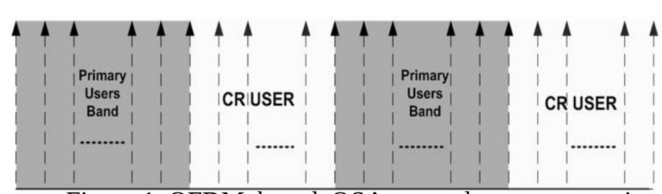

Figure 1 OFDM based OSA secondary user coexists with primary use.

In OFDM based OSA system, to enable coexistence with primary user, the constituent tones/subcarriers can be turned off at the prime user's channel, creating spectrum notches to limit interference perceived by primary user. The concept of the coexistence between an OFDM based OSA system and a primary user is illustrated in Fig.1. Orthogonal frequency division multiplexing (OFDM) has proven to be the prime candidate for spectrum pooling based wireless transmission systems as it can achieve high data rate communications, by collectively utilizing a number of orthogonally spaced frequency bands which are modulated by many slower data streams, and this division of the available spectrum into a number of orthogonal subcarriers makes the transmission system robust to multipath channel fading.

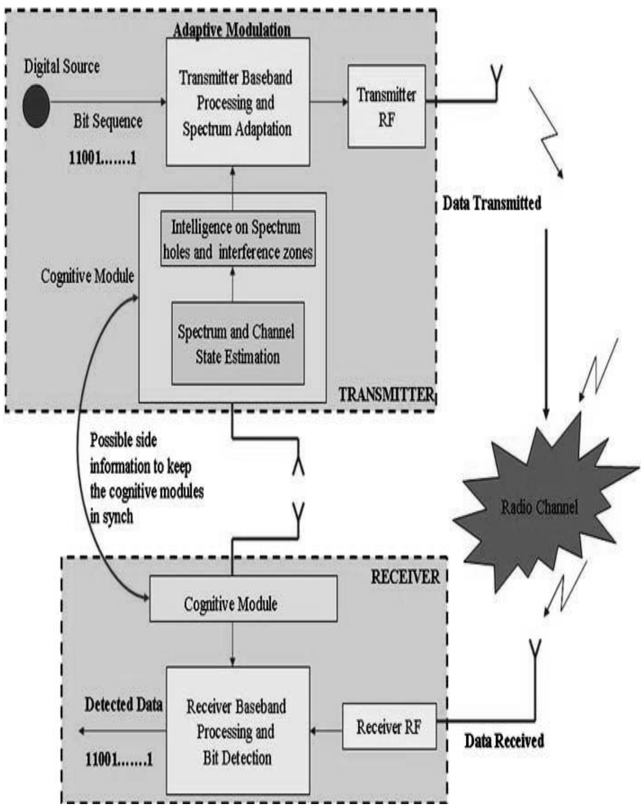

Figure 2 System models of the Cognitive Radio transmitter and Receiver.

Furthermore, it is possible to turn off the subcarriers in the vicinity of the primary user transmissions, and thus the spectral white spaces can be filled up efficiently. Even though the secondary transmissions help in improving the spectral efficiency by transmitting in the spectral white spaces left unused by the primary users, the large side lobes resulting from the use of OFDM result in high out-of-band (OOB) radiation. Thus, the coexistence of the primary and the secondary users in the form of spectrum sharing is dependent on the suppression of the interference from the rental systems to the legacy systems. The basic idea is to improve the system performance of an OFDM-based cognitive radio by solving an important problem that makes the coexistence of the legacy and the rental systems a practical solution to the existing under-utilization of the radio spectrum.

1.1 System Operation and Cognitive Cycle

Figure 2 gives the blocks of a CR system. The **three fundamental tasks of the system are:**

1. Spectrum Estimation: Gauge the radio spectrum scenario and perform radio scene analysis.

2. Channel State Estimation and Predictive Modeling: Accurate and timely channel state information (CSI) at the transmitter is important for accurate power control, prediction of channel capacity, and scheduling.

3. System Reconfiguration: based on the radio spectrum scenario and the channel state information, the system dynamically adapts transmission parameters such as power, spectrum, and modulation scheme and data rate.

The spectrum estimator senses the spectrum and detects the presence of interference regions and spectrum holes and the channel estimator gauges the channel to derive the channel state information. Based on this information the transmitter adapts one or more of the following: signal spectrum, modulation scheme, constellation size of code, data rate, and power. Consequently a pulse waveform that has little or no energy in the interference domains is constructed. The stream of data is modulated by the pulse waveform to obtain a transmission signal. The signal is then transmitted through the channel. At the receiver, the signal, corrupted by interference, is received and the data is detected using a suitable detector. Figure 2 illustrates the cognition cycle by which the system interacts with the environment and communicates.

1.2 Advantages of OFDM Based CR

1. OFDM is a multicarrier modulation technique that can overcome many problems that arise with high bit rate communications, the biggest of which is time dispersion.

2. The inter-symbol interference (ISI) is removed by extending the OFDM symbol with a cyclic prefix (CP). Using CP, OFDM reduces the dispersion effect of multipath channels encountered with high data rates and reduces the need for complex equalizers.

3. OFDM includes high spectral efficiency.

4. Robustness against narrowband interference (NBI).

5. Removes Fading and Harmonic distortion.

6. Scalability and easy implementation using fast Fourier transform (FFT).

7. It is possible to allow the overlap of the individual subcarriers without leaving spectral guard bands, and still be able to avoid the adjacent subcarrier interference.

8. Faster transmission than FDM.

9. Bandwidth Efficiency.

2. PORPOSED MODELLING

A main point for the success of CR is its ability to shape signal spectrum to maintain minimum interference to PU. OFDM has been proposed as a candidate signaling technology for such applications. By dividing the spectrum into sub bands that are modulated with orthogonal subcarriers, OFDM spectrum can be shaped with more ease compared to other signaling techniques.

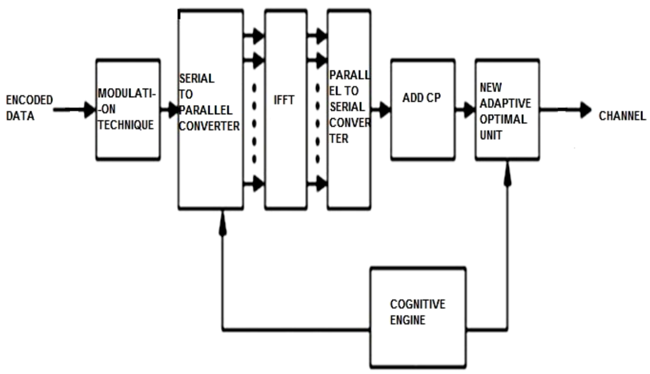

Figure 3 System Model of proposed method.

2.1 GENERATION OF OFDM SIGNAL

In this subsection, the process of generating an OFDM signal and its characteristics are explained with the help of the general schematic of an OFDM-based transceiver shown in fig.3

Let d= (d1, d2... d_n) be a data stream modulated to x= (x1, x2... x_n) by any Phase Shift Keying or an M-ary quadrature amplitude modulation (M-QAM) modulator. The modulated data stream is then split into N slower data streams using a serial-to-parallel (S/P) converter. Each of these streams is transmitted on one of the N orthogonal subcarriers and then summed up to give a composite OFDM signal.

OFDM-based transceivers that are capable of deactivating the subcarriers based on the spectrum sensing methods are referred to as non-contiguous OFDM-based transceivers.

If, $X_{k,m}$, m = 0, 1, ...,N − 1 represents the complex modulated symbol over subcarrier, m at the k-th instant of time, then one baseband OFDM symbol, multiplexing N subcarriers is given by,

$$S_K(t) = \frac{1}{N}\sum_{m=0}^{N-1} X_{k,m} e^{j2\pi f_m t} \quad 0 < t < NT$$

Where T is the symbol duration and

$$f_m = \frac{m}{NT} \qquad m = 0, 1, ...,N-1$$

are the equally spaced orthogonal subcarrier frequencies,fm.

After adding a cyclic prefix to the OFDM symbol, it is passed through a parallel-to-serial (P/S) converter, then the signal is up sampled and passed through a digital to analog (D/A) converter for converting it into an analog signal, followed by low pass filtering. Then, the signal is translated to the desired band pass frequency and amplified by a power amplifier.

At the receiver, the signal is translated to baseband, low pass filtered and converted to a digital signal by passing through an analog-to-digital (A/D) converter. By passing through a S/P converter, this digital data stream is converted to N+l parallel streams, where l is the number of symbols added as cyclic prefix. These l symbols are discarded next, before performing the DFT operation,

$$X_{k,m} = \sum_{n=0}^{N-1} r_{n,m} e^{j2\pi\frac{mn}{N}} \quad n = 0,1,....., N-1$$

The remaining N parallel streams are converted to a serial stream using a P/S converter and then demodulated to obtain an estimate of the transmitted data stream.

With respect to the interference caused by the unlicensed user to the licensed user, the important issue that needs to be taken into consideration when designing an OFDM-based overlay system is that its impact on the legacy system should be very small. Thus, the basic aim of any algorithm for sidelobe suppression is to reduce the sidelobe power levels while causing little or no effect to the other secondary system parameters. A brief mathematical representation of the interference to the legacy system is provided in this section.

2.2 INTERFERENCE POWER

Assuming the transmit signal, s(t) on each subcarrier of the OFDM-transceiver system is a rectangular non-return-to-zero (NRZ) signal, the power spectral density of s(t) is represented in the form :

$$\phi_{ss}(f) = A^2 T \left(\frac{\sin\pi fT}{\pi fT}\right)^2$$

where A denotes the signal amplitude and T is the symbol duration which consists of the sum of symbol duration, TS and guard interval, TG. The assumption that the transmit signal s(t) on each subcarrier is a rectangular NRZ signal is valid since it matches the wireless LAN standards. Now assuming that, the legacy system is located in the vicinity of the rental system, the mean relative interference,$P_{Interference}(n)$, to a legacy system subband is defined as

$$P_{Interference}(n) = \frac{1}{P_{Total}}\int_n^{n+1} \phi_{ss}(f)df$$

where P_{Total} is the total transmit power emitted on one subcarrier and n represents the distance between the considered subcarrier and the legacy system in multiples of Δf.

3. SIDELOBE SUPPRESSION USING GENETIC ALGORITHM

Genetic algorithms are feature choice algorithms supported the mechanics of natural process and natural biology. A GA may be a random search technique that searches for the most effective feature from a groundwork area provided to that. This search is finished supported an objective function, otherwise known as a fitness function, that is employed for locating the most effective match at intervals the search area. This operate is evaluated at every individual search purpose within the population over many generations till a configuration is found that meets the specified objective. The search area is nothing quite a population of configurations. These configurations area unit the binary coded options known as chromosomes or strings.

An effective GA illustration and purposeful fitness analysis are the keys to success in GA applications. GA is thought for its simplicity as an economical search formula, like its power to speedily discover the most effective solutions for issues flat multidimensional. The advantage of the GA approach is that the ease with that it will handle impulsive types of constraints and objectives. These things are often handled as weighted components of the fitness operate. GA may be excellent tools which will facilitate us handily find the most effective answer.

3.1 WORKING OF GENETIC FORMULA

Genetic algorithms are enforced as a technique within which a population of chromosomes of candidate solutions to a problem downside evolves toward higher solutions. Historically, solutions are represented in binary as strings of 0s and 1s; however alternative encodings also are attainable. The four basic operators utilized in GAs are:

- Initialization
- Selection
- Crossover
- Mutation

Reproduction may be a method within which configurations are traced on to future generation according to their fitness function values. The configurations with the next worth of fitness function have the next likelihood of tributary one or additional offspring's to future generation. Crossover may be a recombination operator that mixes subparts of 2 parent chromosomes to supply offspring that contain some components of each parents' genetic material. Mutation is an operator that introduces variations into the chromosome. The evolution typically starts from a population of arbitrarily generated individuals and happens in generations. In every generation, the fitness of each individual within the population is evaluated; multiple individuals are stochastically selected from the present population supported their fitness score, and changed victimization crossover and mutation to make a replacement population. The new population is then utilized in future iteration of the formula. Commonly, the formula terminates once either a most variety of generations has been created, or a satisfactory fitness level has been reached for the population. If the formula has terminated attributable to a most variety of generations, a satisfactory answer could or might not are reached . shows the GA procedure. Initially, a random population is generated and therefore the fitness operate values area unit evaluated over every configuration. Any configuration that meets the improvement objective is taken into account as a best configuration. The configurations that don't meet the improvement objective bear replica, crossover and mutation that successively cause a replacement population of configurations. This new population can currently bear identical method as declared earlier till the most effective configurations are found.

4. SIMULATION RESULT

The performance of proposed method with the same parameters and also having some parameters as snr_min = -10, snr_step = 2, snr_max = 10, N = 1024, compen_len = 12, total_frames = 10, LU_start_sub_carr = 64, LU_end_sub_carr = 128, M = 2, gard_band_len = 0, cp_length = 4 with same modulation technique (QPSK or PSK, PAM, QAM) is shown in Figure

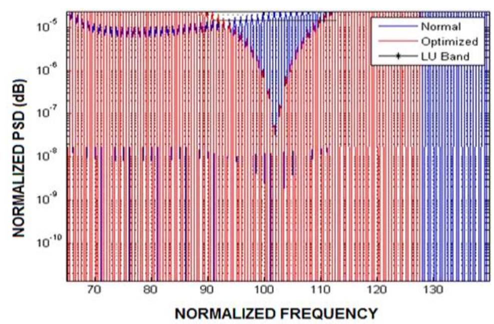

Figure 4 Plot of SNR by using the new adaptive optimal method.

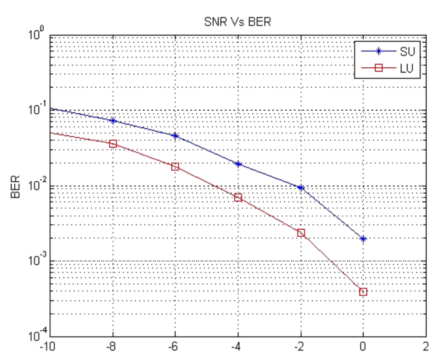

Figure 5 SNR Vs BER plot.

5. CONCLUSION

In this thesis, an attempt has been made for suppressing the interference power resulting from the rental system to the legacy system to acceptable levels. Consequently, the coexistence of the legacy and the rental systems is made more feasible. A novel algorithm that has been proposed in this thesis will introduce a new adaptive optimal method to improve performance of CR. The new system can be optimized to error performance.

This new adaptive method is having a constant signal peak-to-average-power radio (PAPR) and keeps a low SNR loss. The BER vs. SNR graph shown in result depicts the high performance of the proposed system.

The result shows that the interference reduces further to less than −70dB. Also this result is better as compared to the previous AST method in which the suppression gain is found to be 50dB.

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