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A Software Defined Radio Implementation of Spectrum Sensing and Sharing on a Full Duplex Mode

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ABSTRACT

A cognitive radio is a keenly intellective radio network that can be programmed and configured dynamically. The transceiver of the cognitive radio is intended to utilize the best remote correspondence channels. Such as cognitive radio intelligently detects which channels are busy and which channels are not busy in wireless spectrum, then accordingly changes its transmission or reception specification to allow more concurrent wireless communication in a given spectrum band at one location. Cognitive radio networks (CRNs), where the secondary users (SUs)dynamically utilize the idle licensed channels of Primary Users (PUS), can achieve high spectrum utilization and improve the quality of wireless applications. In CRNs, the SUs sense the states of the PUs and use the licensed channels when they are not occupied by the PUs. Usually spectrum sensing is done in half duplex mode where the radio will sense first and transmit next. The major drawback of the half duplex spectrum sensing is that it is less spectral efficient. To overcome from the above problem full duplex spectrum sensing method is used. Several signal detection techniques, such as the energy detection, matched filter detection and correlation based method can be used by secondary user to sense the presence of primary user. In this Paper correlation based method is used to sense the primary user by the secondary user.

Index Terms: Cognitive Radio Networks(CRNs), full duplex spectrum sensing, primary users(PUs), Secondary Users (SUs)

I. INTRODUCTION

Spectrum scarcity problem has emerged as primary problem when we are trying to launch a new wireless service. In order to overcome from the spectrum scarcity problem the licensed spectrum has to be reused when it is free.The higher spectrum utilization can be achieved by using the cognitive radio networks and it is a prototype approach networks. Cognitive radio is a wise radio in which correspondence frameworks know about their inside state and environment. Cognitive Radio Networks innovation is rising as the following real stride forward empowering more viable radio correspondences framework to be produced. Cognitive radio, with the ability of dynamically exploiting idle spectrum and adaptably adjustingits transmission specifications, is broadlyconsidered as a promising innovationthat deals with the spectrum scarcity problem caused by the current rigid range portion strategy. In its most essential structure, CR is a hybrid technology including software defined radio (SDR) as connected to spread range interchanges.A Software Defined Radio (SDR) is a radio correspondence framework where the equipment segments, for example, channels, multipliers, modulators and demodulators, and so forth, are actualized by method for programming rather than hardware implementation. Cognitive radios are basically classified into two types. one is full cognitive radio and second type is spectrum-sensing cognitive radio. Full cognitive radio takes into account all specifications that a wireless node or network can be aware of it. Spectrum-sensing cognitive radio is utilizedto recognize diverts in the radio frequency spectrum.In general, the spectrum sharing techniquesare classified into three types. 1) Opportunistic spectrum access and also known as spectrum

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overlay, under which a SUs accesses a band only when itis not being used by the PUs; 2) Spectrum sharing and also knownas spectrum underlay, where the SUs coexists with the PUsand transmits with power constraints to guarantee the Quality Of Service (QoS) of the PUs and 3) Sensing-based spectrumSharing, with which the SUs first senses the status of the PUs and then selects an appropriate spectrum sharingmode based on the sensing result.

II. FULL DUPLEX SPECTRUM SENSING AND SHARING SYSTEM MODEL

Usually spectrum sensing is done in half duplex mode where the radio will sense first and transmit next.The major drawback of the half duplex spectrum sensing is that it is less spectral efficient. To overcome from the above problem full duplex spectrum sensing method is used. In full duplex mode, the informationcan be transmitted in both headings on a signal carrier at the same time. The full duplex spectrum sensing is more spectral efficient than the half duplex spectrum sensing mode. To detect the presence of the Primary Users, the Secondary Users need to sense the licensed channel both in sensing and transmission period.

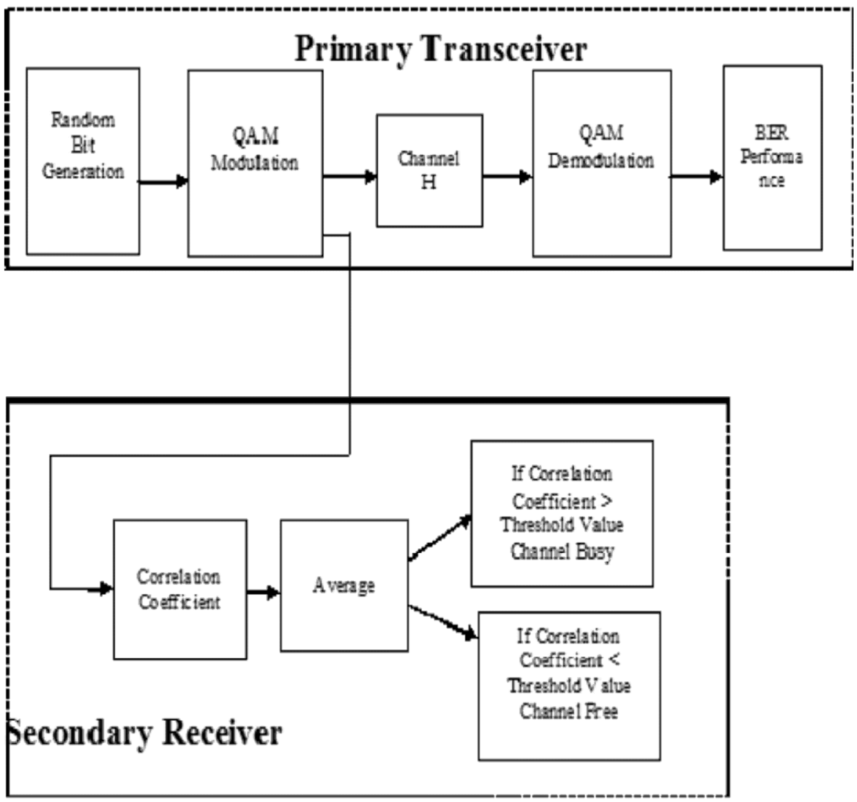

Figure 1: Block diagram of full duplex spectrum sensing and sharing

(A) Primary transceiver and secondary receiver

In primary transmitter, initially 1000 random bits are generated. These random bits are modulated using QAM(Quadrature Amplitude Modulation). These resultant modulated signals are transmitted to the primary receiver side. In primary receiver side, received modulated signals are demodulated by using QAM demodulation and obtained the signal to perform Bit Error Rate. In secondary receiver, correlation coefficient sensing method is used to sense the primary user by secondary user. The average value of correlation coefficient is determined. Then the threshold value is calculated and the threshold value is compared with the average correlation co-efficient value. If correlation co-efficient value is greater than threshold value then the primary user channel is occupied and if the average correlation co-efficient value is lesser than the threshold value then the primary channel is free.

(B) Quadrature Amplitude Modulation (QAM)

Quadrature amplitude modulation (QAM) is both ansimple (analog) and a digital modulation scheme. It passes on two analog message signals, or two digital bit streams by evolving (modulating) the amplitudes of two carrier waves, utilizingthe amplitude-shift keying(ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The two carrier waves, usually sinusoids, are out of stage with each other by 90° and are subsequently called quadraturetransporters or quadrature segmentshence the name of the scheme. The adjustedwaves are summed, and the final waveform is a mix of both phase-shift keying and amplitude-shift keying, or (in the analog case) of phase modulation and amplitude modulation. In the digital QAM case, a limited number of no less than two stages and no less than two amplitudes are utilized.

(C) Bit Error Rate (BER)

In digital transmission, the number of bit errors is the quantity of received bits of an information stream over a correspondence channels that have been modified because of commotion, impedance, twisting or bit synchronization mistakes. The Bit Error Rate (BER) is the quantity of bit mistakes per unit time. The bit error ratio is the quantity of bit blunders isolated by the aggregate number of exchanged bits amid a contemplated time interim. BER is a unit less execution measure, regularly communicated as a rate. The bit error probability pe is the desire estimation of the bit error ratio. The bit error ratio can be considered as a surmised evaluation of the bit error probability. This assessment is exact for quite a while interim and a high number of bit errors.

(E) Mathematical Model of Full Duplex Spectrum Sensing

Several signal detection techniques, for examples, the energy detection, feature detection, matched filter and correlation co-efficient based methods can be utilized for the SUs to sense the presence of the PUs. The correlation co-efficient based method is efficient and easy to be implemented whilecontrastedwith alternate strategies.

Under the wireless full-duplex mode, the PU's transmit signal received at the SU at time *t*, signifiedby *r*(*t*), can be written as follows

$$r(t) = \sqrt{khs(t)} + w\omega(t) \tag{1}$$

Where *h* is the instantaneous amplitude gain of the channel between the PU and the SU, which follows Rayleigh distribution.*s*(*t*) is signal sent by PU with transmit power *Es*; ω(*t*) represents the Additive White Gaussian Noise (AWGN)with zero mean and variance of σ2; κ(0 < κ ≤ 1) is the self-interference mitigation coefficient, defined as the impact of self-interference mitigation on the wireless full-duplex communication.

Then, the test statistics of wireless full-duplex energy detection for the channel from the PU to the SU, denoted by *YN*(*r*), as follows:

$$Y_N(r) = \begin{cases} \frac{1}{U}\left(\Sigma_{m=0}^{d}\left|\sqrt{khs(m)} + \omega(m)\right|^2 + \Sigma_{m=d+1}^{U}\,|\,\omega(m)\,|^2\right)_{if\,\aleph_{10}} \\ \frac{1}{U}\left(\Sigma_{m=0}^{a}\,|\,\omega(m)\,|^2 + \Sigma_{m=a+1}^{U}\left|\sqrt{khs(m)} + \omega(m)\right|^2\right)_{if\,\aleph_{01}} \end{cases} \tag{2}$$

Where ℵ10 implies that the primary is active for d samples and then becomes inactive, ℵ01 implies that the primary is inactive for *a* samples and then becomes active, *U* is the number of samples for the entire sensing period.By considering the circularly symmetric complex Gaussian (CSCG) signal for the primary signal $s(m)$ and the noise $\omega(m)$. The CSCG signal represents signals with rich inter-symbol interference such as orthogonal frequency division multiplexing (OFDM) signals or OFDM signals with linear preceding. When U is relatively large, using the central limit theorem, under the hypothesis $H10$, the probability density function of $YN(r)$, denoted by $p10(x)$, can be approximated by a Gaussian distribution. Also, under hypothesis $H01$, the probability density function of $YN(r)$, denoted by $p01(x)$, can be approximated by a Gaussian distribution.

III. RESULTS AND DISCUSSION

The labviewfront panel view of primary transceiver and secondary receiver are shown in figure 2. In this primary transceiver 1000 random bits were generated. It is then modulated using 8-QAM modulation and demodulated using 8-QAM demodulation. The values of Random bits generator are mentioned as output bit streams in fig. 2. The status of the primary user is mentioned as indicator in fig. 2. If x>y indicator is on that means the correlation value is greater than then threshold value therefore the primary user channel is occupied and if the x<y indicator is on then the correlation value is lesser than the threshold value therefore the primary user channel is free.

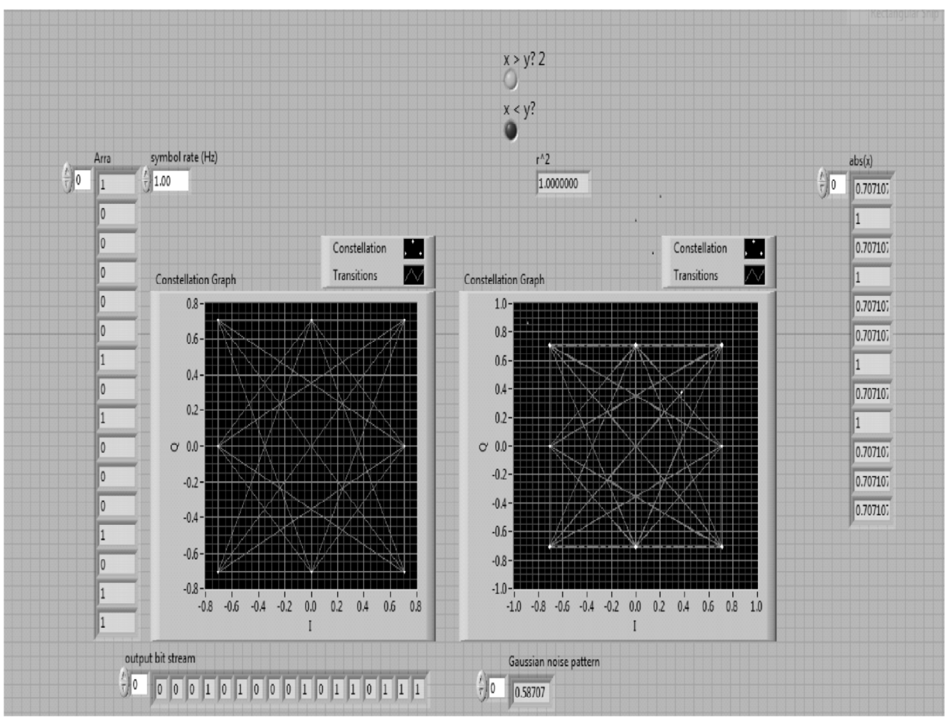

Figure 2: LABVIEW front panel view of primary transceiver and secondary receiver

The labviewblock diagram of primary transceiver and secondary receiver are shown in figure 3. In primary transceiver 1000 random bits were generated at the symbol rate of 1kHz. It is then modulated using 8-QAM modulation and demodulated using 8-QAM demodulation

IV. CONCLUSION

In this paper, a software defined radio implementation of spectrum sharing and sensing on full duplex mode, initially in the transmitter block of the system model the random bits were generated and modulated using 8-QAM modulation successfully. The resultant is then transmitted successfully to the receiver side. The received signal is then demodulated to analyze the performance of BER of signal. The BER analysis

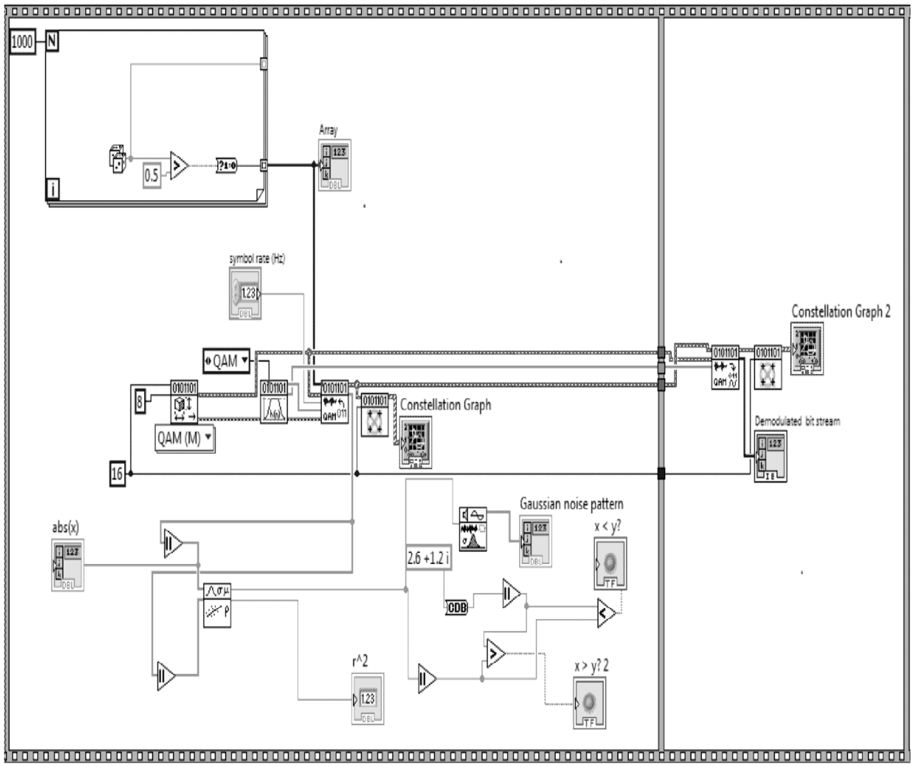

Figure 3: LABVIEW block diagram of primary transceiver and secondary receiver

was successfully completed. Correlation process is done in the secondary receiver in order to detect the primary user then the average value of correlation co-efficient is taken. If the correlation coefficient value is greater than threshold value then the channel of the primary user is busy and if the correlation co-efficient value is lesser than the threshold value then the channel of the primary user is free.

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