THROUGHPUT MAXIMIZATION IN COGNITIVE RADIO NETWORK BY SPECTRUM SHARING

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Abstract: The next generation communication employ cognitive radio network an assuring technology which enables the secondary users (SUs) to use the free spectrum bands which are licensed originally to the primary users (PUs) without inducing interference and deploy the spectrum well planned . This cognitive radio aims to investigate Carrier Frequency Offset (CFO) and Sampling Frequency Offset (SFO) estimation problems in distributed OFDM systems. Spectrum sharing should be carried out frequently in order to transmit the data successfully through secondary users without causing significant interference with the primary users and to achieve the maximum throughput. In this paper we address the synchronization problem in spectrum sharing scenario and propose a block type pilot based synchronization algorithm to suppress the CFO and SFO mismatch. The pilot pattern used here is CAZAC (Constant Amplitude Zero Autocorrelation) sequence. Simulation results show the proposed method can significantly improve throughput performance when synchronization errors vary.

Keywords: cognitive radio(CR), carrier frequency offset(CFO), sampling frequency offset(SFO), zero force beam-forming(ZFBF),constant amplitude zero-force autocorrelation(CAZAC) algorithm, spectrum sharing and monitoring.

1. Introduction

In communication system, the Radio Frequency spectrum is approached by Static Spectrum Access where the spectrum is fixed to licensed or primary users (PU) while secondary users (SU) or unlicensed users are refused for accessing those spectrums even when the primary users are unengaged called Spectrum holes or White Space. Hence there occur congestion in secondary user and also improvident use of frequency spectrum in primary user. This leads to progressive spectrum access which proposed a new technique called cognitive radio networks (CRN) in which secondary users (SU) can use the vacant spectrum of primary users (PU).

The secondary user must have spectrum sensing potential to sense whether there is presence of PU prior to transmission. This provides spectrum efficiency and also increases the staging of the network. Cognitive radio network is an overlay network. In this method, secondary users will sense the spectrum of primary users if the PU spectrum is unoccupied, then SU can then use the spectrum for conveyance, but at the same time SU must periodically able to recognize signals from the primary users during which SU will remain silent and does not involve in conveyance by observing the shared band to quickly vacate the occupied spectrum. If signal is not detected during sensing phase then SU persist in using the primary spectrum thus escalating throughput and Quality of Service (QoS).

If signal is detected SU stops its transmission by vacating the occupied spectrum and choose another desolate spectrum. This will make the SU receiver to deplete its synchronization with transmitter and also have moderate quality of services and throughput. During this process, the CR system takes a long time for detecting the habituation of primary users and this interval is known as the sensing interval, during which the secondary user does not manipulate the spectrum during this detection so it is called as Quiet Period (QP).

2. Materials and methods used in CR network

In the proposed cognitive radio system, we inspect the performance of techniques used in the system by generating random input to the transmitter. The proposed system has four modules of execution as follows:

a) CFO and SFO minimization using CAZAC algorithm.
b) Beam-forming using joint maximum likelihood algorithm.
c) Spectrum sharing and monitoring using energy ratio algorithm.
d) Throughput maximization using 1-tap equalizer.

The block diagram of the proposed system is given below:

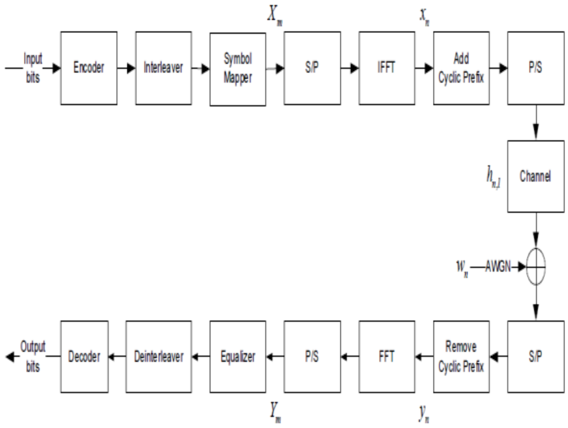

Figure-1. Block diagram

2.1 CFO and SFO minimization using cazac algorithm

In this section, we will confer the proposed block type pilot based synchronization errors suppression algorithm. The pilot pattern used here is the CAZAC sequence, which is one of the strongest candidates as pilot pattern in CR network and has been exploited by LTE-Advanced standard. Let *L* to be any positive integer larger than one and *M* to be any number, which is relatively prime with *L* is shown in figure-2.

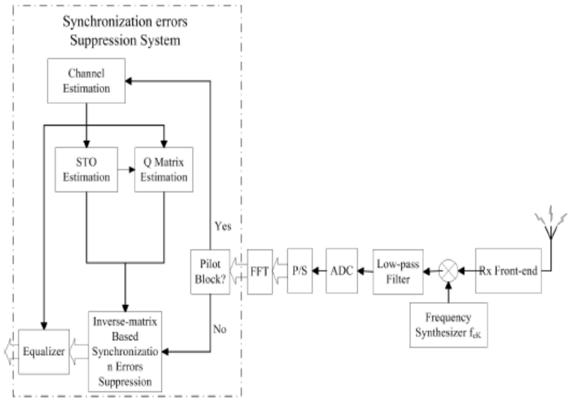

Figure-2. Block diagram for cazac algorithm

The cazac sequence is given by,

$$\sum_{n=0}^{L-1} c_M(n).c_M\,(n+\tau)_{mod\,L} = \begin{cases} L, \tau = 0 \\ 0, \tau \neq 0 \end{cases} \quad (1)$$

2.2 Beam-forming using joint maximum likelihood algorithm

In our CR network, we elicit a closed-form expression for the transmit beamformer using the power iteration for the two transmit antenna system. In this paper, we assert a low complexity non-iterative solution for two or more antenna systems with two users. With the maximal ratio combining tactics at the receiver (i.e., w = Hf/kHfk), which is an equitable design choice (but not necessarily the only one) since we come very close to capacity under the zero interference suppresion, we have the optimization problem as follows:

$R_1 = H_1 * H_1/||H_1||^2, R_2 = H_2 * H_2/||H_2||^2 \quad (2)$ are the Nt × Nt normalized matched channel matrices and f1, f2 are the transmit beamformers of size Nt × 1. There may be several transmit beamformer vectors that satisfy the zero interference suppressions for more than two transmit antenna systems. Also, there is no non-iterative solution yet for the transmit beamformers for two or more transmit and receive antennas. Here we propose a low complexity algorithm for finding the beam-formers.

2.3 Spectrum sharing and monitoring using energy ratio algorithm

On the time-frequency grid of the OFDM frame and before the IDFT, a number of tones, *NRT* , are reserved for the spectrum monitoring purposes. These tones are reserved for the whole time except the time of

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the training symbol(s) not to change the preamble waveform, which is used for synchronization at the receiver. The tones are advanced by Δr positions every OFDM symbol. When the last index of the available subcarriers is reached, the spanning starts again from the first subcarrier. Hence, by considering small values for Δr, the reserved tone sequence injected to the energy ratio spans the whole band. The reasons for this scheduling are: (1) The primary user may have some spectrum holes because of using OFDM as well. If the reserved tones from the SU are synchronized with those spectrum holes in the PU side, then the algorithm will fail. On the contrary, if the PU uses a traditional single carrier modulation technique like QAM, this issue does not have a harm effect on the algorithm since the PU signal has a flat spectrum over the entire band. (2) The reserved tones typically occupy narrow band and the primary to secondary channel may introduce notch characteristics to this narrow band resulting in detecting lower primary power level, which is referred to the narrow band problem. Therefore, it is recommended that the

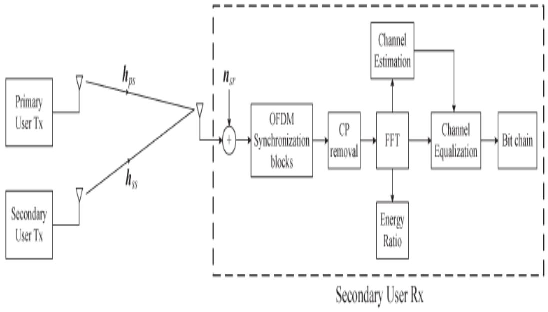

Figure-3. Communication model for channel estimation

The reserved tones are rescheduled by changing the value of Δr over time to mitigate the channel effect and to protect the reserved tones from falling into primary holes.

2.4 Throughput maximization using 1-tap equalizer

Throughput maximization is done for fixed allocation of channel. Fixed allocation of channel means the number of primary users allocated to a channel is considered to be fixed, but the number of users is different for different channels. Cognitive users sense the channel whether the channel is free or not. Throughput maximization used for performance measurement in percentage It is observed that throughput performance increases with the increase in time slots and also with increase in number of channels.

3. Results and discussion

The SNR Vs BER comparison output reveals the performance of two modulation techniques. Figure shows that QAM is better than QPSK. But QAM and QPSK are seen to have the same performance. QAM is preferred to QPSK for the better performance because it is more bandwidth efficient and has high data rate than that of QPSK.

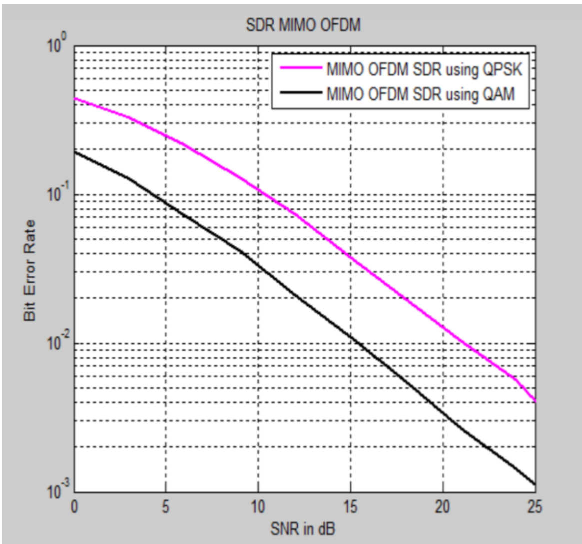

Figure-4. Comparison of modulation techniques

By applying the zero force beam-forming to the CR network, the 1*2 antennas shows the minimum error.

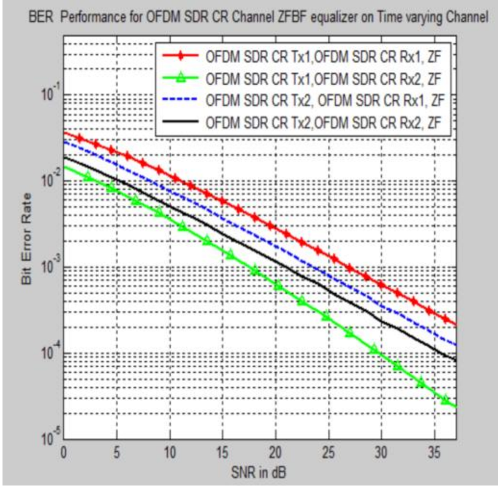

Figure-5. BER performance for CR channel ZFBF equalizer on time varying channel

The performance of spectrum sharing technique can be enhanced by reducing the carrier frequency offset.

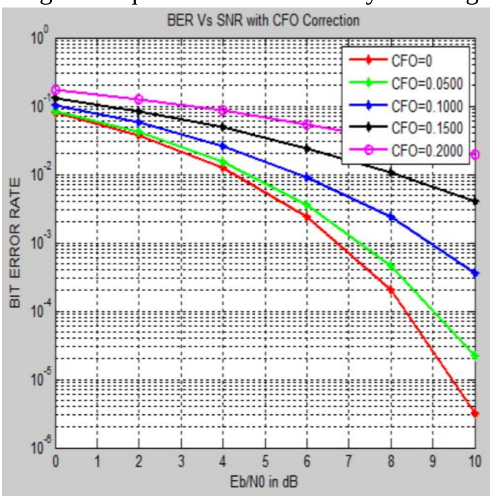

Figure-6. CFO correction using CAZAC algorithm

Further, the SNR is increased to 62dB(theoretically) by spectrum sharing and monitoring.

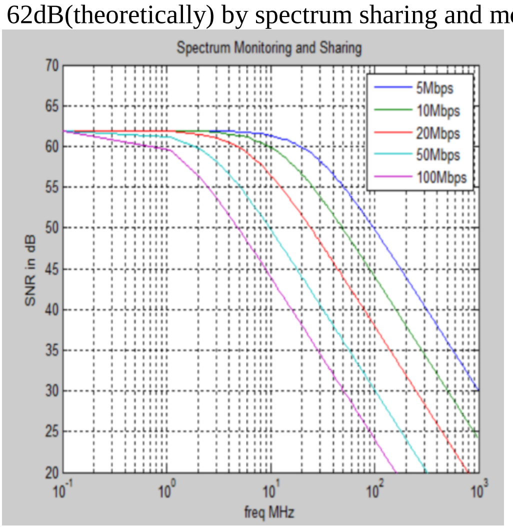

Figure-7. spectrum sharing and monitoring

The throughput is maximized to 100percent theoretically and in practical estimation it has some fluctuations and reaches maximum.

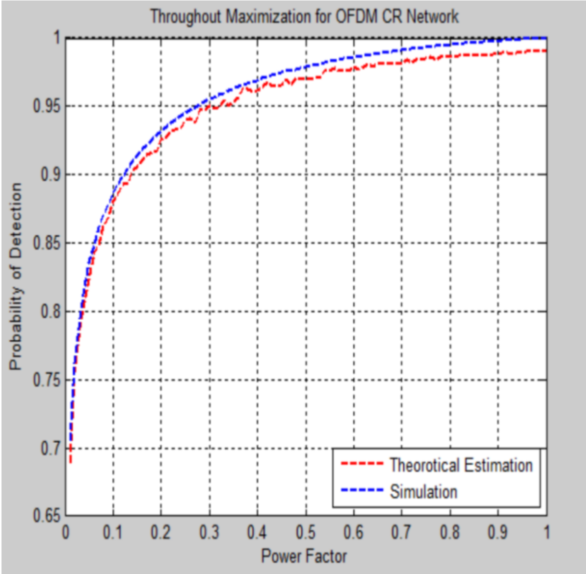

Figure-8. Throughput maximization

Conclusion

We proposed a spectrum monitoring algorithm that can sense the reappearance of the primary user during the secondary user transmission. For computational complexity, the energy ratio architecture is investigated where it was shown that it requires only about double the complexity of the conventional energy detector. The energy ratio algorithm is shown to achieve good performance that is enhanced by involving CR network systems. Therefore, our proposed spectrum sharing algorithm can greatly enhance the performance of cognitive networks by improving the throughput performance with a very limited reduction in the secondary network throughput.

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