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Optimization of Sensing time and Power Control for Spectrum Sensing in Cognitive Radio Network

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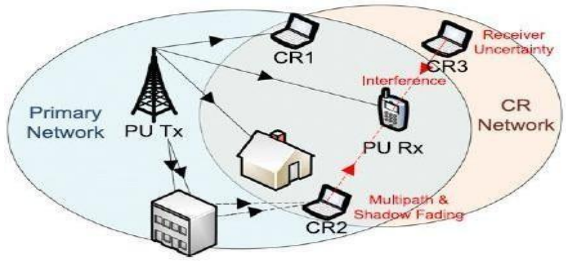
***Abstract* - Cognitive radio enabled small cell network is an emerging technology to address the exponential increase of mobile traffic demand in next generation mobile communications. Recently, many technological issues, such as resource allocation and interference mitigation pertaining to cognitive small cell network have been studied, but most studies focus on maximizing spectral efficiency. Different from the existing works, we investigate the power control and sensing time optimization problem in a cognitive small cell network, where the cross- tier interference mitigation, imperfect hybrid spectrum sensing, and energy efficiency are considered. The optimization of energy efficient sensing time and power allocation is formulated as a non convex optimization problem. An iterative power control algorithm and a near optimal sensing time scheme are developed by considering imperfect hybrid spectrum sensing, cross-tier interference mitigation, minimum data rate requirement, and energy efficiency. Simulation results are presented to verify the effectiveness of the proposed algorithms for energy efficient resource allocation in the cognitive small cell network.**

INTRODUCTION

Energy Detection

Sensitivity to noise uncertainty is a fundamental limitation of current spectrum sensing strategies designed to detect the presence of primary users in cognitive radio networks (CRN). Because of noise uncertainty, the performance of traditional detectors such as matched filters, energy detectors, and even cyclostationary detectors deteriorates rapidly at low Signal-to- Noise Ratios (SNR). Without accurate estimation of background noise, there exists an absolute “SNR wall” below which a detector may fail to be robust, no matter how long the detector can observe the channel.

Noise uncertainty can be alleviated by on- line calibration, but it cannot be completely eliminated. The SNR wall problem might be overcome by macro scale features under the assumption of prior knowledge of channel characteristics and infinite sample size. However, these assumptions usually do not hold in practice. The idea to use entropy for spectrum sensing in CR is presented, where the information entropy is estimated directly from the output sequence of a matched filter in the time domain. Entropy-based



sensing is based on the fact that the entropy of a stochastic signal is maximized if the signal is Gaussian noise. If the received signal contains the primary user‟s modulated signal, the entropy is reduced. However, the adaptability ofthe scheme is limited by the assumptions of perfect knowledge of primary signal and synchronization, which usually do not hold in practice.

COGNITIVE RADIO NETWORK

The rapid growth in wireless communications has contributed to a huge demand on the deployment of new wireless services in both the licensed and unlicensed frequency spectrum. However, recent studies show that the fixed spectrum assignment policy enforced today results in poor spectrum utilization. To address this problem, cognitive radio (CR) has emerged as promising technologies to enable the access of the intermittent periods of unoccupied frequency bands, called white space or spectrum holes, and thereby increase the spectral efficiency. The fundamental task of each CR user in CR networks, in the most primitive sense, is to detect the licensed users, also known as primary users (PUs), if they are present and identify the available spectrum if they are absent.

SPECTRUM SENSING

This is usually achieved by sensing the RF environment, a process called spectrum sensing. The objectives of spectrum sensing are twofold: first, CR users should not cause harmful interference to PUs by either switching to an available band or limiting its interference with PUs at an acceptable level and, second, CR users should efficiently identify and exploit the spectrum holes for required throughput and quality-of service (QoS). Thus, the detection performance in spectrum sensing is crucial to the performance of both primary and CR networks.

QUALITY OF SERVICE

Detection performance can be primarily determined on the basis of two metrics: probability of false alarm, which denotes the probability of a CR user declaring that a PU is present when the spectrum is actually free, and probability of detection, which denotes the probability of a CR user declaring that a PU is present when the spectrum is indeed occupied by the PU. Since a miss in the detection will cause the interference with the PU and a false alarm will reduce the spectral efficiency, it is usually required for optimal detection performance that the probability of detection is maximized subject to the constraint of the probability of false alarm.

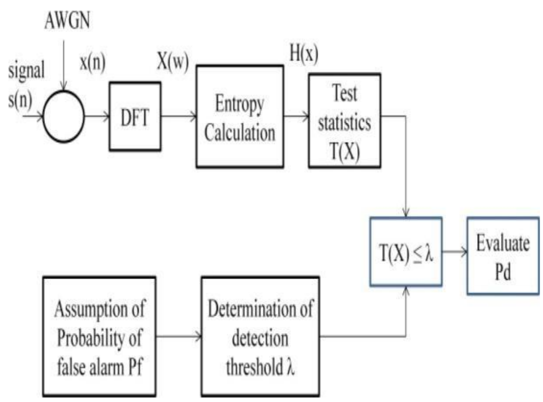
Many factors in practice such as multipath fading, shadowing, and the receiver uncertainty problem may significantly compromise the detection performance in spectrum sensing. Multipath fading, shadowing and receiver uncertainty are illustrated. As shown in the figure, CR1 and CR2 are located inside the transmission range of primary transmitter (PU TX) while CR3 is outside the range. Due to multiple attenuated copies of the PU signal and the blocking of a house, CR2 experiences multipath and shadow fading such that the PU‟s signal may not be correctly detected. Moreover, CR3 suffers from the receiver uncertainty problem because it is unaware of the PU‟s transmission and the existence of primaryreceiver (PU RX).

As a result, the transmission from CR3 may interfere with the reception at PU RX. However, due to spatial diversity, it is unlikely for all spatially distributed CR users in a CR network to concurrently experience the fading or receiver uncertainty problem. If CR users, most of which observe a strong PU signal like CR1 in the figure, can cooperate and share the sensing results with other users, the combined cooperative decision derived from the spatially collected observations can overcome the deficiency of individual observations at each CR user. Thus, the overall detection.

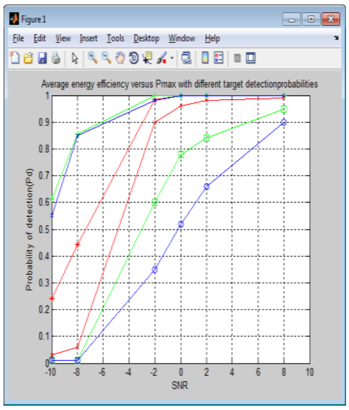
PERFORMANCE EVALAUTION

Performance can be greatly improved. This is why cooperative1 spectrum sensing (simply called cooperative sensing thereafter) is an attractive and effective approach to combat multipath fading and shadowing and mitigate the receiver uncertainty problem.

II. PROPOSED DETECTOR



III.SIMULATION RESULTS



III. CONCLUSION

This paper presents a Renyi entropy based spectrum sensing in CRNs. In the proposed method, the primary user signal has been sensed in the presence of all the three fading channels namely, Rician, Rayleigh and Nakagami Fading. The SNR wall for both QPSK and OFDM signals using the proposed method gave at least 2 dB improvement in both with fading and without fading channel conditions. For the QPSK signal, the best SNR wall obtained is -17dB with Renyi entropy for single node and for the OFDM signal, the best SNR wall obtained is -9 dB. In the multi node scenario, the hard decision fusion techniques, were successfully implemented under fading, which gave a 3 dB improvement in detection. The Renyi entropy method outperforms the Tsallis method with significant improvement in SNR wall.

SCOPE OF FUTURE NETWORK

In future work we applied the optimization technique for spectrum sensing , the spectrum sensing time required to successfully detect a primary user (PU) is inversely proportional to the PU's signal strength.sensing time optimization algorithm aiming at maximizing the spectral efficiency of the ultra wideband (UWB) based CR system by finding the optimal tradeoff between the length of the sensing window and the detection probability in low –SNR regime.compared with the time fixed sensing methods,the optimization algorithm can produce a significantly longer transmission time for the UWB based CR system to effectively utilize the detector spectrum band while guaranteeing protection to the PU‟s.

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