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Bayesian Detector based Superior Selective Reporting Mechanism for Cooperative Spectrum Sensing in Cognitive Radio Networks

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Abstract

Cognitive radio network(CRN) coupled with spectrum sensing technology enables unlicensed secondary users (SUs) to opportunistically access the unused licensed spectrum of primary users (PUs). Cooperative Spectrum Sensing (CSS) significantly improves the detection probability of primary user transmission. Nevertheless, current CSS techniques render shortcomings including energy consumption and overhead in sensing phase. Overheads are consequence of multiple cooperative SUs reporting their decision to the fusion center. In this paper, we propose Bayesian Detector based Superior Selective Reporting Cooperative Sensing(BD-SSRCS)scheme. Superior Selective Reporting (SSR)scheme, competently reduces reporting overhead and mitigates interference to PUs. Bayesian based sensing technique for local sensing improves detection performance, spectrum utilization and secondary user throughput. Our analysis and simulation results manifest the outcome of presented work in terms of higher detection probability, lower miss detection rate and lesser detection overhead, as opposed to the traditional cooperative sensing methods. Moreover, miss detection probability and sensing time can be reduced by ideally choosing sensing time allocation factor.

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Keywords: Cognitive radio network; Bayesian detector; cooperative detection; detection probability; local sensing; traditional cooperative spectrum sensing; sensing time.

1. Introduction

Current radio communication regulations have allocated almost all available spectrum to Primary Users(PUs) and restrict any usage by Secondary Users(SUs). It has been noted that most of this licensed spectrum is largely unoccupied for long spans of time and/or in certain geographical areas[1]. To combat under-utilization, a cognitive radio has been proposed in[2], allowing the SUs to exploit unused spectrum without causing interference to PUs. The success of such a scheme is reliant on the ability of cognitive radio to quickly and accurately sense spectrum opportunities through measurements of the spectrum, making it an important and difficult task. Spectrum sensing techniques are generally divided into two categories: a) local sensing b) cooperative sensing[3,4]. As the name suggests, SU locally detects PU's presence in local sensing[5]. Energy detector, matched filter detector, cyclostationary feature detection

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technique and covariance based detector are conventional detectors adapted for local sensing. Each of the detectors have their own advantages and disadvantages with varying detection performance, implementation complexity and detection time. Energy detection senses state of PU by calibrating the power of obtained signal[6]. Complete knowledge of signal is required for matched filter type detector which is not feasible in practical application. Cyclostaionary features of the primary signal is exploited in cyclostationary based detector. In this paper we have chosen Bayesian detector for local sensing which makes use of the prior status of PU as test statistics to sense the state of primary user, thereby improving SU throughput and spectral utilization of secondary users. However, channel uncertainties such as fading and shadowing make it a tedious job to improve local sensing precision[7]. Cooperative Spectrum Sensing(CSS) has been introduced to combat these channel uncertainties, whereby a fusion center detects state of PU in assistance with other SUs[8].

1.1. Related Work

In centralized cooperative CR network, the more SUs participate in reporting, the better is the performance of cooperative sensing. Nevertheless, as the number of reporting SUs increases, more reporting time is required, which leaves less time for data transmission. Moreover, this increase in the number of cooperative SUs generate notable overhead[9]. Thus, cleverly leveraging the trade-off between reporting overhead and achievable throughput of the secondary users becomes an important research issue. Cooperative sensing strategies based on user selection has been presented in[10] to reduce overhead in cooperative sensing. Reporting sensing results, only by those cooperative SUs which fail to detect presence of PU is employed in[11], which in turn reduces the reporting overhead.

Allotting more time for PU detection results in reduced time availability for the reporting phase. Thus, there exist a trade-off between detection and reporting performance. To that end, design of optimum time duration for detection and reporting phases in cooperative sensing are essential. Most of the above mentioned studies formulated a sensing throughput trade-off problem without considering the reporting overhead. Although few works investigated the effect of reporting overhead, they failed to propose an idea that reduces it[12].

Detection delay, energy consumption, sensing overhead to secondary users, interference to PU are the factors to be addressed while employing cooperative sensing technique to improve the detection performance of a CR system. In this article, both sensing overhead to SU and interference to PU are reduced by employing a Superior Selective Reporting (SSR) based sensing scheme which make use of Bayesian detector. This strategy triggers cooperative sensing only when essential, thus minimizing the overhead. In the first step a designated SU also called as center SU(fusion center) solely performs local sensing using Bayesian detector. If center SU fails to detect presence of PU in a particular time slot, the second step occurs in which the cooperative SUs will assist center SU to detect state of PU.

1.2. Paper contribution

This paper discusses a framework of superior selective reporting based CSS scheme for a centralized cooperative CR network using Bayesian detector. The simulation results of the proposed spectrum sensing algorithm leads to formulation of effective cooperative sensing strategies to reduce sensing time and to overcome interference to PU. The main contributions of this paper are described as follows:

- Bayesian detector is employed for local sensing thereby accommodating the low SNR regime, improving spectrum utilization and SU throughput .
- SSR triggers CSS only when essential, thus minimizing the reporting overhead.
- The interference to PU and sensing overhead is reduced, since only one of the cooperative SUs are chosen to report the local decision.
- Performance comparison of traditional and proposed SSR strategy are carried out to analyze the sensing overhead and detection probability.