Chapter 10
Cooperative Spectrum Sensing Under Double Threshold With Censoring and Hybrid Spectrum Access Schemes in Cognitive Radio Network

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ABSTRACT

The spectrum sensing performance in cooperative cognitive radio (CR) network is studied under a double threshold (DTH)-based detection with censoring of CRs, and thereafter, the study is extended for a hybrid spectrum access scheme in presence of Rayleigh faded sensing (S) and reporting (R) channels. In spectrum sensing, a CR employs an energy detection to detect the presence of primary user (PU) and compares the received energy statistics with the DTH. The CRs with energy statistics lying in fuzzy zone are not allowed to send their sensing information to the fusion centre (FC). Further, the qualified CRs are censored (rank-based and threshold-based censoring) to report their decisions based on quality of R-channel. The incorporation of DTH-based sensing and censoring of CRs not only improves the detection performance but also reduces the transmission overhead. In spectrum access, two hybrid spectrum access schemes, namely conventional hybrid spectrum access scheme (CHSAS) and a modified hybrid spectrum access scheme (MHSAS) are studied and compared.

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INTRODUCTION

Cognitive Radio (CR) has evolved as a smart technology to resolve the spectrum scarcity issue in the secondary network. In an overlay or underlay CR network, a CR node exploits the licensed spectrum band without creating harmful interference to the primary user (PU). In overlay network, a CR user accesses the PU band only if the PU is found to be absent, while in an underlay network, both the users (CR and the PU) share the spectrum. Thus, accuracy in sensing the presence of PU has a great importance in CR technology otherwise a PU has to face an undesirable interference (Haykin, 2005). In spectrum sensing (SS), a CR may employ an energy detector (ED) to detect PU in the given channel (Ghasemi, 2005). Each CR of a secondary network senses the status of PU and compares the received energy statistics with a predefined threshold, i.e., a single threshold based (STH) based detection (Ghasemi, 2005). Spectrum sensing can also be performed using double threshold (DTH) (Bhowmick, 2015a). It is observed that DTH based spectrum sensing reduces the transmission of sensing overhead at the cost of some performance loss (Bhowmick, 2015a; Chunhua, 2007). In DTH based sensing, the CRs with energy statistics lying in fuzzy zone (between two thresholds) are not allowed to send the sensing information to the fusion centre(FC) (Chunhua, 2007). If the R-channels are heavily faded, the overall decision, i.e., cooperative decision at FC may be affected (Bhowmick, 2015a). Thus, it is required to eliminate CRs having bad R-channels from the cooperation process. In (Nallagonda, 2013a), authors proposed censoring techniques, i.e., Threshold-based censoring (TBC) and Rank-based censoring (RBC) to combat with such type of adverse scenarios. Censoring of CRsis done in (Nallagonda, 2013a) on the basis of R-channel quality. In (Bhowmick, 2015a; Bhowmick, 2014), authors studied the censoring schemes under DTH. The incorporation of censoring of CRs with DTH based sensing improves the performance of SS and at the same time it reduces the overhead of the transmission (Bhowmick, 2015a; Bhowmick, 2014). It is shown in (Bhowmick, 2014), Reduction in overhead of the transmission improves the agility gain of the network. A cooperative SS (CSS) under DTH with censoring has been studied for perfect and imperfect estimation of channel and different fusion strategies such as Majority, and Maximal Ratio Combining (MRC) (Bhowmick, 2015a).

In spectrum access schemes (SAS), two HSAS: CHSAS and MHSAS are studied and compared (Bhowmick, 2016; Prasad, 2016). A CR uses an overlay mode in absence of PU while it transmits in an underlay mode of co-existence if the PU's presence is found in the spectrum. In overlay mode, a CR transmits with high power while in underlay mode, a CR has to control its transmission power to such that the interference remains within a tolerable limit at PU receiver. The channel state information (CSI) of the interfering linkhelps the CR system to control its transmission power (Prasad, 2016). In (Musavian, 2007; Stotas, 2011; Chen, 2012), the authors have studied the performance of CR considering the CSI of the link between CR and PU is perfect. In practice, the CSI is imperfect (Musavian, 2009; Suraweera, 2010). The manager of the band helps to know the link CSI (Peha, 2005) or via proper signaling between a CR and a PU (Kang, 2010). In CHSAS, a CR usesonly the transmission phase of a detection frame while in MHSAS, a CR uses the entire detection frame (sensing (S) phase plus transmission (T) phase) for its own transmission (Bhowmick, 2016). The outage performance of HSAS is studied in (Prasad, 2016).

A cooperative CR network is studied in two-fold. At first, the SA performance is studied under double threshold with censoring and thereafter the study is extended for a hybrid SAS in presence of Rayleigh faded sensing (S) and reporting (R) channels. Furthermore the performances of MHSAS and CHSAS schemes are compared and it is shown that MHSAS outperforms the CHSAS.