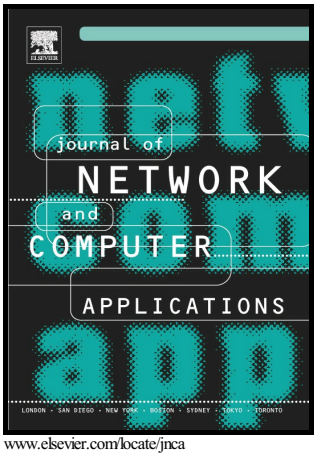

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Opportunity Prediction at MAC-Layer Sensing for Ad-hoc Cognitive Radio Networks

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Abstract

Knowledge of channel usage pattern of primary users (PUs) helps in predicting future channel availability which can reduce MAC-layer sensing overhead in cognitive radio networks. In this work, two important issues of MAC-layer sensing have been investigated for underlay mode cognitive radio networks. These are - (a) estimation and modeling of licensed channel usage pattern of PUs, while tolerating interference from secondary users (SUs), and (b) usage of learnt channel usage patterns for discovery of opportunities by the SUs. Accordingly, a Hidden Markov Model (HMM) based channel usage pattern of PUs is proposed for use by the SUs to predict the spectrum opportunity. The proposed model uses estimated interference power constraint (IPC) in determining the interference due to presence of SUs to protect the PUs from harmful interference. A formulation deriving the availability metric (AM) for licensed channels is developed which helps in selecting the best channel by an SU for its transmission needs. Experimental results show that the trained HMMs can be used for predicting future channel availability, provided the same IPC condition prevails for a certain period. It is also observed that the AM of the channel sequences generated by the trained HMMs is effective in selecting a suitable channel for transmission. Furthermore, a distributed medium access control protocol for data dissemination (DMDD) in underlay mode CRNs is proposed which utilizes the proposed channel usage model. Simulation based results have shown the effectiveness of the proposed channel usage model.

Keywords: cognitive radio networks, dynamic spectrum access, secondary user, primary user, interference power constraint, spectrum sensing and spectrum sharing.

1. Introduction

The opportunity detection in licensed channel is the key functionality for success of cognitive radio network (CRN). The cognitive radio (CR) Mitola and Maguire (1999) user, also called secondary user (SU), has to detect the existence or return of the primary users (PUs) in licensed channel ensuring the protection of PUs from potential harmful interference. To utilize the detected opportunities by spectrum sensing module at physical, the higher layer protocol design requires to estimate the licensed channel usage pattern of PUs to ensure PU protection. The protocol level decision about the availability of opportunities in the licensed spectrum is taken at medium access control (MAC) level sensing Kim and Shin (2006a). The task of the MAC-layer sensing is to improve upon the opportunity detection efficiency with protocol level policy making and to decide on the best licensed channel to be used for secondary communication. The MAC-layer sensing is done in terms of either proactive or reactive manner. SU takes decision about the type of MAC-layer sensing depending on application level requirement. The proactive sensing indicates the policy of periodic sensing, whereas the reactive sensing is performed following the on-demand policy. With the strict requirement of primary protection for underlay mode of channel access Mehmeti and Spyropoulos (2014), performing the MAC-layer sensing is challenging. The policies for MAC-layer sensing by SUs for underlay mode of access Mehmeti and Spyropoulos (2014) require the information about the availability of licensed channels and the estimation of interference level to PUs. In such a scenario, the SUs require to learn about the channel's usage pattern of PUs. This enables SUs to predict future channel availability, which in turn helps them to alleviate the sensing overhead problem of proactive sensing. In this context, the correct estimation of a licensed channel usage pattern by PUs is a challenging task.

Most of the existing works in the literature Mohammed Hamid (2010); Kim and Shin (2008a); Li and Fu (2009); Kim and Shin (2006b); Akbar et al. (2007); Park et al. (2007); Jianling et al. (2011); Zhang et al. (2016); Wang et al. (2009) propose mechanisms to discover unused spectrum holes in licensed band using the interweave mode of access and assumes ON-OFF primary channel usage model. Niu *et al.* Niu et al. (2015) have proposed a message dissemination mechanism using copy limited flooding over opportunistic networks. They address the problem to establish connections among different nodes based on node's movement probability using Markov rule and Random graph hierarchies. But the problem of opportunistic channel access is not considered in the proposed technique, which could improve the opportunity discov-

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