Computers and Electrical Engineering 000 (2016) 1–11

Contents lists available at ScienceDirect

Computers and Electrical Engineering

journal homepage: www.elsevier.com/locate/compeleceng

Hidden Markov Model based channel selection framework for cognitive radio network

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ARTICLE INFO

Article history:
Received 27 August 2015
Revised 29 June 2016
Accepted 29 June 2016
Available online xxx

Keywords:
Cognitive radio network (CRN)
Channel selection
Hidden Markov Model (HMM)
Rayleigh channel
Time-slot based optimal routing

ABSTRACT

Due to the effective utilization rate of the radio frequency spectrum, Cognitive Radio Network (CRN) has gained more popularity in the current research field. The spectrum sensing techniques detect the presence of the idle channel and reallocate to the Secondary Users (SUs). However, the existing spectrum sensing and channel estimation approaches incurs delay while searching for the new channels. To reduce the delay and achieve optimal selection of the channel in CRN, this paper proposes a Hidden Markov Model (HMM)-based channel selection framework. The Time-Slot based optimal routing mechanism is introduced to minimize the delay occurred during the channel search and optimize the range of the spectrum band. Therefore, the bandwidth range of the node is estimated, and the channel is allocated to the SU. The proposed framework exhibit better end-to-end throughput, bandwidth-power product and lower running time, energy consumption, and average end-to-end delay when compared to the existing schemes.

1. Introduction

CRN [1] solves the radio spectrum scarcity problems and maximizing the spectrum utilization efficiency. The Cognitive Radio (CR) is considered as a vital technology for the next generation that offers the capability for the efficient utilization of the spectrum. CRN is a collection of the primary and secondary networks. The main benefit of the CRs is to reduce the exploitation of the unused spectrum resources by using the characteristics of reconfigurability and intelligent sensing. Instead of the spectrum resources, the channel K-factor and bandwidth are considered as the additional communication parameters [2,3]. The cognitive approach is to permit the coexistence of various networks on the same transmission resources. In the overlay approach, it is ensured that the SUs do not produce any detrimental interference to the Primary Users (PUs). The CR system is based on the sensing and reconfigurability characteristics to fulfill the above requirements. The users can either interconnect with each other in a multi-hop manner or contact the Base Station (BS).

The CR users can either interconnect with each other in a multi-hop manner or contact the BS. The three distinct access types over the heterogeneous CRNs are described as follows:

- **CR network access:** CR users can define their sharing policy and contact their own BS both in licensed and unlicensed spectrum bands. All the interactions happen within the CRN.

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http://dx.doi.org/10.1016/j.compeleceng.2016.06.016
0045-7906/

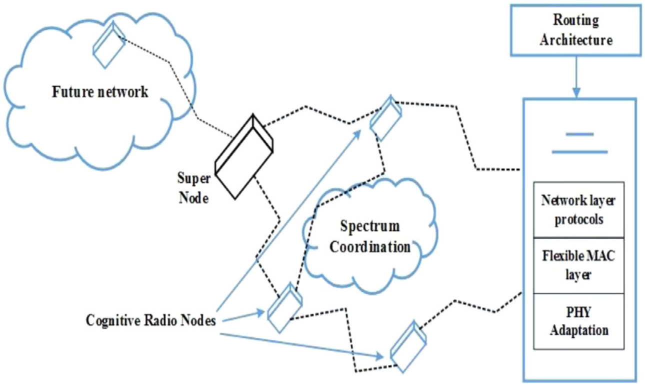

Fig. 1. Basic structure of CRN.

- **CR ad hoc access:** The ad hoc connection enables communication between the users on both the licensed and unlicensed frequency spectrum bands.
- **Primary network access:** The CR user can access the primary BS via the licensed bands by using adaptive Media Access Control (MAC) protocol.

Fig. 1 shows the CRN architecture. Wireless CRN is employed for the simultaneous communication of several users on a shared spectrum. It is also used to minimize the signal interference for licensed PUs and SUs in the similar frequency band range. The communication hierarchical architecture system considers the physical layer, media access layer and network layer. The CRN utilizes the similar spectrum frequency range for the recent communication system. The SUs search for the desired channels based on the bandwidth requirements. There is a need to find the alternative channels to sustain the traffic requirements of the network, during the addition of new PUs. However, the existing spectrum sensing and prediction-based sensing techniques consume more energy and exhibit low data transmission rate. This paper proposes an HMM-based channel selection framework to overcome the drawbacks of the existing approaches. The proposed approach achieves high transmission speed and low data loss, by obtaining the best-matched channel for the user. The main contributions of the proposed methodology are described as follows:

- Our channel selection framework minimizes the delay incurred during the channel selection, and optimizes the spectrum band range by using the time-slot based routing algorithm.
- The proposed framework is enhanced by implementing the routing algorithm along with the HMM.
- The channel estimation is applied for data transmission during the allocated scheduling time.
- For data transfer between nodes, the minimum time-slot consumption is achieved.

This paper is organized as follows. Section 2 reviews the existing works related to the spectrum sensing, channel allocation, and routing process in the wireless CRN. Section 3 explains the proposed HMM-based channel selection framework for optimal routing in the wireless CRN. Section 4 describes the performance evaluation results of the proposed method with the existing techniques. Section 5 presents a brief conclusion and future implementation of the proposed work.

2. Related work

This section reviews the relevant literature of the spectrum sensing, channel allocation, and routing process in the wireless CRN. Xing, Jing, Li, Huo, Cheng, and Znati [4] investigated the problem of optimal spectrum sensing interval for SUs. This approach was adaptive to the requirements of SUs and the network environment. By exploring the tradeoffs between the energy consumption and network throughput, the spectrum sensing interval was optimized using the energy-aware model. Due to the increase in the sensing interval, the network throughput was reduced. Amini and Dziong [5] presented an economic framework that incorporates the Call Admission Control (CAC) and routing and channel allocation in cognitive wireless mesh networks. The decomposed model permits for a decentralized channel allocation and the routing procedures. However, the proposed framework suffers due to the increase in the average rejection rate. Koroupi, Talebi, and Salehinejad [6] proposed an Ant Colony System (ACS) approach for spectrum allocation in the CRN. This approach was based on the Graph Coloring Problem (GCP). The running time and computation time of the proposed ACS approach were high.

Jia, Lin, Chen, Li, and Wang [7] discussed the joint channel and routing scheduling problem for wireless CR mesh networks. A mathematical model was developed along with a mixed integer non-linear programming formulation for optimizing the layers. To discover the globally optimal solution, an efficient nested optimization framework was introduced. This