Coordinated Non-Sensing MAC Protocol in Dynamic Spectrum Access Networks

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Abstract In this paper, we propose a coordinated non-sensing medium access control (MAC) protocol in dynamic spectrum access networks namely distributed coordinated dynamic spectrum reservation (DCDSR) protocol, which is not based on the cognitive radio technology. All licensed users (LUs) and unlicensed users (UUs) have two transceivers operating in a common control channel and licensed data channels to access control and data packets in the corresponding control and data frames respectively. LUs will inform UUs which channels will be used in next data frame and then UU reserve one of remainder channels by contending with each other during contention interval (CI) in control frame. The available channels which can be reserved by UUs will depend on the channel utilization of LUs and further affect the throughput of UUs. Whenever UU successfully reserves channel in a CI, it will start access the channel in next data frame. This will cause the wasted idle time for UUs which have successfully reserved channel and wait to enter next data frame. UU which couldn’t successfully reserve channel in current control frame should try to reserve again in next control frame. Thus, the duration of CI will affect the delay and wasted idle time of UUs. We analyze and simulate the performance of throughput, delay and wasted idle time in DCDSR. The analytical and simulation results show that the proposed DCDSR performs very well.

Keywords Dynamic spectrum access (DSA) networks · Distributed coordinated dynamic spectrum reservation (DCDSR) · Medium access control (MAC) protocol
1 Introduction

The growing demand in the wireless services has led to a dense allocation of relevant frequency bands. Although a particular range of frequencies is reserved for a standard, the large part of licensed bands is unused and found free at particular time and location. Federal Communications Commission (FCC) estimates that the variation of using the licensed spectrum ranges from 15 to 85% [1], however only 2% of the spectrum is in use in US at any given moment according to the defense advanced research projects agency (DARPA). The traditional static frequency allocation, however, leads to inefficient usage in both spatial and temporal domains. As we know, dynamic spectrum access (DSA) could be used to make a better efficiency in lower usage of licensed radio spectrum.

Generally speaking, DSA networks have two main groups: primary user (PU) and secondary user (SU). A PU uses the licensed frequency band which may be shared by SUs, while SUs are the unlicensed users and need to find the unused spectrum and then dynamically operate in the spectrum holes. The SUs in cognitive radio networks (CRN) perform spectrum sensing to find the spectrum holes, so their performance depend on the capability of spectrum sensing algorithm very much. Several spectrum sensing methods have been proposed to improve performance in CRN recently [2–5], which are challenged by several sources of uncertainty in device- and network-levels. Therefore, CRN requires a higher detection sensitivity to overcome the uncertainty introduced by channel randomness and some scheduling schemes in the medium access control (MAC) layer to assign the sensing sequence among SUs. In the queuing and channel state information (QCI) based on the sensing scheduling [6], they arrange SUs to perform spectrum sensing according to the quality of service (QoS) requirement and channel state among SUs. In the joint coding and scheduling (JCS) [7], a good idea is applied to reduce the waiting time caused by waiting for a PU to inactivate channel, but it also increases the cost in hardware structure. The negotiation-based sensing policy MAC protocol [8] also employs a control channel licensed by SUs to exchange the information of available licensed channels. Actually, they provide a good framework and obtain a good performance for dynamic spectrum access wireless networks but the delay is still limited by the spectrum sensing.

Pawelczak has classified the DSA MAC protocols into sensing and non-sensing [9]. The CRN works on the sensing protocol. The non-sensing protocols such as busy burst (BB) DSA [10] and single-radio adaptive channel (SRAC) [11] may reduce the overhead caused by the sensing. In the opportunistic cognitive (OC) MAC protocol [12], SUs use a common control channel to compete with each other for reserving licensed channel. The sender sends the information of available channels and possible transmission durations, which predict according to the tolerable damage percentage in the PU side. In the slot-based MAC protocol [13] and opportunistic spectrum access (OSA) MAC protocol [14], SUs contend for accessing the available licensed channels in a special contention interval, which will reduce the transmitting time. Wang et al. design a MAC protocol based on a special frame structure, but they do not specify the durations of contention interval and data windows [15]. We further propose a non-sensing distributed coordinated dynamic spectrum reservation (DCDSR) protocol to dynamically reserve the channel which isn’t used by the licensed users (LUs). LUs will inform unlicensed users (UUs) about using a channel in the next frame, which can reduce the overhead caused by spectrum sensing.

The remainder of this paper is organized as follows. Section 2 describes the proposed DCDSR protocol; Sect. 3 analyses and formulates the DCDSR protocol; and Sect. 4 simulates the system and shows results. Finally, the conclusion is made in Sect. 5.