Cooperative Power and Contention Control MAC Protocol in Multichannel Cognitive Radio Ad Hoc Networks

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I. EXTENDED ABSTRACT

Wireless networks are regulated by a fixed spectrum assignment policy and the spectrum is assigned to license holders or services on a long term basis for large geographical regions. The variation range in the utilization of the assigned spectrum is about 15% to 85% with a high variance in time according to Federal Communications Commission (FCC). A new communication technique is proposed to overcome the limited available spectrum and the inefficiency that is to take advantage of the existing wireless spectrum opportunistically. This new networking technique is referred to as NeXt Generation (xG) Networks as well as Dynamic Spectrum Access (DSA) and Cognitive Radio Networks (CRNs) [1], [2], [3].

In CRNs, secondary users (SUs) can opportunistically utilize the spectrum when this spectrum of primary users (PUs) is idle. In cognitive radio ad hoc networks, spectrum can be divided into several channels. One channel can be used by SU when there is no interferences with other SUs and no interferences between the SUs and PUs and this will improve the network performance. In multichannel cognitive radio ad hoc networks, channels are unreliable due to collisions between SUs and PUs. Therefore the medium access control (MAC) protocols are quite important to avoid the collisions between SUs and PUs and to overcome the hidden terminal problems and exposed terminal problems.

The MAC protocol in multichannel cognitive radio ad hoc networks has two approaches. One is centralized and focus on infrastructure-based networks. For this network, the spectrum assignment of SUs is assigned by coordinator. Another is distributed approach and the spectrum allocation is processed by the contention-based channel access policy.

In [4], the authors proposed a hardware-constrained cognitive MAC (HC-MAC) for efficient spectrum management for CRNs and consider sensing constraint and transmission constraints of practical cognitive radios. A decentralized cognitive MAC (DC-MAC) for opportunistic spectrum access in ad hoc networks is proposed in [5]. DC-MAC allow SUs to independently search for spectrum opportunities without a central coordinator and assume SUs may not be able to perform full-spectrum sensing or may not be willing to sensing the spectrum channel when it has no data to transmit.

In [6], the authors proposed an opportunistic spectrum MAC (OS-MAC) protocol for spectrum-agile wireless networks. OS-MAC can adaptively and dynamically search and take advantage of opportunities in the PUs’ spectrum and can access and share among SUs and PUs. In [7], a cognitive MAC (C-MAC) protocol for multi-channel wireless networks is proposed. C-MAC, each channel is divided into some superframes. Each superframe contains a slotted beaconing period which can provide the control messages exchange and negotiate channel usage. Each SU sends a beacon in a slot during beaconing period to overcome the hidden terminal problems, channel reservations and mobility.

In [8], the authors proposed an efficient cognitive radio-enabled multi-channel MAC (CREAM-MAC) protocol for wireless networks. In CREAM-MAC, each SU is equipped with a cognitive radio transceiver and multiple channel sensors and can overcome the collisions among SUs and between the SUs and PUs. A MAC protocol for opportunistic spectrum access (OSA-MAC) in cognitive radio networks is proposed by [9].
exchange control informations in a dedicated control channel. OSA-MAC uses the idea from PSM (Power Saving Mechanism) in IEEE 802.11 DCF-based WLANs and assume that time is divided into beacon intervals and all of the SUs are synchronized by periodic beacon transmissions.

In [10], a novel MAC (N-MAC) scheme for multichannel cognitive radio ad hoc network is proposed. N-MAC has three features and their are collaborative opportunistic sensing, transmission power control for PU protection and multiple packet transmission on the reserved channel. In [11], an energy-efficient distributed multichannel MAC protocol for CR networks (MMAC-CR). MMAC-CR can achieve energy-efficient communication and sensing algorithms has following phases. One is a low-power inaccuracy scan and another is a high-power accurate scan.

In [12], a cooperative transmit-power (CTP) estimation in MANETs is proposed. CTP provided a fundamental confidence level for the accuracy of the power estimation and enables the development of techniques for allocating network monitors. CTP proposed a simple, distributed cooperation model for multiple monitors. Even with a small number of cooperating monitors, the accuracy of estimation can be significantly improved.

In this paper, we will propose a Cooperative Power and Contention control MAC (CPC-MAC) protocol in Cognitive Radio Ad Hoc Networks to solve the multichannel hidden terminal PUs and SUs problems and multichannel exposed terminal SUs problem by build appropriate number of monitor nodes in suitable positions.

There are three functions in CPC-MAC. First, SU transmitter sends the RTS frame including transmission power to SU receiver, SU receiver sends CTS frame including receiving power to SU sender. Monitor nodes send position and receiving power to SU sender and SU receiver. SU transmitter selects three monitors that their receiving powers are approach to each other. SU transmitter estimates its position and sending power by deterministic propagation model. This will reduce the interference to hidden PU terminal. Second, the SU in the transmission range of the PU will send one highest priority interrupt frame in control channel to one-hop neighbors of SU to protect the PU. Third, CPC-MAC adds one channel confirm control frame in IEEE CSMA/CA to overcome the exposed SU problem.

We also compare our proposed scheme to the existing IEEE 802.11 DCF and the other MAC protocols in Cognitive Radio ad hoc networks using ns2 simulation tool. We will show that CPC-MAC will improve the system throughput and reduce the energy consumption.

REFERENCES