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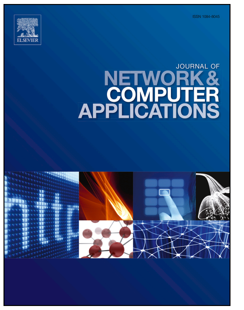

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Cooperation-based Multi-hop Routing Protocol for Cognitive Radio Networks

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Abstract

In the scope of cognitive radio networks, typical routing protocols avoid areas that are highly congested with primary users, leaving only a small fragment of available links for secondary route construction. In addition, wireless links are prone to channel impairments such as multipath fading which renders the quality of the available links highly fluctuating. In this paper, we propose *Undercover*: a multi-hop routing protocol for cognitive radio networks in which we integrate the collaborative beamforming technique with layer 3 routing. Specifically, our protocol revisits a fundamental assumption taken by the state of the art routing protocols designed for overlay cognitive radio networks; this assumption is that secondary users cannot use the spectrum when primary users are using it. In *Undercover*, we allow a group of secondary users, each with a single antenna, to collaborate together and transmit in the regions of primary users activity. This is done through nulling out transmission at primary receivers via beamforming. Moreover, *Undercover* is designed to enhance the transmission quality at the secondary destinations whenever possible. To account for the excessive levels of interference typically incurred due to cooperative transmissions, we allow our protocol to be interference-aware. Thus, cooperative transmissions are penalized in accordance with the amount of negatively affected secondary flows. We evaluate the performance of our proposed protocol via NS2 simulations which show that our protocol can enhance the network goodput by a ratio reaches up to 250% compared to other state-of-art cognitive routing protocols with minimal added overhead.

Key words: Cognitive Radio Networks, Cooperative Communication, Routing Protocols

1. Introduction

Cognitive Radio Networks (CRNs) was proposed as a promising solution for the spectrum scarcity problem. This problem is increasing more and more and that is why CRNs are imminent to pervade into all fields of wireless communications. We backup this assertion with the following observations. First, with the inherent inefficiency of the static spectrum licensing policies [1] and proliferation of spectrum accessing mobile and connected devices [2], we are quickly heading towards a wireless spectrum crisis [3]. Second, the spectrum regulatory authorities are now working towards new regulations allowing for wireless spectrum reuse by unlicensed users [4]. These regulations allow the unlicensed secondary users (SUs) to access the spectrum as long as needs of the licensed primary users (PUs) are satisfied.

One of the emerging use cases of Cognitive Radios is 5G. 5G networks utilize the concept of Licensed-Assisted-Access (LAA) [5], which basically says that, in order to get very high rates (and due to spectrum scarcity), the network does not just rely on the licensed part of the spectrum, but also uses part of the unlicensed and shared spectrum. However, using the shared spectrum should be done carefully to avoid interference between different parties. For example, 5G should be able to provide cellular access to IoT networks, which are mainly private networks that consist of many devices which should co-exist. Since they are supposed to use the same shared spectrum as that of WiFi, then in such a scenario the WiFi access points could act as the primary users, while the IoT devices are secondary ones. In such a network, powerful nodes (which have multiple antennas for example) should use their capabilities to avoid interfering with the less powerful ones.

In order to use the Cognitive Radio (CR) in practice, many challenges need to be considered. Since one of the biggest goals is ensuring the integrity of the PU transmissions, all components of the CR cycle are developed such that this goal is attained [6]. For example, various spectrum sensing and sharing techniques have been developed, each with varying levels of complexity and efficiency[7]. In addition, different spectrum management policies have been envisioned which are better suited for different CR scenarios. For example, an overlay access policy allows

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