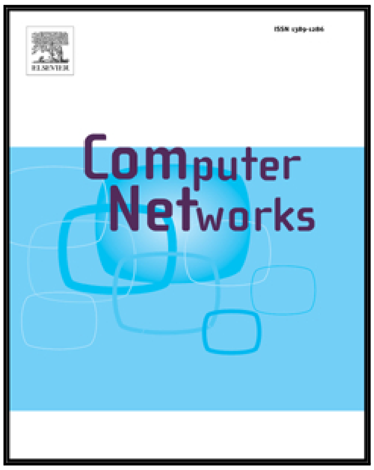

Approximating the Largest Connected Topology in Cognitive Radio Networks

Ram Narayan Yadav, Rajiv Misra

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Approximating the Largest Connected Topology in Cognitive Radio Networks

Ram Narayan Yadav, Rajiv Misra
Department of Computer Science and Engineering
Indian Institute of Technology Patna
Patna, India - 800013
Email:{ram.pcs13,rajivm}@iitp.ac.in

***Abstract*—Connection between two secondary users (SUs) in cognitive radio networks (CRNs) is not only determined by their transmission power and distance, it also depends on the availability of a common channel for both SUs to open it for communication. In CRN, each SU is equipped with a number of antennas, denoted as β, which is the maximum number of channels that an SU can open simultaneously, known as antenna budget constraint. As each SU has a limit on the maximum number of channels it can open simultaneously, so network may not be connectable. But, it is desirable to connect the largest subset of SUs while minimizing the interference introduced due the nearby transmissions among SUs on the same channel, this problem is called the largest-connected minimum-interference topology control (LMTC) problem in CRNs. In this paper, we model the network of SUs as a potential graph $PG = (V(PG), E(PG))$, where $V(PG)$ is set of SUs and $E(PG)$ is set of potential edges. First, we show that the LMTC problem is NP-hard then we propose an approximation algorithm to address LMTC problem with $\min(m/\log n, n.\beta/2\log n)$ ratio, where n and m are the number of nodes and edges in potential graph respectively. We also propose a distributed algorithm called $distributed$-LMTC with message complexity $O(n^2)$, to address the LMTC problem. To address this NP-hard problem, we combine both topology control and channel assignment phase. In topology control phase, a network subgraph is derived with satisfying antenna budget constraints. In channel assignment phase, we assign channel to link to minimize interference. Simulation results show that the constructed topology can achieve higher connectivity and throughput than other competitive topology control algorithms.**

***Index Terms*—cognitive radio networks; connectivity; approximation algorithm, topology control**

I. INTRODUCTION

Cognitive Radio is a promising solution to the spectrum shortage problem by implementing opportunistic spectrum access over the licensed spectrum. It is the key technology that enables unlicensed user to use unused licensed spectrum opportunistically. The unlicensed users in cognitive radio networks (CRNs) that access channels opportunistically are called cognitive users or secondary users (SUs) [1]. In CRNs, there may be several SUs coexist with licensed users (or called primary users). Primary users (PUs) are licensed users of radio spectrum whereas SUs have no license for accessing the channel. In CRN, SUs are allowed to temporarily access the channels depending on the spectrum availability [2]. To avoid interference to PUs, SUs must use spectrum sensing techniques[3], [4], [5] and vacate the channel when it is reclaimed by PU. When a PU reclaims licensed channel, network partitions may occur since multiple links may be affected if they all are operating on the channel reclaimed by PU [6]. These affected links may limit the overall performance of CRN due to packet loss or delay in packet transmission. The available channel of an SU may change over time since a channel becomes unavailable whenever it is reclaimed by PU [7], [8]. As a result, multiple SUs in the CRN have to cease their data transmissions or switch their transmissions to other unoccupied spectrum. Due to dependency on channel availability, communication in CRNs is more challenging than traditional wireless networks.

Communication in CRNs by assuming single radio[1] per node is possible but this model has certain drawbacks [9], [10]. Each node[2] has to dynamically switch between the available channels while coordinating with neighboring nodes to ensure communication over a common channel. Frequent switching between channels increases synchronization overhead can not utilize available spectrum resources effectively. The use of multiple radio per node allow simultaneous transmission on different channels. In a multi-radio multi-channel network model [11], [12], each SU has fixed number of antennas and it can open only a limited number of channels to communicate with its neighboring nodes. Given a CRN is said to be connectable if there exists a spectrum assignment under which any two SUs are connected by either a bi-directional link or a bi-directional path. The problem to determine whether a given CRN is connectable is NP-Complete [13]. As each SU has a limit on the maximum number of channels it can open simultaneously, a given CRN may not be connectable. But, it is desirable to connect the largest subset of SUs to provide connectivity among maximum number of nodes.

In CRN, there are different factors such as PU activity, spectrum sensing errors, and media access for SUs which influence the network throughput [14]. In addition to the interference between PUs and SUs caused by spectrum sensing errors, the interference among SUs also degrade the performance of the network [6], [15]. When multiple SUs try to access the same channel, the severe interference are introduced due the nearby transmissions on the same channel. To avoid such interference,

[1]We will use the terms “radio” and “antenna” synonymously.

[2]We will use the terms “SU” and “node” synonymously throughout the paper.