Energy-Efficient Resource Allocation for Heterogeneous Cognitive Radio Network based on Two-Tier Crossover Genetic Algorithm

Yan Jiao and Inwhee Joe

Abstract: **Cognitive radio (CR) is considered an attractive technology to deal with the spectrum scarcity problem. Multi-radio access technology (multi-RAT) can improve network capacity because data are transmitted by multiple RANs (radio access networks) concurrently. Thus, multi-RAT embedded in a cognitive radio network (CRN) is a promising paradigm for developing spectrum efficiency and network capacity in future wireless networks. In this study, we consider a new CRN model in which the primary user networks consist of heterogeneous primary users (PUs). Specifically, we focus on the energy-efficient resource allocation (EERA) problem for CR users with a special location coverage overlapping region in which heterogeneous PUs operate simultaneously via multi-RAT. We propose a two-tier crossover genetic algorithm-based search scheme to obtain an optimal solution in terms of the power and bandwidth. In addition, we introduce a radio environment map to manage the resource allocation and network synchronization. The simulation results show the proposed algorithm is stable and has faster convergence. Our proposal can significantly increase the energy efficiency.**

Index Terms: **Cognitive radio network, energy-efficient resource allocation, multi-RAT, radio environment map, two-tier crossover genetic algorithm.**

I. INTRODUCTION

With the development of wireless communication technology, spectrum resources have become increasingly scarce. In the past 10 years, researchers have mostly focused on new techniques and innovations to achieve a higher spectral efficiency, such as cognitive radio (CR). CR users, which are referred to as secondary users (SUs), share wireless channels with licensed primary users (PUs) who have already been assigned a specified spectrum, as long as the interference to the PU is kept below present thresholds (called interference temperatures) [1]. In addition, rapidly rising energy costs and increasingly rigid environmental standards have led to an emerging trend of addressing the *energy efficiency* of wireless communication technologies [2]. CR plays an important role in improving the energy efficiency of wireless networks because, from the green communication perspective, the spectrum is a natural resource that should be shared rather than wasted.

Recently, because of its potential for performance improvement, multi-radio access technology (multi-RAT) has recaptured the attention of researchers. It has been shown that performance can be improved by more effective resource utilization among multi-radio access network [3], [4].

Therefore, multi-radio access (MRA) system, where data streams are split into multiple sub streams which transfer simultaneously, becomes the focus of researches. Many issues, such as how to reduce energy consumption, have yet to be resolved the problem.

By a low-power and low-cost short-range device-cellular telecommunications base stations, femtocell technology provide improved cellular coverage within a building by providing a high-quality short-distance link to the user equipment. Consequently, it is a promising solution to reduce energy consumption for wireless networks. By harnessing the advantages of femtocell and CR technology, a cognitive femtocell [5] is a promising potential component for future heterogeneous networks. However, compared with non-CR femtocells, a cognitive femtocell requires more transmission power to support extra signal processing, such as spectrum sensing. Thus, it cannot ignore energy efficiency in this network. An energy-efficient resource allocation (EERA) for a cognitive femtocell has been addressed in [6]–[9]. Xie *et al*. proposed a three-stage Stackelberg game-based scheme [6]. In [7], authors proposed an approach for selecting an optimal base station in two-tier networks to reduce the cross-tier interference. In [8], An *et al*. introduced a low-complexity iteration algorithm based on a gradient-assisted binary search algorithm for an optimization problem. In [9], Chen *et al*. proposed a new energy-efficient power allocation scheme to balance the trade-off of spectral efficiency and energy efficiency.

Motivated by the aforementioned researches, embedding multi-RAT and femtocell technology in the cognitive radio network (CRN) is a promising paradigm, which not only to improve network capability, but energy efficiency. For this reason, a new CRN model, which includes multi-RAT based PU networks (PNets) and cognitive femtocell based SU networks (SNets), is developed in this study. In particular, we focus on EERA of SNets in the overlapping region of heterogeneous PNets coverage. At this point, it is different from previous works only assume homogeneous PNets [6]–[9].

Wang *et al*. assumed multiple PU types in the system model and studied the joint sub carrier and power allocation problem for orthogonal frequency division multiple access (OFDMA)-based CR networks from an energy efficiency (EE) perspective

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Yan Jiao is with the Department of Electronics and Computer Engineering, College of Engineering, Hanyang University, 222 Wangsimri-ro, Seongdong gu, Seoul, 04763, Korea, email: kubohao007@gmail.com.

Inwhee Joe is with the Division of Computer Science & Energineeing, College of Engineering, Hanyang University, 222 Wangsimri-ro, Seongdong gu, Seoul, 04763, Korea, Corresponding Author, email: iwjoe@hanyang.ac.kr.

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