Chapter 6
Interference Mitigation and Energy Management in Heterogeneous Networks: A Cognitive Radio Perspective

Chungang Yang
Xidian University, China

Jiandong Li
Xidian University, China

ABSTRACT
In Long Term Evolution (LTE) 4G systems, coexistence of multiple in-band smallcells defines what is called heterogeneous cellular networks. There is no doubt that the development of heterogeneous networks and the popularization of intelligent terminals facilitate subscribers with great convenience, better Quality of Experience (QoE) guarantee, and much higher traffic rate. However, interference management will be indispensable in heterogeneous networks. Meanwhile, with emerging various energy-hungry services of subscribers, energy-aware design attracts a wide attention. Motivated by interference mitigation and energy-saving challenges of the heterogeneous networks and the promising cognitive radio techniques, more advanced energy-saving and interference control techniques based on cognitive radio should be developed for better QoE. In this chapter, the authors first review cognitive radios, multiple types of smallcells, and introduce the benefits of cognitive radio-enabled heterogeneous networks. Then, focusing on the scheme design of cognitive interference management and energy management, finally, simulation results are provided to show the improved performance of these proposed cognitive schemes.

INTRODUCTION AND MOTIVATION
Next generation (xG) wireless networks will contain a number of radio access networks (RANs). Different RANs employ different radio access technologies (RATs). Meanwhile, subscribers who are equipped with smart terminals are pursuing much better user experience with multi-mode, reconfigurable and cognitive equipments. In long term evolution (LTE) 4G systems, coexistence of multiple in-band smallcells defines what is called heterogeneous cellular networks. Since

DOI: 10.4018/978-1-4666-5978-0.ch006
its first introduction, the LTE standard has significantly evolved toward LTE-Advanced one, where numerous spectral efficiency and peak data rate improvements have been introduced. Meanwhile, various transmission techniques are introduced to approach the limits of these point-to-point capacity rate requirements. Among those advanced techniques, it is worth mentioning the improved multiple input multiple-output (MIMO) techniques (e.g., the 3D and massive MIMO), carrier aggregation (CA), and enhanced intercell interference coordination (R1-101369, 2010; R1-104968, 2010; R1-104661, 2010). However, as the spectral efficiency of a point-to-point link in cellular networks approaches its theoretical limits, with the fore-casted explosion of data traffic, there is a need for an increase in the node density to further improve network capacity due to its proved powerful network enhanced capacity space. However, in already dense deployments in today’s networks, cell splitting gains can be severely limited by high inter-cell interference. Moreover, high capital expenditure cost associated with high power macro nodes further limits viability of such an approach. Therefore, the promisingly discussed scheme is the need for an alternative strategy, where low power nodes are overlaid within a macro network, creating what is referred to as a heterogeneous network (R4-110284, 2011).

The rational behind the heterogeneous network is that macrocell-only networks may not be able to carry the predicted future broadband traffic. Therefore, the next big leap in cellular system performance improvement is estimated to come from the introduction of additional smallcells to complement traditional macrocell installations. This raises the questions on how smallcells are most spectrally efficiently introduced, and how to integrate them with the macro-tier to maximize the performance benefits while keeping capital expenditures (CAPEX) and operational expenditure (OPEX) at tolerable levels. For this purpose, two state-of-the-art LTE-Advanced heterogeneous network integration schemes should be examined: co-tier and cross-tier interference management between macrocells and smallcells, or among themself, and energy-aware resource management strategy design between tiers, especially in the scenario of massive deployment of smallcells. In both use cases, we will highlight the benefits of cognitive radio-motivated schemes to push the system performance to its maximum, and in fact, extensive cognitive radio-based schemes have been poured attentions in the cellular systems, for example, cognitive LTE and cognitive femtocell networks (Lopez-Perez, Guvenc, & Roche, 2011).

Spectrum and energy are both scarce resources for wireless networks, specifically, the spectrum resource is the real source of the interference. Effective and efficient interference management and dynamic energy management with respect to the variations of the traffic and channel state, are both critical and important to further enhance the capacity and improve the quality of user experience. In this chapter, we concentrate on the cognitive radio based interference management and energy management, since they have shown a strong capabilities on the resource management and energy harvesting, and in the future they will play a greater role. We first summarize the current research and the necessary conditions of interference management and control, especially, the inter-cell interference coordination and energy management strategies using cognitive radios (Attar, Krishnamurthy & Gharehshiran, 2011; Li & Sousa, 2010; Viering, Dottling, & Lobinger, 2011; Saatsakis, Tsagkaris & Von-Hugo 2008; Wang, Yu & Huang, 2013; Yang, Li, 2012), finally we verify cognitive energy management for the heterogeneous networks to enhance the network energy efficiency and cognitive interference shift (capacity offload) for two-tiered heterogeneous networks, respectively. Meanwhile, the future research directions and typical issues on cognitive ideas for heterogeneous networks are summarized, which conclude the chapter.

www.igi-global.com/e-resources/library-recommendation/?id=109

Related Content

Semantic Mobile Applications for Service Process Improvement
Markus Aleksy, Bernd Stieger and Thomas Janke (2013). Web-Based Multimedia Advancements in Data Communications and Networking Technologies (pp. 69-84).
www.igi-global.com/chapter/semantic-mobile-applications-service-process/71890?camid=4v1a

Session Initiation and IP Multimedia Subsystem Performance Evaluation
www.igi-global.com/chapter/session-initiation-and-ip-multimedia-subsystem-performance-evaluation/177482?camid=4v1a

Vertical Handover Decision Schemes in Fourth Generation Heterogeneous Cellular Networks: A Comprehensive Study
www.igi-global.com/article/vertical-handover-decision-schemes-in-fourth-generation-heterogeneous-cellular-networks/193570?camid=4v1a

On Internet of Things and Big Data in University Courses
www.igi-global.com/article/on-internet-of-things-and-big-data-in-university-courses/185611?camid=4v1a