Chapter 14
Optimized Base Station Sleeping and Smart Grid Energy Procurement Scheme to Improve Energy Efficiency

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ABSTRACT

In this chapter, the authors propose a joint BS sleeping strategy, resource allocation, and energy procurement scheme to maximize the profit of the network operators and minimize the carbon emission. Then, a joint optimization problem is formulated, which is a mixed-integer programming problem. To solve it, they adopt the bi-velocity discrete particle swarm optimization (BVDPSO) algorithm to optimize the BS sleeping strategy. When the BS sleeping strategy is fixed, the authors propose an optimal algorithm based on Lagrange dual domain method to optimize the power allocation, subcarrier assignment, and energy procurement. Numerical results illustrate the effectiveness of the proposed scheme and algorithm.

INTRODUCTION

With the exponential increasing of the number of the mobile terminals and traffic demands, reducing the power consumption of the cellular radio networks becomes more and more urgent to reduce the cost of the transmission and the pollution on the environment. Indeed, the carbon emission caused by the information and communication technologies (ICT) accounts for more than 2%. Meanwhile, the energy cost constitutes a significant portion of the expenditure of the operators. Thus, the technologies of green communication becomes more and more popular in industry and academia. Especially, base station (BS) sleeping strategy is a well known technique to improve the energy efficiency. Indeed, for the wireless communication system, over 70%-80% power is consumed by base stations, and an active base station

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in idle status expends more than 50% of the energy because of circuit processing and air conditioning (Wu, Zhou & Niu, 2013; Marsan, Chiaraviglio, Ciullo, & Meo, 2013). Therefore, switching off redundant BSs is an efficient technology to decrease the energy consumption of the wireless networks. BS sleeping can enable the BS in light sleep mode in the low-load time slot to decrease the energy consumption.

On the other hand, the integration of the wireless networks and smart grids is also investigated to decrease the carbon emission (Huang, Crow, Heydt, Zheng, & Dale, 2011; Yu, Zhang, Xiao, & Choudhury, 2011; Erol-Kantarci and Mouftah, 2011; Lu, Wang, & Ma, 2013; Bu, Yu, Cai, & Liu, 2012; Ghazzai, Yaacoub, Alouini, & Abudayya, 2014). Smart grids are new generation electricity grids, and they can significantly improve the energy efficiency of the wireless network since smart grids can enhance energy savings and reduce carbon emission to achieve the green goals of consumers through using the massive renewable energy (wind energy, solar energy and conventional energy, etc.). Furthermore, smart grids make customers have more feasible procurement strategy due to the intelligent scheduling. Due to the limited availability and the uncertainty about the timing and the quantity of renewable energy (e.g., the solar energy can be used only in the daytime.), the smart grid should determine to sell power to each BS from which energy retailers and sell how much power from each energy retailer, which is called smart grid procurement strategy in this paper. Besides BS sleeping and the smart grid procurement, the energy efficient for the OFDMA cellular networks is also important to improve the system energy efficiency since suitable subcarrier and power allocation can significantly enhance the system throughput with the same energy consumption (Ghazzai et al., 2014).

As aforementioned, obviously, it will create a lot of advantages to jointly consider the BS sleeping, resource allocation and smart grid procurement decision to decrease the system energy consumption. It is worth nothing that these issues are not independent but have strong correlation. In fact, the smart grid procurement decision is dependent on the radio resource allocation and power control which determines the energy consumption of the cellular network. Meanwhile, the BS sleeping strategy is dependent on the smart grid procurement decision, resource allocation and power control. Therefore, joint optimization is necessary to achieve high system energy efficiency. Nonetheless, to the best of our knowledge, there are no paper which consider these issues at the same time, and most of the relation works only consider the subset of the above issues.

Evolutionary algorithm (EA) is a strong optimization approach which can be used to solve a lot of complicated optimization problems (Wenyong, & MengChu, 2017). Due to its simpler implementation, faster convergence speed and strong global search ability, EA has been wildly adopted in engineering field, such as(Junzhi, Zhengxing, Ming, & Min, 2016; Nataraj, Tanuj, & Vivek, 2017; Rui, Yuzhou, & Liuqing, 2017; Safdar, Hazlie, Hamzah, Kanendra, Javed, Anis, & Mohd, 2016; Santosh, & Sanjay. 2016; Shuangxin, Guibin, Dingli, & Yijiang, 2015; Zhao-Hua, Hua-Liang, Qing-Chang, Kan, Xiao-Shi, & Liang-Hong, 2017). Rui, et al. (2017) consider the multiple constrained quality-of-service (QoS) routing in named data networking which is a representation and implementation of an information centric network. Then, a particle swarm optimisation-forwarding information base (PSO-FIB) algorithm which uses the forwarding experiences of particles to maintain the forwarding probability of each entry in the FIB is proposed to solve the problem.

In this chapter, we combine the BS sleeping with subcarrier assignment and power allocation to decrease the cellular network's energy consumption due to their strong complementarity. Meanwhile, we consider the scenario in which the cellular network is powered by the distributed smart grid, and there are some different retailers in the smart grid to provide power with different prices and pollutant levels depending on the nature of the generated energy. As already noted, the cellular network should

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