Chapter 6
Energy Efficient Schemes for Base Station Management in 4G Broadband Systems

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ABSTRACT

Reducing the energy consumption in wireless networks has become a significant challenge, not only because of its great impact on the global energy crisis, but also because it represents a noteworthy cost for telecommunication operators. The Base Stations (BSs), constituting the main component of wireless infrastructure and the major contributor to the energy consumption of mobile cellular networks, are usually designed and planned to serve their customers during peak times. Therefore, they are more than sufficient when the traffic load is low. In this chapter, the authors propose a number of BSs switching off algorithms as an energy efficient solution to the problem of redundancy of network resources. They demonstrate via analysis and by means of simulations that one can achieve reduction in energy consumption when one switches off the unnecessary BSs. In particular, the authors evaluate the energy that can be saved by progressively turning off BSs during the periods when traffic decreases depending on the traffic load variations and the distance between the BS and their associated User Equipments (UEs). In addition, the authors show how to optimize the energy savings of the network by calculating the most energy-efficient combination of switched off and active BSs.

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1. INTRODUCTION

During the last few years, the rapid and radical evolution of mobile telecommunication services along with the emerging demand for multimedia applications due to the widespread use of laptops, tablets and smart-phones have led to a growing demand for data transmission. The traffic load is experiencing a growing increase by the factor of 10 every 5 years approximately (Global Action Plan, 2007; Cisco, 2013). Overall mobile data traffic is expected to reach 11.6 exabytes per month by 2017, a 13-fold increase between 2012 and 2017 and at a Compound Annual Growth rate (GAGR) of 66% from 2012 to 2017. The mobile applications, in particular, are expected to grow in staggering rates, with mobile video showing the higher growth and getting up to 66.5%.

To meet these demands, the development of new standards and architectures is more than compulsory. Long Term Evolution (LTE), that is the natural upgrade of Universal Mobile Telecommunications System (UMTS), is an evolving wireless standard developed by the 3rd Generation Partnership Program (3GPP) as a candidate Fourth Generation (4G) system, while LTE-Advanced constitutes the most advanced version of LTE (3GPP, 2012), (Martin-Sacristan, Monserrat, Cabrejas Penuelas, Clabuig, Carrigas, & Cardona, 2009). IEEE 802.16m standard is the 4G system proposed by International Mobile Telecommunications-Advanced (IMT-Advanced). These new standards promise higher data rates for mobile phones and terminals, ubiquitous connectivity and enhanced spectral efficiency.

Along with the development of the new telecommunications standards, operators face the need to expand their wireless infrastructure in order to tackle with the challenges of future mobile networks and handle the predicted increase in mobile traffic volume. As a result, more Base Stations (BSs) are deployed and small cells alongside with the macro sites are used in high traffic areas. The telecommunications companies work towards the mass deployment of 4G systems as there are more than 4 million BSs serving mobile users, with this number expected to double by the end of 2012 (Correia et al., 2012).

The BS, called Evolved Node B (eNB) in LTE-Advanced, is the principal energy consuming entity of Information and Communications Technology (ICT) (Chen, Zhang, Zhao, & Chen, 2010), whereas mobile telephone exchange and data centers consume less energy (Motorola, 2007). The BSs consume up to 1350 Watts, while more than 50% of the total energy is consumed by the transmit antennas and the Power Amplifiers (PAs). On the other hand, data transmission is a less energy consuming contributor to wireless cellular networks. Therefore, reducing the energy consumption of BSs through a “greener” BSs operation in the cellular networks has become an important research topic. Improving the hardware and developing less consuming PAs is a way to go, but it does not promise great energy savings.

Energy efficient BSs operation can achieve significant energy consumption reduction through switching off the unused BSs by taking into account the time varying traffic conditions. Considering that access networks are usually dimensioned according to the peak hour traffic, the resources of the network are shared among the existing users, so as to meet specific Quality of Service (QoS) constraints. On the other hand, when traffic decreases due to normal load variations throughout the day, networks are over-dimensioned, resources become redundant and the existing traffic in a given area can be served by just a subset of the deployed BSs. Thus, the unnecessary BSs could be switched off in a smart way during the low traffic periods in order to save energy. After the BSs switching off, the existing traffic is served by the remaining active BSs, which, in turn, may need to increase their transmission power in order to extend their coverage area. The number of switched off BSs and the transmission power increase of the active ones leads to a tradeoff that
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