Abstract

The heterogeneous deployment of small cells (e.g., femtocells) in the coverage area of the traditional macrocells is a cost-efficient solution to provide network capacity, indoor coverage and green communications towards sustainable environments in the future fifth generation (5G) wireless networks. However, the unplanned and ultra-dense deployment of femtocells with their uncoordinated operations will result in technical challenges such as severe interference, a significant increase in total energy consumption, unfairness in radio resource sharing and inadequate quality of service provisioning. Therefore, there is a need to develop efficient radio resource management algorithms that will address the above-mentioned technical challenges.

The aim of this thesis is to develop and evaluate new efficient radio resource management algorithms that will be implemented in cognitive radio enabled femtocells to guarantee the economical sustainability of broadband wireless communications and users' quality of service in terms of throughput and fairness. Cognitive Radio (CR) technology with the Dynamic Spectrum Access (DSA) and stochastic process are the key technologies utilized in this research to increase the spectrum efficiency and energy efficiency at limited interference. This thesis essentially investigates three research issues relating to the efficient radio resource management: Firstly, a self-organizing radio resource management algorithm for radio resource allocation and interference management is proposed. The algorithm considers the effect of imperfect spectrum sensing in detecting the available transmission opportunities to maximize the throughput of femtocell users while keeping interference below pre-determined thresholds and ensuring fairness in radio resource sharing among users. Secondly, the effect of maximizing the energy efficiency and the spectrum efficiency individually on radio resource management is investigated. Then, an energy-efficient radio resource management algorithm and a spectrum-efficient radio resource management algorithm are proposed for green communication, to improve the probabilities of spectrum access and further increase the network capacity for sustainable environments. Also, a joint maximization of the energy efficiency and spectrum efficiency of the overall networks is considered since joint optimization of energy efficiency and spectrum efficiency is one of the goals of 5G wireless networks. Unfortunately, maximizing the energy efficiency results in low performance of the spectrum efficiency and vice versa. Therefore, there is an investigation on how to balance the trade-off that arises when maximizing both the energy efficiency and the spectrum efficiency simultaneously. Hence, a joint energy efficiency and spectrum efficiency trade-off algorithm

is proposed for radio resource allocation in ultra-dense heterogeneous networks based on orthogonal frequency division multiple access. Lastly, a joint radio resource allocation with adaptive modulation and coding scheme is proposed to minimize the total transmit power across femtocells by considering the location and the service requirements of each user in the network.

The performance of the proposed algorithms is evaluated by simulation and numerical analysis to demonstrate the impact of ultra-dense deployment of femtocells on the macrocell networks. The results show that the proposed algorithms offer improved performance in terms of throughput, fairness, power control, spectrum efficiency and energy efficiency. Also, the proposed algorithms display excellent performance in dynamic wireless environments.