Graduate School of Global Information and
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博　士　論　文　概　要
Doctoral Thesis Synopsis

論　文　題　目
Thesis Theme

Studies on Energy optimization and Mobility Robustness for Green Cellular Networks

エネルギー最適化及び移動耐性をもつグリーンセルラ網に関する研究

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Abstract

The explosion in data consumption will drive significant impact on future mobile system architectures, technical developments, and evolution. The ongoing 5G cellular networks are expected to meet the demand for imperative energy and radio resource crises, especially exploiting flexible management regarding intensive instantaneous traffic. The dissertation aims at providing novel and timely solutions as robust enablers with the perspective of addressing greenness regarding the requirements and challenges for the next-generation 5G cellular networks, which is composed by 7 chapters with 4 original proposed works including both uplink and downlink considerations in terms of system design, theoretical analyses, and comprehensive performance evaluations.

Chapter 1 states the general introduction with a retrospect of the development roadmap from 2G to 5G, and then indicates the future trends and key evolutions for the ongoing 5G cellular systems. Chapter 2 provides the fundamental literatures of green cellular networks, which is helpful for smoothly understanding the following chapters in this dissertation.

In chapter 3, two energy optimizing solutions are proposed for homogeneous cellular networks with the tradeoff consideration regarding spectrum efficiency and Quality of Service (QoS), which adapt to the instantaneous traffic variance based upon dynamic cell configurations. To characterize the optimal energy savings for macro base stations (MBSs), an active cell rotation (ACR) scheme is cyclic activated to control the number of active macro cells by appropriately scheduling among different work patterns in 7 cells composed hexagonal cell groups, and hence guarantee QoS requirement of the user equipments (UEs) by a recovery mechanism if sudden traffic increment occurs. Furthermore, an enhanced cooperative active cell rotation (CACR) scheme is also proposed, which enable BSs to achieve better spectrum utilization while pursuing energy efficiency in terms of traffic load. In addition, closed-form stationary results as well as asymptotic analysis are also derived for formulating the instantaneous traffic variance and state transitions of by a Markov based framework. The system performances are validated by means of numerical simulation and theoretical results in comparison with the conventional schemes, which indicate that the proposed methodologies can have positive effects on addressing greenness for both energy and spectrum dimensions to meet the upcoming intensive traffic and QoS requirements.

In chapter 4, an optimal solution of power savings is discussed for femtocell cluster deployments in the sleep mode involved macro-femto two-tier scenarios. The proposed scheme aims at achieving high SINR with optimal transmit power of femto access point (FAP) by coordinating downlink cross-tier interference and intra-interference with utility and traffic-based power control (UTPC) when MBS is under sleep activation. Since the optimal radius of femtocells can be obtained according to dynamic coverage extension, several sleep patterns can be defined for open access permitted hybrid femtocells. In this case, more FAPs can be switched into sleep mode and managed by the main active FAPs in the cluster. As a result, the number of active femtocells can be controlled in accordance with dynamic cell configurations, which can effectively reduce the energy impact of

the femtocell cluster. The simulation results show that our proposed scheme enables positive influence on power efficiency and interference coordination for femtocell cluster in the two-tier heterogeneous networks, especially during the night zone.

In chapter 5, a self-optimizing based energy-efficient scheme with a dynamic coverage expansion of femtocells is proposed in the macro-femto two-tier networks. High signal-to-interference-plus-noise ratio (SINR) and low power consumption can be benefited by coordinating downlink cross-tier interference and intra-interference with a neuron control based adaptive power adjustment when sleep mode is involved in the MBS. Moreover, by allowing open access in the hybrid femtocells, more near-indoor MUEs, especially located around the edge of the macrocell can be served by indoor FAP, which results in MBS having more of a probability to maintain sleep mode when the traffic is low. Many related performances are evaluated with a comparison of UBPC scheme, the energy impact of both MBS and FAP can be largely improved with optimal transmit power, which means the sleep mode technology can be enhanced, as shown in the simulation.

In chapter 6, diversely architectural evolution and intensive data explosion in the forthcoming 5G severely impact on providing seamless and robust mobility management. A P-persistent energy-aware handover (HO) decision strategies with mobility robustness are proposed for intra-handover case while a femto user equipment (FUE) roams into another femto access point (FAP), and for cross-tier handover case while a macro user equipment (MUE)/FUE roams into/out of a FAP in a dynamic cell sizing involved macro-femto two-tier networks. To approximate the densely deployed smallcells, a unique RF fingerprint (RFF) based localization is employed to enable efficient small-cell detection by a RFF matching mechanism. The prediction of HO trigger is jointly determined by a P-persistent decision mechanism which formulates the specific HO behaviors when a MUE/FUE roams into (HO-in) and out of (HO-out) a femtocell in terms of the correlated coverage variance and UE mobility features, whereas the target selection follows a utility function in consideration of UE travelling time and the achievable throughput. The closed-form stationary probabilities of the proposed VHO/HHO decisions are analyzed by a Semi-Markov based framework. In addition, an adjustable sensing mechanism with dynamic intervals are proposed when UE located distantly from the RFF matching region, which can have a positive influence on reducing unnecessary UE energy consumption. Numerical results are presented regarding the decision accuracy analyses (too early, too late, and ping-pong HOs), energy-efficiency and also resource utilization of the two-tier system. The comprehensive evaluations indicate that the proposed scheme can enhance the mobility robustness and enable optimal trade-off between energy-efficiency and system capacity while eliminating the architectural impacts caused by dynamic topology and densely deployment for the next-generation macro-femto two-tier networks.

Finally, chapter 7 provides the conclusion and outlook of my dissertation. It can be explicitly concluded that the proposed works as well as the possible subsequent research will significantly encourage the future studies on enhancing the energy-scale performance for the future sustainable 5G cellular networks.