On the optimal operation of wireless networks

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1 Abstract

With the ever increasing mobile traffic in wireless networks, radio frequency spectrum is becoming overcrowded. Researchers propose advanced radio technology-Cognitive Radio to make use of the uncommonly used and under-utilized licensed bands to improve overall spectrum efficiency. Mobile service providers deploy small base stations on the street, into the shopping center and users' household in order to improve spectrum efficiency per area. In this thesis, we study network resources cooperation schemes in cognitive radio network as well as heterogeneous network to improve network throughput and spectrum efficiency, reduce network power consumption and provide network failure protection capability.

In the first work of the thesis, we study a multicast routing problem in Cognitive Ratio Networks (CRN). In this work, all Secondary Users (SUs) are assumed not self interested and they are willing to provide relay service for source SUs. We propose a new network modeling method, where we model CRNs using a Multi-rate Multilayer Hyper-Graph (MMHG). Given a multicast session of the MMHG, our goal is to find the multicast routing trees that minimize the worst case end-to-end delay, maximize the multicast rate and minimize the number of transmission links used in the multicast tree. We apply two metaheuristic algorithms (Multi-Objective Ant Colony System optimization algorithm (MOACS) and Archived MultiObjective Simulated Annealing Optimization Algorithm (AMOSA)) in solving the problem. We also study the scheduling problem of multicast routing trees obtained from the MMHG model. Our simulation results show that MOACS can find more than 60% of the approximated Pareto Front (APF) in small CRNs, and AMOSA can find approximately 45%. Moreover, the solutions found by MOACS and AMOSA that are not in the APF are within 10% relative distances to solutions in the APF.

In the second work of the thesis, we study the cell outage compensation function of the self-healing mechanism using network cooperation scheme. In a heterogeneous network environment with densely deployed Femto Base Stations (FBSs), we propose a network

cooperation scheme for FBSs using Coordinated Multi-Point (CoMP) transmission and reception with joint processing technique. Different clustering methods are studied to improve the performance of the network cooperation scheme. Simulation results show that our proposed network cooperation scheme using CoMP can improve Femto User Equipment (FUE) throughput by more than 30% compared to non-cooperation solution, and CoMP schemes with spectral clustering and k-means clustering algorithms can improve FUE throughput by up to 50%. What's more, CoMP operation schemes provide cell outage compensation capability by preventing the system total rate loss from having the same speed of radio resource loss when failures happen.

In the final work of the thesis, we study the user cooperated multi-path routing solution for wireless User Equipments (UEs)' streaming application using auction theory. We assume that UEs use multi-path transport layer service, and establish two paths for streaming events, one path goes through its cellular link, another path is established using a Wi-Fi connection with a neighbor UE. We study user coordinated multi-path routing solution with two different energy cost functions (LCF and EAC) and design user cooperated real-time optimization and failure protection operations for the streaming application. To stimulate UEs to participate into the user cooperation operation, we design a credit system enabled with auction mechanism. We compare the performance of user cooperation schemes to the no-cooperation scheme, and the simulation results show that applying the proposed user cooperation schemes and establishing multi-path connections for the streaming event has great advantage in improving service rate and streaming event success rate, reducing energy consumption compared to non-cooperation solution. User cooperation scheme with LCF energy cost function can also help balance the energy consumption among UEs in the system compared to user cooperation scheme with EAC energy cost function.