論 文 内 容 の 要 旨

With the current state of research on wireless networks, the dominant paradigm used hexagonal lattices and square lattices in early generation, but modern wireless networks follow the irregular deployment of large base stations (BSs) and small BSs (e.g., macro BS, micro BS, pico BS and femto BS). As a result, wireless network design has shifted from deterministic to random wireless networks, and stochastic geometry has attracted much attention as a tool for the design and analysis of modern wireless networks. In the meantime, cognitive radio (CR) has been proposed as a means of adapting to radio frequency spectrum scarcity and also as a way of improving spectral utilization efficiency. In that light, holistic approaches to random CR network have recently attracted widespread research attention in both academia and industry. In this dissertation, we focus an uplink and downlink model of random CR network that is not only tractable but also relevant with current deployment of BSs.

Firstly, we investigate the outage probability and energy efficiency of the primary receiver (PR) and secondary receiver (SR) in CR network, modelling the locations of primary user (PU) and secondary user (SU) as a Poisson point process (PPP). We derive closed-form expressions for outage probability and energy efficiency, with consideration of the probabilities of unoccupied (not utilized by PU) channel selection and successful transmission for imperfect detection in CR network. Furthermore, we propose a method for transmit antenna selection of secondary transmitter (ST) in such networks and accordingly develop closed-form expressions for outage probability and energy efficiency with imperfect detection. The study reported here highlights the importance of combining the capabilities of unoccupied channel selection and successful transmission in CR network to achieve optimal performance regarding outage probability and energy efficiency. In terms of energy efficiency, there is an optimal threshold that maximizes energy efficiency. For implementation in transmit antenna selection, the outage probability can significantly decrease as the number of transmit antennas increases, even though energy efficiency is maximized under the target outage probability.

Secondly, we investigate the performance of CR network using a stochastic geometry approach in Rayleigh-Lognormal fading. We present a geometric model of CR network where primary transmitters (PTs), PRs, STs, and SRs are distributed as a PPP. We analytically derive the coverage probability and transmission rate of that network. Moreover, we obtain closed-form expressions of coverage probability and transmission rate. We then numerically evaluate coverage probability and transmission rate performance. It is shown that for the coverage probability and transmission rate, the results are better for lower densities of PTs and STs.

Thirdly, we investigate the coverage probability and spectral efficiency of a CR network with a single-tier uplink model based on a stochastic geometry framework. The locations of STs, SRs, PTs, and PRs are modeled as independent PPP. We derive mathematical expressions for the coverage probability and spectral efficiency of this network, as well as closed-form expressions for a path-loss exponent equal to 4. For the uplink transmission, truncated channel inversion power control is employed for the ST with a cutoff threshold at the SR because of the limited transmission power. We consider two locations of the SR (i.e., inside and outside the primary exclusion region) for uplink transmission. We found that the location of the SR impacts on coverage probability and spectral efficiency. Numerical analysis confirms that (i) the coverage probability is higher and (ii) the spectral efficiency is higher when the SR is outside the primary exclusion region.

Fourthly and last, we report a comprehensive study of energy harvesting CR network where locations of users of primary and secondary networks follow a PPP. In our design of random CR network, we focus on the two-slope path-loss function so as to have a realistic scenario of propagation environments. A new expression of outage probability is theoretically derived for SR in active mode. Also, we obtain an explicit expression of harvested energy for SR in active and inactive modes. Finally, we investigate the harvested energy maximization problem under a particular outage probability constraint, and also obtain an optimal solution of transmission power and density of STs. Numerical results for outage probability, harvested energy and maximization of harvested energy are presented for evaluation of the performance and characteristics of this network.