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Backhaul and Cooperation

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Preface

The current growth rate of wireless data exceeds both spectral efficiency advances and availability of new wireless spectrum; a trend towards network densification is essential to respond adequately to the continued surge in mobile data traffic. To this end, there are two common ideas to densify the network, one is by aggregating lots of antennas at the base station to achieve large diversity gain, termed massive multiple-input-multiple-output (MIMO), and the other one is by spreading antennas into the network and form small autonomous regions to provide better path loss, known as small cell network.

The focus of this book is on combining these two techniques and to investigate a better utilization of the excessive spatial dimensions to improve network performance. Particularly, we point out two directions that the large number of antennas can be used for: (1) interference suppression, where we propose a linear precoding scheme termed cell-edge aware zero forcing (CEA-ZF) that exploits the extra degrees of freedom from the large base station antenna array to mitigate inter-cell interference at cell-edge neighboring users; (2) wireless backhaul, where we propose using the massive antenna array at macro base stations to simultaneously serve several small access points within their coverage by spatial multiplexing, thus connecting different tiers in a small cell network via wireless backhaul and perform an energy-efficient design. In order to quantify the performance of our proposed schemes, we combine random matrix theory and stochastic geometry to develop an analytical framework that accounts for all the key features of a network, including number of antenna array, base station density, inter-cell interference, random base station deployment, and network traffic load. The analysis enables us to explore the impact from different network parameters through numerical analysis. Our results show that on the one hand, CEA-ZF outperforms conventional zero forcing in terms of coverage probability, aggregated per cell rate, and edge user rate, demonstrating it as a more effective precoding scheme to achieve better coverage probability in massive MIMO cellular networks. On the other hand, we show that a two-tier small cell network with wireless backhaul can be significantly more energy-efficient than a one-tier cellular network. However, this requires the bandwidth division between radio access links and wireless backhaul to be optimally designed according to the load conditions.

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