Signal Processing Design and Performance Enhancement Techniques for Non-Orthogonal Multiple Access (NOMA)

ABSTRACT:

With the tremendous increase in the number of mobile devices, a plethora of multimedia services, there is a demand for the development of new access schemes that can have properties of high capacity and spectral efficiency, low latency, and capabilities to accommodate a massive number of devices. Non-orthogonal multiple access (NOMA) is proposed as a promising access technology for beyond fifth generation (B5G) and sixth generation (6G) communication systems having all the desired properties. Unlike orthogonal multiple access (OMA), the same physical resource (e.g., frequency and time) but with different power is allocated to multiple users in NOMA, which greatly increases spectral efficiency. The combination of non-orthogonal multiple access (NOMA) and cooperative communications can be a suitable solution for the fifth generation (5G) and beyond 5G (B5G) wireless systems with massive connectivity, because it can improve fairness compared to the non-cooperative NOMA. This thesis offers a comprehensive approach to this recently emerging technology, from the fundamental concepts of NOMA to its combination with space-time block codes (STBC) to the cooperation with users with weak channel conditions, as well as analysis of the effect of practical impairments such as timing offsets, imperfect successive interference cancellation (SIC) and imperfect channel state information (CSI). We derive closed-form expressions of the received signals in the presence of such realistic impairments and then use them to evaluate outage probability. Further, we provide intuitive insights into the impact of each impairment on the outage performance through asymptotic analysis at a high transmit signal-to-noise ratio (SINR). We also compare the complexity of STBC-CNOMA with existing cooperative NOMA protocols for a given number of users.

In addition, to meet the highly diverse quality-of-service (QoS) requirements of the Internet of Things (IoT) devices, we propose a novel Q-learning-based self-organizing and self-optimizing multiple access techniques for radio resource allocation in NOMA systems. We optimize the sum-rate and spectral efficiency (SE) of the overall network by using a Q-learning algorithm that assigns optimal bandwidth and power to the users with the same range of data rate requirements. Simulation results show that the proposed algorithm can significantly enhance the overall system throughput and SE while satisfying heterogeneous QoS requirements.