INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

This work focuses on the modeling and optimization of transmitter and receiver design for code-domain non-orthogonal multiple access (CD-NOMA) systems, a key enabler for 6G wireless networks aiming to support ultra-high bandwidth efficiency, low latency, massive connectivity, and high reliability. CD-NOMA techniques, particularly sparse code multiple access (SCMA) and dense code multiple access (DCMA), allow multiple users to share the same resource element, enabling grant-free access and reducing signaling overhead. This thesis investigates CD-NOMA from three perspectives: SCMA codebook design, efficient detection for both SCMA and DCMA systems, and grant-free CD-NOMA implementation. A novel diversity-based framework is developed to design SCMA codebooks with high overloading factors, leveraging constellation rotation and dimensional permutation to optimize key performance indicators (KPIs) for symbol error rate (SER). These codebooks perform equally well in both uplink and downlink scenarios. To address the high complexity of conventional message passing algorithm (MPA)-based detection especially in dense systems and MIMO setups, an iterative detector based on the alternating direction method of multipliers (ADMM) is proposed, enabling efficient, resource-wise detection for both sparse and dense CD-NOMA systems. Furthermore, for grant-free scenarios, where joint activity and data detection (JADD) is critical, the work extends the ADMM framework using block compressive sensing (BCS) with group LASSO formulations. A robust, low-complexity prior-aided ADMM algorithm is introduced to exploit temporal correlations in user activity, significantly improving performance under dynamic conditions. Extensive simulations and analysis confirm that the proposed techniques enhance performance while maintaining computational efficiency, making them well-suited for future 6G machine-type communication networks.