6G-RIC
Research and Innovation Cluster

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Per-replica power diversity for modern random access

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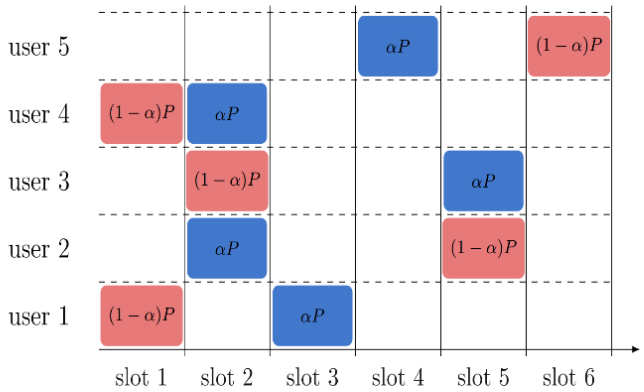
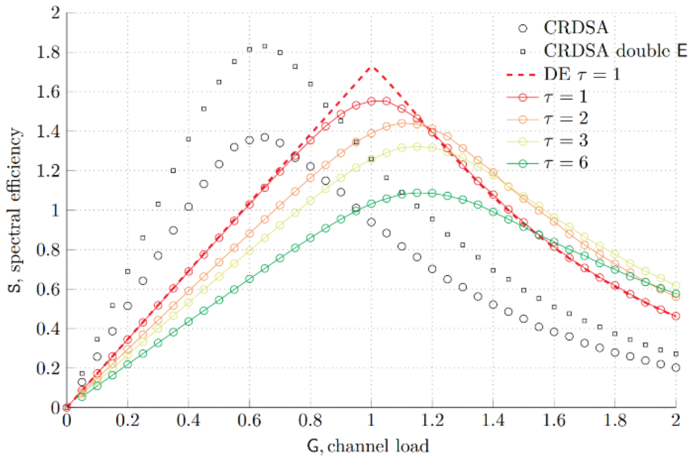
How can modern random access schemes be enhanced to support highest throughput and increase spectral efficiency?





Modern random access protocols based on slotted ALOHA exploit time diversity to improve the system performance. Uncoordinated nodes transmit multiple replicas of their packets across different time slots. Time diversity serves to facilitate the receiver in decoding through the application of successive interference cancellation (SIC). However, SIC suffers from lock situations when users transmit their replicas in the same slots. For example, as picture in the first figure, the traditional schemes will be not able to solve user 2 and user 3. To overcome this challenge, per-replica power diversity is introduced in RA.

KEY FINDINGS

Developing energy-efficient network protocols that ensure reliable communication and optimal performance for IoT systems stands as a key objective for 6G. To this end, we propose to apply power diversity to the modern random access schemes, allowing users to transmits copies of the same packets at different powers. The system is designed to enable the transmission of each replica at two distinct power levels, with each level representing a fraction of the available peak power. The advantage of the chosen approach is not only to reduce overall power consumption but also to create diversity between the replicas, potentially capturing the strongest signal in one slot. By precisely defining the decoding threshold, the receiver may exploit the capture effect, resolving lock situations that are not solvable in the traditional versions of the protocols.

The proposed approach was analytically studied for the case of infinite frame length and via simulation for the finite case. In the second figure the spectral efficiency [bits/s/Hz] as a function of the channel load [packet/packet duration] for the proposed scheme is plotted. Blacks markers represent the results for the traditional scheme CRDSA. Circular markers denote an energy consumption per user of E, while square markers indicate 2E. Various colors represent distinct configurations illustrating how the two power levels are chosen. As shown, the proposed scheme demonstrates a significant improvement in spectral efficiency under high channel load conditions.

E. Recayte and F. Clazzer, "Per-Replica Power Diversity in Grant-Free Multiple Access: Design and Performance Evaluation," 2023 IEEE Globecom Workshops (GC Wkshps), Kuala Lumpur, Malaysia, 2023, pp. 1976-1981, doi: 10.1109/GCWkshps58843.2023.10465037.