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EEI KOLLOQUIUM

Low-Density Code-Domain NOMA: Better Be Regular

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Non-orthogonal multiple-access (NOMA) is one of the key technologies considered for 5G cellular networks and beyond.

The idea is to loosen the paradigm of orthogonal transmissions, so that users (or “layers") are allowed to concurrently share the same physical resources, in either time, frequency or space. More connections can thus be supported in massive Machine-Type-Communications (mMTC).

Alternatively, a higher total throughput can be achieved in enhanced Mobile Broadband (eMBB) scenarios.

In this talk, we derive a closed-form analytical expression for the limiting empirical squared singular value density of a spreading (signature) matrix corresponding to sparse low-density code-domain (LDCD) NOMA with \emph{regular} random user-resource allocation. The derivation relies on associating the spreading matrix with the adjacency matrix of a large semiregular bipartite graph. For a simple repetition-based sparse spreading scheme, the limiting density directly follows from a rigorous result by Godsil and Mohar (1988) on spectral measures of infinite graphs. Turning to random (sparse) binary spreading, we harness the heuristic cavity method from statistical physics,

whose underlying principles will be shortly reviewed. We then show that the limiting spectral density coincides in both cases.

Next, we use this density to compute the normalized input-output mutual information of the underlying vector channel in the large-system limit. The latter may be interpreted as the achievable total throughput per dimension with optimum processing in a corresponding multiple-access channel setting or, alternatively, in a fully-symmetric broadcast channel setting with full decoding capabilities at each receiver.

Surprisingly, the total throughput of regular LDCD-NOMA is found to be not only superior to that achieved with irregular user-resource allocation, but also to the total throughput of \emph{dense} randomly-spread NOMA, for which optimum processing is computationally intractable.

In contrast, the superior performance of regular LDCD-NOMA can be potentially achieved with a feasible message-passing algorithm. This observation may advocate employing regular, rather than irregular, LDCD-NOMA in 5G cellular physical layer design.