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Exact Random Coding Error Exponents for the Two-User Interference Channel

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Abstract

This paper is about exact error exponents for the two-user interference channel under the random coding regime. Specifically, we first analyze the standard random coding ensemble, where the codebooks are comprised of independently and identically distributed (i.i.d.) codewords. For this ensemble, we focus on optimum decoding, which is in contrast to other, heuristic decoding rules that have been used in the literature (e.g., joint typicality decoding, treating interference as noise, etc.). The fact that the interfering signal is a codeword, and not an i.i.d. noise process, complicates the application of conventional techniques of performance analysis of the optimum decoder. Also, unfortunately, these conventional techniques result in loose bounds. Using analytical tools rooted in statistical physics, as well as advanced union bounds, we derive exact single-letter formulas for the random coding error exponents. We compare our results with the best known lower bound on the error exponent, and show that our exponents can be strictly better. It turns out that the methods employed in this paper, can also be used to analyze more complicated coding ensembles. Accordingly, as an example, using the same techniques, we find exact formulas for the error exponent associated with the Han-Kobayashi (HK) random coding ensemble, which is based on superposition coding.

Index Terms

Random coding, error exponent, interference channels, superposition coding, Han-Kobayashi scheme, statistical physics, optimal decoding, multiuser communication.

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