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Design of Polar Code Lattices of Moderate

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In 2008, Arikan first proposed the concept of channel polarization, then channel polarization was explained in more detail, and a new encoding method was given. Polar codes are the only known channel coding method that can be strictly proven to "reach" channel capacity when the code length goes to infinity under successive cancellation (SC) decoding. Thus, polar codes have attracted the attention of academia and industry in the past decade.

Lattice codes are linear codes defined over Euclidean space and also have attracted attention in recent years. In wireless communications, lattice codes can be used to perform shaping technique efficiently to obtain about 1.53 dB shaping gain on the additive white Gaussian noise (AWGN) channel. In addition, lattices are integral to certain Gaussian network coding approaches, including compute-forward relaying and integer-forcing MIMO.

In this thesis, we propose a design of polar code lattices using Construction D of moderate dimension. Construction D forms lattices from binary codes and allows decoding lattices using binary code decoder. In the design, we use the dimension *N* and the target decoding error probability P_{trgt} as parameters. Furthermore, we use the explicit finite-length properties of the polar code to select the code rates of the Construction D component codes. Under SC decoding, over the AWGN channel, instead of using the approximation of the Bhattacharyya parameter, we use density evolution to select the information bit positions that allows obtaining the probability distribution for each position. Then, choose code rates for the component codes that satisfy the equal error probability rule. We propose a function ρ defined as the greatest code rate with error rate under P_{trgt}; under SC decoding ρ may be found by density evolution efficiently. Under successive cancellation list decoding and ordered statistic decoding, since density evolution is not practical, function ρ can be obtained by Monte Carlo simulation.

Dimension N=128 polar code lattices are given as design example. From the simulation results, under SC decoding with complexity $O(N\log N)$, polar code lattice comes within 1 dB of the best-known BCH code lattice. Under SCL decoding with L=128 and CRC-6, polar code lattice comes within 0.2 dB of the BCH code lattice. SCL decoding with list size L, complexity scales as $O(LN\log N)$. For polar code lattice under OSD, there is 1 dB gap between BCH code lattice. OSD decoding has significantly higher complexity. The complexity of order-l OSD is proportional to $\sum_{i=0}^{l}\binom{K}{i}$.