Abstract

Lattice code is a coded-modulation scheme defined over real numbers, considered as a candidate for next generation wireless communication. Lattice codes provide error correction ability. It is also shown that lattice codes can achieve lower transmission power compared to conventional QAM modulation. Besides, lattice codes preserve the linearity of codewords, therefore can be applied for physical layer network coding. It has been shown that lattice codes achieve the capacity of the Gaussian channel if lattice decoding is performed using optimal decoding coefficient(s).

This research studies finite dimensional lattice codes for practical systems. Single user transmission and multiple access relay using compute-forward (CF) are considered as communication scenarios. The following three challenges are addressed. 1) Even with optimal coefficients, finite dimensional systems have a non-zero error rate, which gives a room on improving error rate. 2) Traditional CF relaying does not have error detection ability, potentially forwarding erroneous packets into network, for which a error detection scheme is required. 3) A lattice design is considered to achieve lower error rate than classic designs.

In this work, a retry decoding scheme is proposed for both single user scenario and CF relaying, which allows additional decoding attempts at receiver to improve error rate by adjusting value(s) of decoding coefficient(s), when errors are detected. A lower bound and an estimate on error probability are derived for single user scenario. The CRC-embedded lattice/lattice code are proposed having error detection ability for enabling retry decoding. The CRC-embedded lattices/lattice codes rely on CRC codes, with modest complexity on error detection. Besides, the error detection is applicable for CF relaying, which was not feasible in conventional systems. For a 2-user CF relay, numerical results show gains of 1.29dB, 1.31dB and 1.08dB at equal error rate 10^{-5} are achieved by $n = 64, 128, 256$ polar lattice codes at code rate $R \approx 1.6406, 1.7422, 1.8438$, respectively, where only one additional decoding attempt is required. At last, a lattice design approach is provided using construction A and binary codes with known minimum Hamming distance and codeword multiplicity, the number of minimum weight codewords. Design examples consider extended BCH codes and polar codes, where lower error rates are achieved than that by classic design rules.

Keywords: Lattices, lattice codes, finite dimensional transmission, CRC codes, compute-forward relaying, construction A.