Abstract

The primary objective of this dissertation is to analyze performances of distributed coding based wireless cooperative communication systems from the perspective of Slepian-Wolf theorem. The particular system assumption in this dissertation is a one-way decode-and-forward relay model, where the original bit sequence at the source and the re-constructed bit sequence at the relay are independently encoded and transmitted to a common destination. The research fundamental lies in the utilization of the correlation knowledge between the two bit sequences, of which concept has potential of significantly improving wireless communication system performance. In this dissertation, both practical coding/decoding algorithms and the theoretical framework setup are focused on.

First of all, we propose a one-way Slepian-Wolf relay system adopting bit-interleaved coded modulation with iterative decoding (BICM-ID) for high spectrum efficiency. It is shown that the extrinsic information transfer (EXIT) curve of the BICM-ID demapper combined with the decoder of doped accumulator (DACC) is well matched with that of the decoders, which enables the EXIT tunnel open until (1,1) mutual information point. Although errors may happen in the source-relay channel (it is referred to as intra-link errors in this dissertation), the re-constructed sequences that may contain some errors are to forwarded to the destination. Strong codes are not needed, and even the systematic part of the coded bit sequences can be simply extracted at the relay node, regardless of whether or not some errors are occurring in the sequences. Therefore, the computational complexity of the relay can be significantly reduced, which indicates that our proposed system is highly energy-efficient.

Moreover, the theoretical outage probability of the proposed Slepian-Wolf relay system is derived over block Rayleigh fading channels. Two cases are considered: in Case 1, we simplify the intra-link transmission as a bit-flipping model, where some of the bits, re-constructed after decoding at the relay, are the flipped versions of the original information bits transmitted from the source. In other words, the intra-link error probability is used as a parameter representing the correlation between the sequences in the practical transmission chain design. As one of the main contributions, the theoretical outage probability expression is derived on

the basis of the admissible Slepian-Wolf rate region, with transmission channels being either temporally independent or correlated. In addition, asymptotic properties of the outage curves are mathematically proven. The theoretical results are verified through a series of simulations. In Case 2, block Rayleigh fading is also assumed for the intra-link, and we express the intra-link error probability by the Hamming distortion represented by the inverse rate distortion function. The outage probability of the Case 2 setup is derived for different relay location scenarios which provides us with more practical performance assessment than with Case 1.

Finally, the power allocation schemes are proposed for the both cases based on the outage derivations described above. Specifically, we aim to (1) minimize the outage probability while keeping the total transmit power fixed and (2) minimize the total transmit power given a fixed outage requirement. By assuming that the source-destination and the relay-destination channels are with high signal-to-noise power ratios, the approximated closed-form of the outage probability expression is derived in Case 1. It is shown that the power allocation scheme for the proposed Slepian-Wolf relay system can be formulated as a convex optimization problem. In Case 2, the power allocation scheme is also applied for different relay location scenarios.

Keywords: Turbo codes, iterative decoding, relay system, Slepian-Wolf theorem, outage probability, power allocation