Abstract

Cooperative wireless communications are investigated from the perspective of exploiting statistical nature of channel property variation. The target of this research is to provide analytical assessments and theoretical bounds of lossy-forward (LF) relaying based cooperative communications in various network topologies and propagation conditions, where the channel variation information is efficiently utilized.

The performance of three-node LF relaying over independent block Nakagami-m fading channels is investigated. Based on the source coding with a helper theorem, the exact outage probability expression with arbitrary values of the shape factor m is derived. Furthermore, the decay of the outage curve, referred to as equivalent diversity order, and coding gain of LF relaying are identified based on a yet accurate high signal-to-noise ratio (SNR) outage probability approximation. It is found that the decay of the outage curve is dominated by the less reliable channel of either the source-relay or the relay-destination link. It is also found that in terms of the outage probability, LF relaying is superior to conventional decode-and-forward (DF) relaying where relay keeps silent if error is detected after decoding. This is because the relay in LF always forwards the decoder output to the destination via re-interleaving and re-encoding of the information sequence. Therefore, the whole system can be regarded as a distributed turbo code. Moreover, with LF relaying, not only the outage probability can be reduced, but also the search area for a relay (helper) can be increased compared to conventional DF relaying while keeping the same or even lower outage probability, resulting in significant coverage expansion of the system.

The outage probabilities of LF, decode-and-forward (DF) and adaptive decode-and-forward (ADF) relaying are analyzed in block Rayleigh fading channels, with the aim of identifying the impact of the spatial and temporal correlations of the fading variations. It is proven that the coding gain with LF is larger than with DF but smaller than with ADF, where the ADF scheme utilizes error-free feedback from the relay to the source. It is found that compared to the independent fading case, in the correlated fading, to achieve the lowest outage probability, the relay should be located closer to the destination, or more transmit power should be allocated to the relay, both for reducing the gain loss caused by the fading correlation.

A comparative study on the outage probabilities of LF relaying with the two distributions, Rician and Nakagami-m, is conducted. Kullback-Leibler divergence (KLD) and Jensen-Shannon divergence (JSD) are used to identify the difference between the distributions. It is found that even with a specific parameter setting yielding the same line-of-sight (LOS) ratio, Rician is not equivalent to Nakagami-m model for representing the shape of the entire portion of the distribution.

Furthermore, we derive an upper bound of the outage probability for a two-way LF relaying system over Rician fading channels with a random K-factor. The K-factor is assumed to follow empirical distributions, normal or logistic distributions, which are derived from measurement data. Compared to the two-way DF transmission, the two-way LF transmission is found to achieve lower outage probability regardless of either logistic or normal distribution is used to represent the variation of K-factor. Because with LF, the relay always broadcast the decoder output regardless of whether error is detected after decoding in the information part or not.

The work is extended to a multi-source multi-relay transmission system, where all the links experience the κ-μ fading variations. It is found that, regardless of whether the LOS component exists in the channel or not, the outage performance of the system with orthogonal transmission with joint-decoding scheme is superior to that with maximum ratio transmission scheme.

Keywords: Outage probability, relay channels, lossy-forward (LF), line-of-sight (LOS) component, diversity order and coding gain