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PERFORMANCE EVALUATION OF
PHYSICAL LAYER NETWORK CODED
PARALLEL RELAY CHANNELS
OPERATING WITH NON-ORTHOGONAL
MULTIPLE ACCESS

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Abstract

Non-orthogonal multiple access (NOMA) is a promising technique in fifth generation (5G) wireless communication with its ability to transmit superimposed multiple signals in the same time/frequency resources. Power-domain NOMA enables transmitting multiple signals by using power-domain multiplexing, which improves user fairness and facilitates simultaneous multi-signal communications in massive wireless networks. Meanwhile, physical-layer network coding (PNC) is a promising technology in two-way relay channel communications which improves throughput in a higher degree (100% in ideal communication) compared to traditional network coding schemes. PNC uses digital XOR mixing in the relay node and employs a decode-and-forward mechanism to communicate with two end nodes by using only two time-slots to complete one round of communication. Incorporating NOMA and PNC together in parallel relay communication would lead the path to obtain a higher spectral gain. In this study, we focus on analysing the performance of a NOMA-PNC communication scheme by evaluating the exact closed form bit error rate (BER) expressions over Rayleigh channels. The maximum likelihood detection rule is used to identify the decision regions of each received signal space in both up-link and down-link communications. Partial BER expressions are derived for each time-slot transmission, and they are statistically combined to obtain the overall BER. The initial analysis was conducted for binary phase-shift keying (BPSK) modulated information, where it was identified when the modulation order is increased the communication complexity is also being gradually increased with the PNC mapped bit detection at each relay node. Thus, further analysis was conducted with quadrature phase shift-keying (QPSK) modulated information bit transfer, and the closed form BER expressions were derived. The methodology can be further extended to derive closed form BER expressions for higher-order modulation schemes such as M-array phase-shift keying (MPSK) based on the decision boundaries identified on the received bit

constellations. The analytical expressions were validated by the Monte-Carlo simulations and shown to match well with the simulation results.

Moreover, when the number of parallel relay channels is large, interference can seriously hinder the NOMA-based communication. To have a spectral efficient and reliable communication in parallel relay channels, this research further proposes a joint NOMA and beamforming scheme. The key contribution is the use of beamforming pre-coding to mitigate cross interference between individual relay based communications. However, NOMA is also used in inter-cluster communication to provide multiple access, which reduces the number of antennas required at the base-station. The proposed multi-channel communication scheme is tested for throughput using parallel relay channels with NOMA only.