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Optimization of a robust collaborative-relay beamforming design for simultaneous wireless information and power transfer

Key words: Simultaneous wireless information and power transfer; Channel state information; Robust beamforming; Semidefinite relaxation; Iterative sub-gradient

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Motivations

1. Simultaneous wireless information and power transfer (SWIPT), which is an energy harvesting (EH) technique, is a promising approach to increase the working hours of energy-constrained terminals in wireless communication networks.

2. In practical scenarios, channel state information (CSI) is usually affected by the quantization and feedback errors. Therefore, CSI errors are usually inevitable.

3. The performance of a beamforming design based on the assumption of perfect CSI will be degraded in the presence of CSI errors.

Main ideas

1. The main aim of this study is to improve the performance of a collaborative-relay beamforming design under an imperfect CSI case by using worst-case performance optimization.

2. The objective of a collaborative-relay beamforming design for SWIPT is to maximize the achievable information rate subject to harvested power requirements and peak transmit power constraints at each relay node.

3. In a robust beamforming design, both the worst-case achievable information rate and worst-case harvested power requirements are considered.

Methods

1. By applying the bisection method and the semidefinite relaxation (SDR) technique, the non-convex optimization problems of both non-robust and robust beamforming designs can be solved.

2. Moreover, the solution returned by the SDR technique may not always be rank-one; thus, an iterative sub-gradient (ISG) method is presented to obtain the rank-one solution.

Major results

1. Feasibility rates

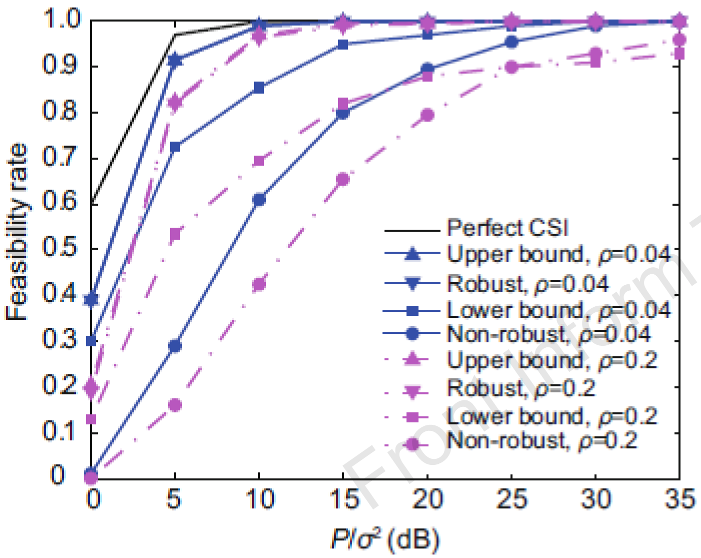

Fig. 2 **Feasibility rates versus P/σ^2 for $Q/\sigma^2 = 10$ dB, $N = 4$, and $\rho = 0.04, 0.2$**

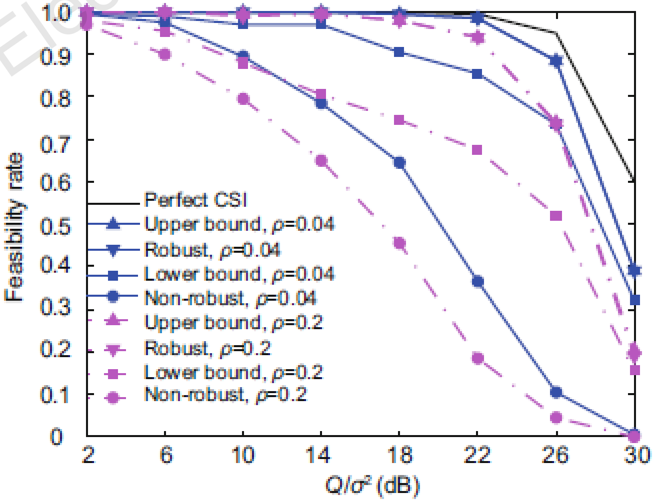

Fig. 3 **Feasibility rates versus Q/σ^2 for $P/\sigma^2 = 20$ dB, $N = 4$, and $\rho = 0.04, 0.2$**

Major results

1. Feasibility rates

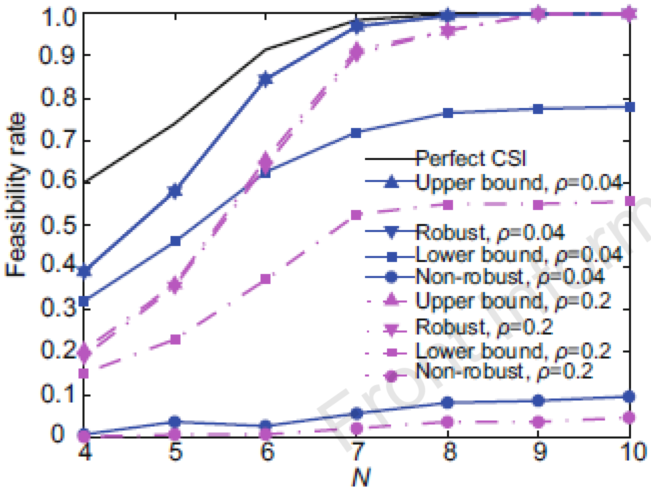

Fig. 4 Feasibility rates versus N for P/σ^2=10 dB, Q/σ^2=20 dB, and ρ=0.04, 0.2

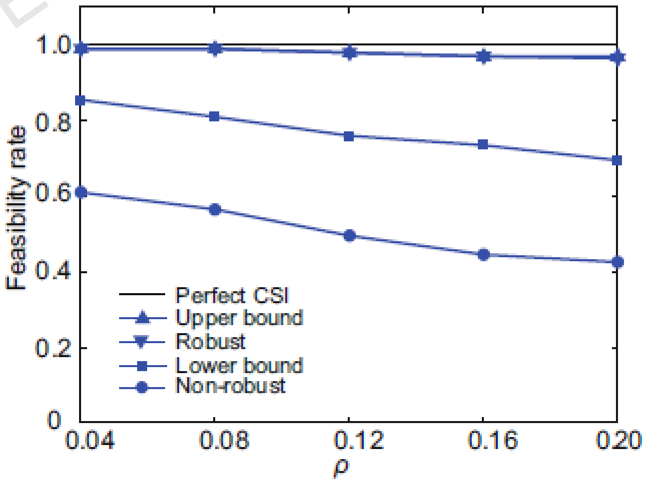

Fig. 5 Feasibility rates versus ρ for P/σ^2 = 10 dB, Q/σ^2 = 10 dB, and N = 4

Major results

2. Rank-one solution proportion

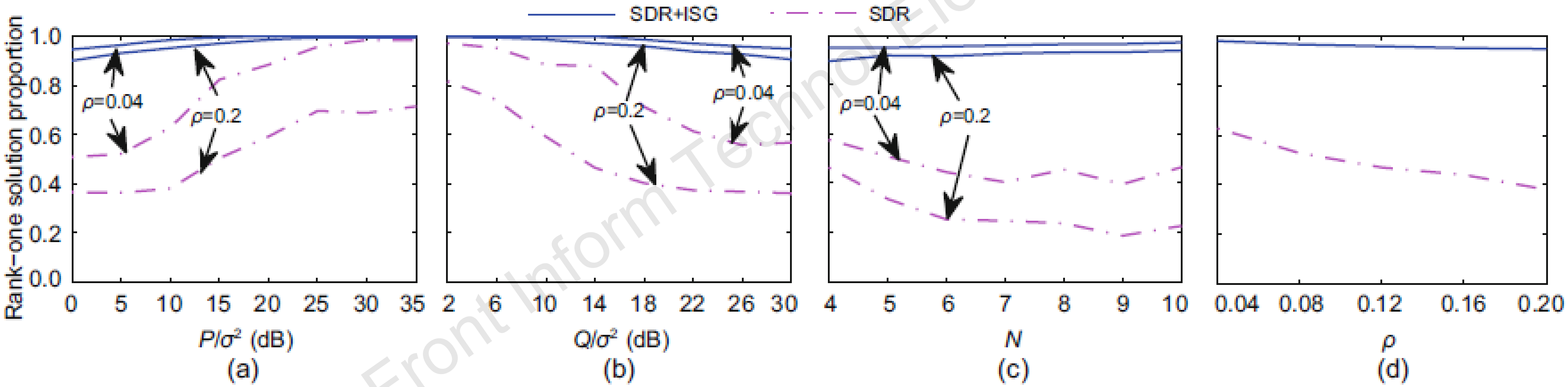

Fig. 6 Rank-one solution proportion: (a) P/σ^2 with $Q/\sigma^2 = 10$ dB, $N = 4$, and $\rho = 0.04, 0.2$; (b) Q/σ^2 with $P/\sigma^2 = 20$ dB, $N = 4$, and $\rho = 0.04, 0.2$; (c) N with $P/\sigma^2 = 10$ dB, $Q/\sigma^2 = 20$ dB, and $\rho = 0.04, 0.2$; (d) ρ with $P/\sigma^2 = 10$ dB, $Q/\sigma^2 = 10$ dB, and $N = 4$

Major results

3. Average worst-case achievable information rate

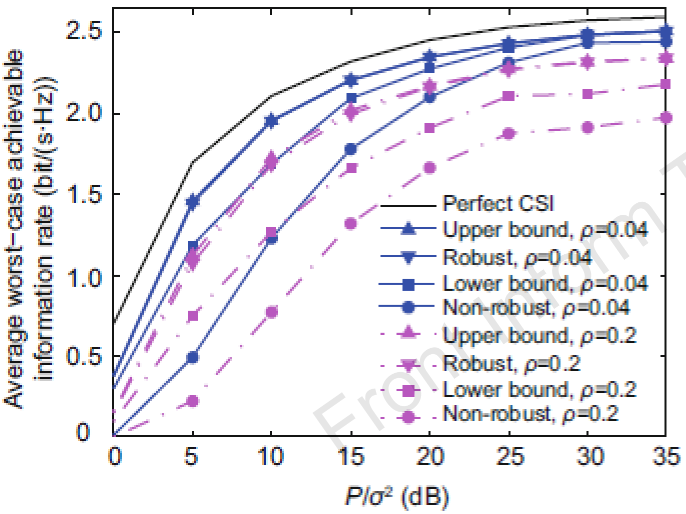

Fig. 7 Average worst-case achievable information rate versus P/σ^2 for $Q/\sigma^2 = 10$ dB, $N = 4$, and $\rho = 0.04$, 0.2

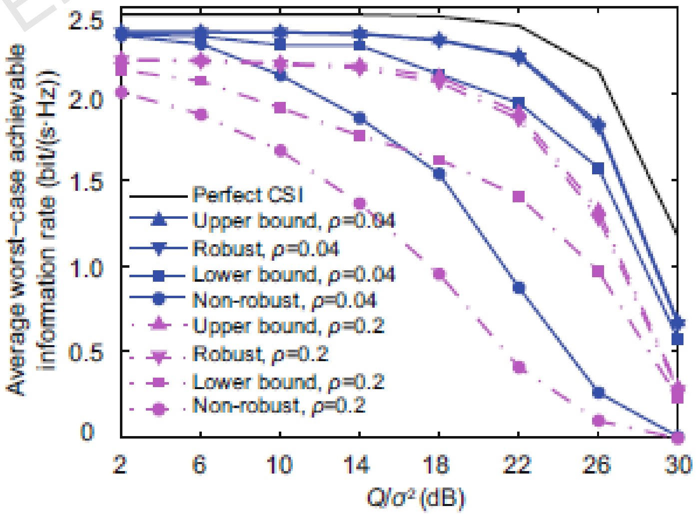

Fig. 8 Average worst-case achievable information rate versus Q/σ^2 for $P/\sigma^2 = 20$ dB, $N = 4$, and $\rho = 0.04$, 0.2

Major results

4. Average worst-case achievable information rate

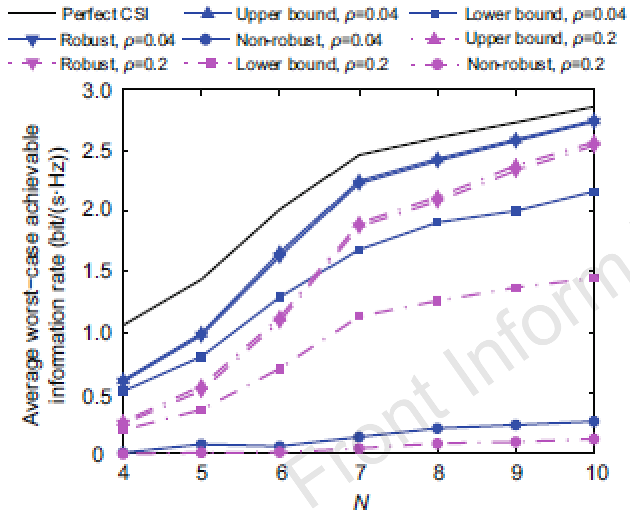

Fig. 9 Average worst-case achievable information rate versus N for $P/\sigma^2 = 10$ dB, $Q/\sigma^2 = 20$ dB, and $\rho = 0.04, 0.2$

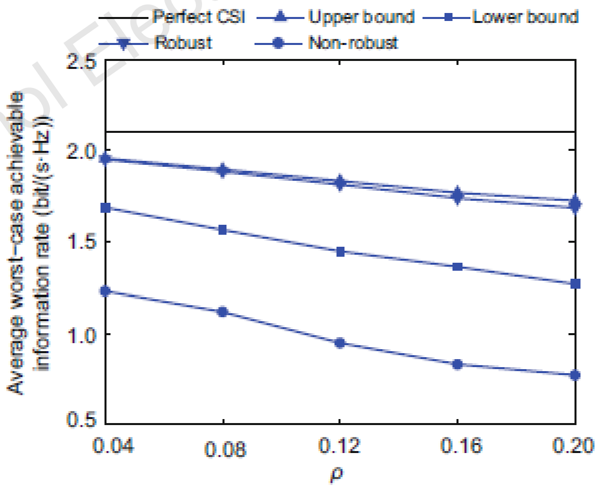

Fig. 10 Average worst-case achievable information rate versus ρ for $P/\sigma^2 = 10$ dB, $Q/\sigma^2 = 10$ dB, and $N = 4$

Conclusions

1. The non-convex optimization problems of the proposed beamforming designs can be solved by the bisection method and SDR technique.

2. When the solution returned through the SDR technique is not rank-one, the proposed ISG method can almost always obtain the rank-one solution.

3. Under an imperfect CSI case, the proposed robust beamforming design can obtain a better performance than the non-robust one.