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# Max-min rate optimization for multi-user MISO-OFDM systems assisted by RIS with a wideband model

**Key words:** Reconfigurable intelligent surface; Max-min rate; Coalition-game subcarrier allocation

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# Motivation

1. Reconfigurable intelligent surfaces (RISs) have the capability to change the wireless environment smartly. Each RIS element has different response characteristics corresponding to the incident signal of varying frequencies due to the limitation of hardware circuit. The design of such practical RIS models is often complex.

2. RIS's flexible control of the wireless channel environment makes it better to deal with the problem of interference suppression. The rate requirements of users can be effectively guaranteed in RIS assisted communication. Therefore, we have some interest in the research on the role of RIS in user fairness.

# Main idea

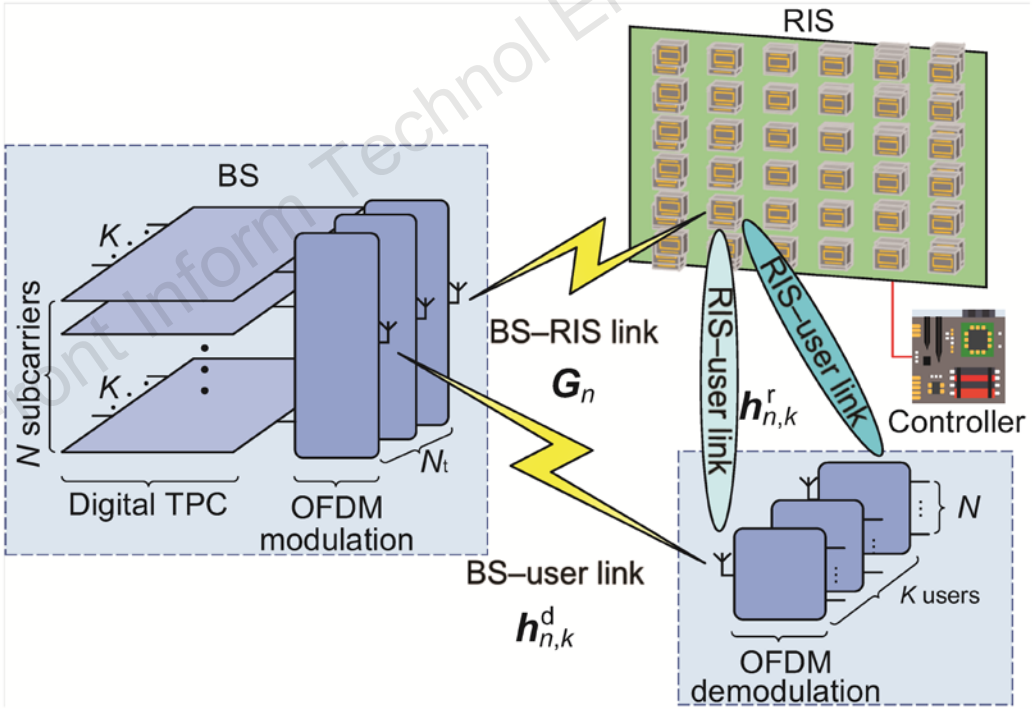
1. We study the joint design of transmit precoding (TPC) matrices and RIS passive beamforming with subcarrier allocation to maximize the minimum rate of dense users with an approximate practical RIS model.

2. We propose a coalition-game algorithm (CSA) to allocate subcarriers for dense users, which can decouple subcarrier allocation from other optimized variables.

3. We design TPC matrices and RIS passive beamforming based on the fractional programming (FP) method. The overall problem is transformed into several subproblems, which can be solved by alternate optimization (AO) to obtain a locally optimal solution.

# System model

Considering user fairness, we focus on the problem of maximizing the minimum rate of dense users for multi-user (MU) MISO-OFDM downlink communication assisted by RIS with an approximate practical model.




A RIS-aided MU-MISO-OFDM downlink communication system

# Method

1. Subcarrier allocation based on a coalition-game

$$c_{n,k} = \begin{cases} 1, \text{ for } k \in \mathcal{S}_n, \\ 0, \text{ otherwise.} \end{cases} \qquad u(\mathcal{S}_n) = \sum_{k \in \mathcal{S}_n} \|\mathbf{h}_k \mathbf{T}_k\|_2^2,$$

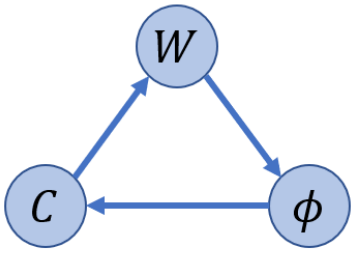
2. TPC matrice design

$$\begin{aligned} \max_{\boldsymbol{W}, R} \quad & R \\ \text{s.t.} \quad & R_k^w(\boldsymbol{w}_k) \geq R, \quad \forall k \in \mathcal{K}, \\ & \sum_{n=1}^{N} \sum_{k=1}^{K} c_{n,k} \|\boldsymbol{w}_{n,k}\|_2^2 \leq P, \end{aligned}$$

3. Passive RIS design

$$\begin{aligned} \text{find } & \boldsymbol{\phi} \\ \text{s.t. } & R_k^{\phi}(\boldsymbol{\phi}) \geq R, \qquad \forall k \in \mathcal{K}, \\ & \phi_{n,m} = g(\theta_m, f_n), \forall n \in \mathcal{N}, \forall m \in \mathcal{M}. \end{aligned}$$

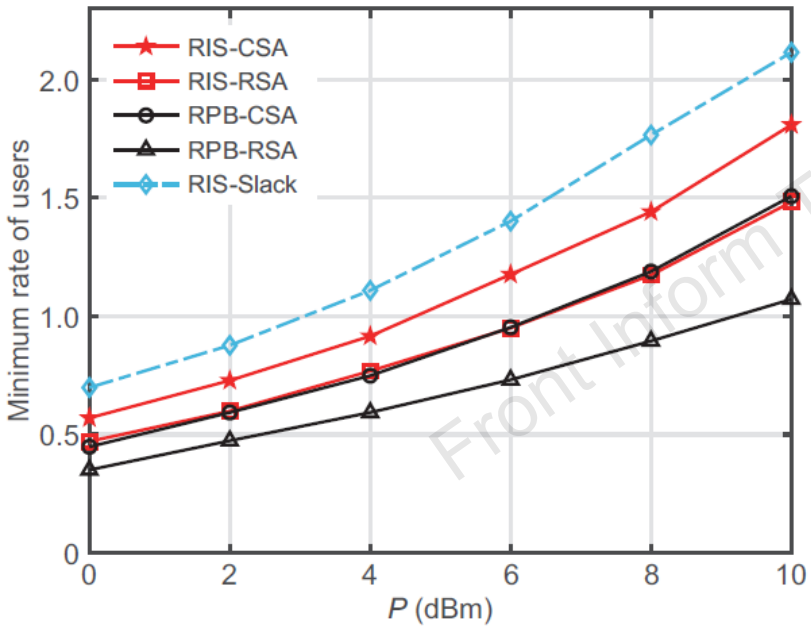




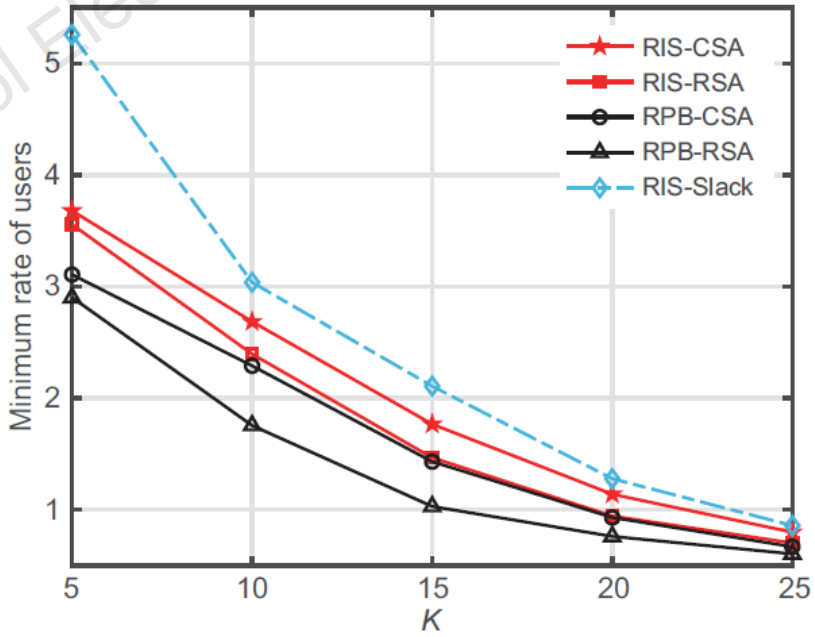

To address the challenges that RIS passive beamforming needs to accommodate the fairness of dense users at all subcarriers and subcarrier allocation, we propose a novel AO framework.

# Major results

The max-min rate of our proposed RIS-CSA method approaches the upper bound (RIS-Slack) closely.




Minimum rate of users versus $P$




Minimum rate of users versus $K$

# Conclusions

1. The spatial degrees of freedom in the system were improved by optimizing RIS passive beamforming. This indicated that deploying RIS simultaneously improves the spectral efficiency for all subcarriers while considering user fairness.

2. The hybrid iterative AO method including CSA and RIS design provides a potential solution for max-min rate enhancement in the MU-MISO-OFDM system.

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