Maximization of the Sum of energy-Efficiency for Type-I HARQ under the Rician channel

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Problem Statement

Multiuser power and bandwidth allocation in an OFDMA system using type-I HARQ and practical MCS is performed under the Rician channel. Only statistical CSI is available. We maximize the sum of the users' energy efficiency under minimum goodput constraint.

I - System Model

Network model:

- **Device-to-device communications**: statistical CSI
- **OFDMA**: no interference
- **Type-I HARQ**: improve reliability
- **Practical MCS**: data rate = goodput

Channel model:

- Independent Gaussian channel taps:
  - $\Rightarrow$ I.d. fading process in the frequency domain
- OFDM + Frequency Hopping
  - $\Rightarrow$ Fast-fading channel
- First tap: possibly non zero mean (LoS component)
  - $\Rightarrow$ Rician channel

Remarks:

- Rician channel versatile
  - $\Rightarrow$ Rayleigh and Gaussian as special cases
- Many applications
  - $\Rightarrow$ mmWave, indoor and outdoor channels

Resource to allocate:

- Transmit power E_ℓ
- Bandwidth proportion γ_ℓ

II - Optimization Problem and Results

Optimization Problem:

$$\max_{(\gamma,E)} \sum_{\ell=1}^{L} \mathcal{E}_\ell \text{ subject to } \begin{cases} \eta_\ell(\gamma_\ell, E_\ell) \geq \eta_\ell^{(0)}, & \forall \ell \\ \sum_{\ell=1}^{L} \gamma_\ell \leq 1, & \\ \gamma_\ell \geq 0, E_\ell \geq 0, & \forall \ell \end{cases}$$

where:

$$\mathcal{E}_\ell := \frac{1 - q_\ell(E_\ell)}{A_\ell E_\ell + C_\ell \gamma_\ell^{-1}} \quad \text{and} \quad \eta_\ell = \gamma_\ell(1 - q_\ell(E_\ell))$$

with q_ℓ the packet error rate, A_ℓ and C_ℓ depends on circuitry power and power amplifier efficiency.

Assumptions on q_ℓ:

- Strictly decreasing and strictly convex function of the SNR
- $\lim_{x\to\infty} q_\ell(x) = 0$ and $\lim_{x\to\infty} q'_\ell(x) = 0$

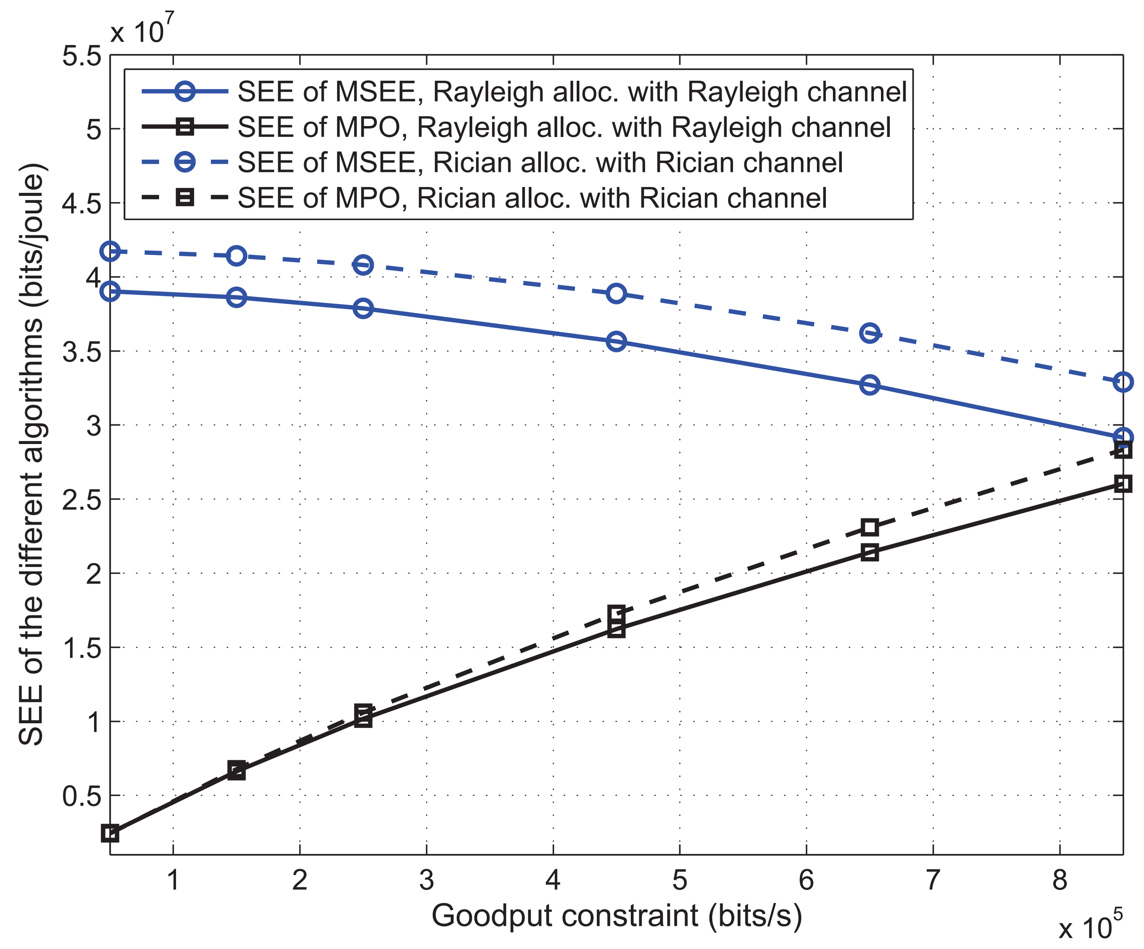
Solution procedure:

- Optimization problem property
  - $\Rightarrow$ Maximizing sum of concave/convex functions
- Optimal solution: Jong's algorithm (iterative)
  - $\Rightarrow$ Iterations: solve a concave maximization problem

Main contribution:

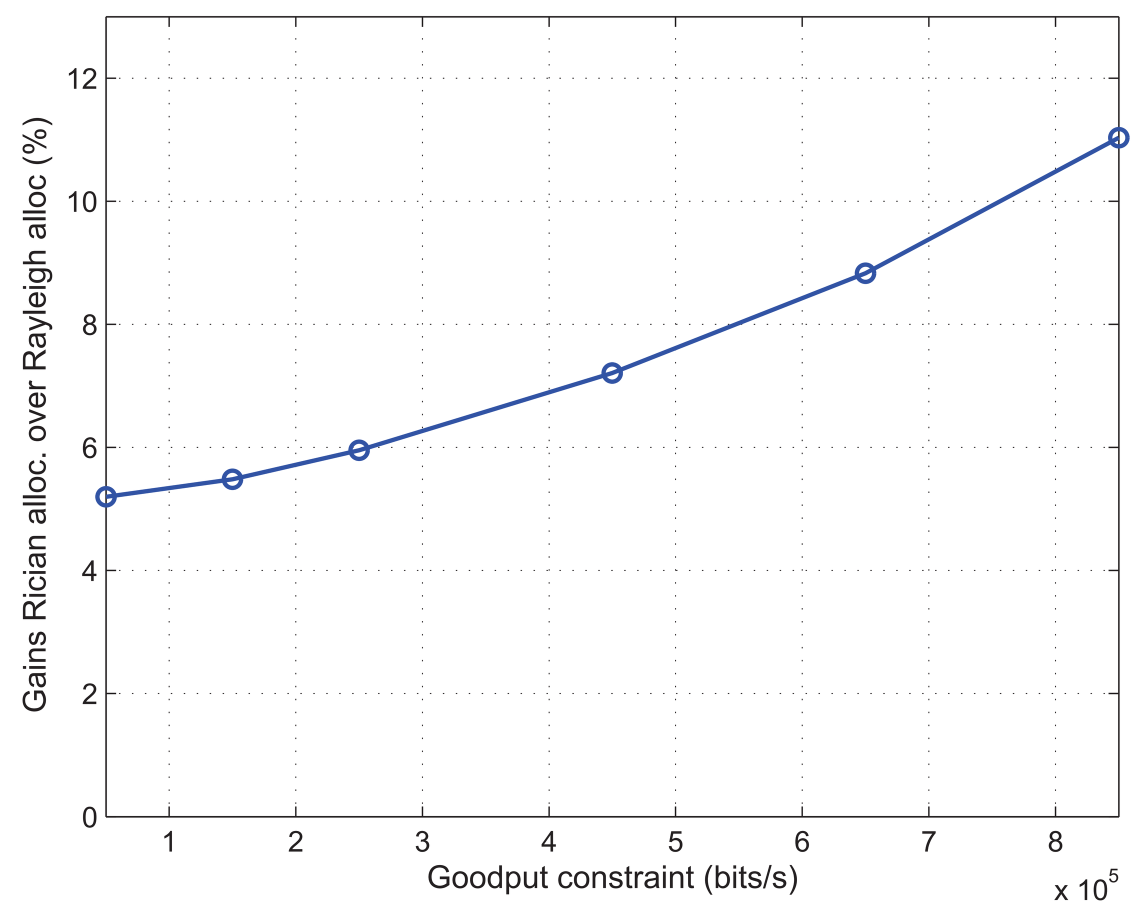
- **Optimal solution of concave maximization problem using KKT conditions**: $E_\ell(x)^* = f_\ell(\lambda^*)$, $\gamma_\ell(x)^* = g_\ell(\lambda^*)$

III - SEE vs $\eta_\ell^{(0)}$



- Proposed algorithm yields much higher SEE than MPO
- SEE under Rician channel higher than under Rayleigh one

IV - Gains Rician alloc./Rayleigh alloc. vs $\eta_\ell^{(0)}$



SEE gains increases with η_ℓ^0

$\Rightarrow$ For $\eta_\ell^{(0)} = 8.5$ bits/s, possible to transmit 19% more bits for same energy

V - Conclusion

Optimal solution to maximize the sum of the users EE under the Rician channel. Outperforms existing algorithms.