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Energy-Efficient Power Allocation for NOMA With Imperfect CSI

Contributions

- Power allocation problem formulated for energy efficiency maximization in NOMA systems with imperfect CSIT
- A low complexity sub-optimal iterative solution is proposed (with polynomial time complexity)

System Model

- A downlink SISO system with a BS serving M users in the same RB
- Channel gain $h_k = g_k d_k^{-\delta/2},\ g_k \sim \mathcal{CN}(0,1)$
- MMSE estimates $\hat{h}_k$ known at the BS with error $\epsilon = h_k - \hat{h}_k$
- BS transmits $x = \sum_{k=1}^{M} \sqrt{\alpha_k P} s_k$

- Received signal
  $y_k = \hat{h}_k\sqrt{\alpha_k P}s_k + \sum_{i\neq k}\hat{h}_i\sqrt{\alpha_i P}s_i + \epsilon\sum_i\sqrt{\alpha_i P}s_i + n_k$
- With SIC, rate is $R_k = \log_2\left(1 + \frac{P|\hat{h}_k|^2\alpha_k}{P|\hat{h}_k|^2\sum_{i=k+1}^{M}\alpha_i + P\sigma_\epsilon^2\sum_{i=1}^{M}\alpha_i + \sigma^2}\right)$
- Energy efficiency maximization:

$$\max_{\theta,\alpha_k,1\leq k\leq M}\left(\sum_{k=1}^{M} R_k\right)/(\theta P + P_c)$$

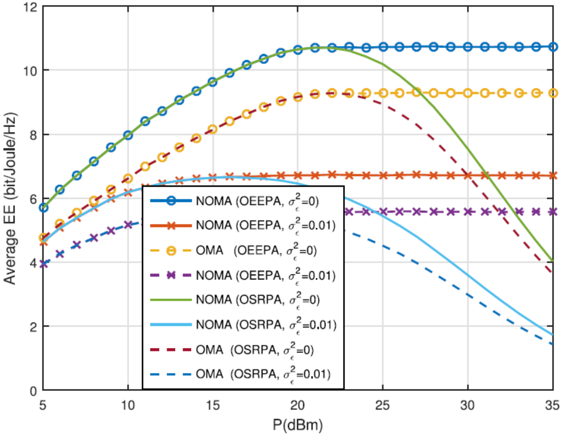
$$s.t. \sum_{k=1}^{M}\alpha_k = \theta$$

$$R_k \geq R_k^{min}$$

$$P \geq \theta P \geq P^{min}$$

Solution & Results

- Stage 1: Keep θ constant and optimize to get α_k in closed form solution. KKT conditions are sufficient.
- Stage 2: Solve for θ and perform power allocation by an iterative algorithm based on DC-programming.



$R_k^{min} = 1$ bit/sec/Hz, $\quad m = 4$ users.

Optimal Inter-Constellation Rotation Based on Minimum Distance Criterion for Uplink NOMA

Contributions

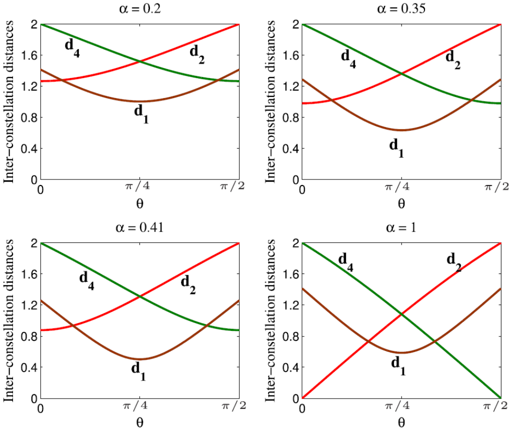
- Closed form expression for optimal rotation angle for uplink NOMA system obtained
- SNR independent minimum distance criterion shown to be more robust and fair than SNR dependent mutual information criterion

System Model

- For a GMAC with equal power transmission, it has been proved that CCC or MI can be increased by rotation of input constellations
- This is dependent on SNR as well as modulation schemes
- Received signal $y_l = h_s\sqrt{(2-\alpha)P}s_l + h_w\sqrt{\alpha P}e^{i\theta}w_l + z_l$
- Knowing the channels, θ can be adjusted $\Rightarrow h = h_s = h_w$

- CCC/MI: $\theta^*_{MI}(\alpha) = \arg\max_{\theta} I\left(\sqrt{(2-\alpha)P}s_I + \sqrt{\alpha P}e^{i\theta}w_I; y_I\right)$

  $\Rightarrow \theta^*_{MI}(\alpha) = \arg\max_{\theta} I\left(\sqrt{\alpha P}e^{i\theta}w_I; y_I\right)$



- Minimum Distance: $\theta^*_{MD}(\alpha) = \arg\max_{\theta} d_{\min}(\theta, \alpha)$

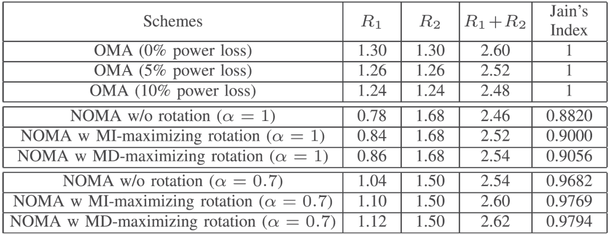
- For joint QPSK constellation, $\theta^*_{MD}(\alpha) = \cos^{-1}\left(\frac{\alpha}{\sqrt{4\alpha(2-\alpha)}}\right)$

  $d^*_s = \sqrt{P(4 - 2\sqrt{8\alpha - 5\alpha^2})}$,

  $d^*_w = \sqrt{2P\alpha}$

- For general constellations $s_l \in \mathcal{M}, w_l \in \mathcal{N}$, group rotation distance defined and it's properties proved
- $D_\theta(a_1, a_2|\mathcal{N}) = \min_{b_1, b_2 \in \mathcal{N}} \|(a_1 - a_2) + (b_1 - b_2)e^{i\theta}\|, \; a_1, a_2 \in \mathcal{M}$
- $D_\theta(a_1, a_2|\mathcal{N})$ is symmetric, translation invariant and only a function of $(a_1 - a_2)e^{-i\theta}$

- $D_\theta(a_1, a_2|\mathcal{N})$ is used to find the optimal d_{min} and hence the optimal θ
- Closed form expressions obtained which are independent of SNRs



Schemes	R_1	R_2	R_1+R_2	Jain's Index
OMA (0% power loss)	1.30	1.30	2.60	1
OMA (5% power loss)	1.26	1.26	2.52	1
OMA (10% power loss)	1.24	1.24	2.48	1
NOMA w/o rotation ($\alpha = 1$)	0.78	1.68	2.46	0.8820
NOMA w MI-maximizing rotation ($\alpha = 1$)	0.84	1.68	2.52	0.9000
NOMA w MD-maximizing rotation ($\alpha = 1$)	0.86	1.68	2.54	0.9056
NOMA w/o rotation ($\alpha = 0.7$)	1.04	1.50	2.54	0.9682
NOMA w MI-maximizing rotation ($\alpha = 0.7$)	1.10	1.50	2.60	0.9769
NOMA w MD-maximizing rotation ($\alpha = 0.7$)	1.12	1.50	2.62	0.9794

Joint Antenna Selection and Analog Precoder Design With Low-Resolution Phase Shifters

Contributions

- Joint antenna selection and analog beamformer design algorithm
- Algorithm has low complexity and maximizes spectral efficiency

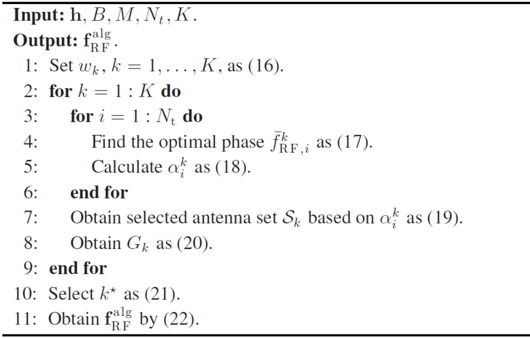
System Model

- Narrow band millimeter wave downlink channel with N_t antennas at the BS
- UEs are single antenna users
- M low-resolution B bit quantized phase shifters are present at the BS
- Goal is to find best set of M antennas jointly with the design of a precoder

- Received signal: $y = \sqrt{P}\mathbf{h}^H \mathbf{f}_{RF} s + n$, $n \sim \mathcal{CN}(0, \sigma^2)$
- Millimeter wave channel $\mathbf{h} = \sum_{l=1}^{L} \alpha_l \mathbf{a}_t(\theta_l)$ known at the BS
- Achievable rate: $R = \log_2\left(\left|1 + \frac{P}{\sigma^2}\mathbf{f}_{RF}^H \mathbf{h}\mathbf{h}^H \mathbf{f}_{RF}\right|\right)$
- Possible entries: $\mathcal{F} = \left\{\frac{1}{\sqrt{M}} \exp\left(\frac{j2\pi b}{2^B}\right) | b = 0, 1, \ldots, 2^B - 1\right\}$
- Precoder design:

$$\begin{aligned} \mathbf{f}_{RF}^* = & \arg\max \left|\mathbf{h}^H \mathbf{f}_{RF}\right|^2 \\ s.t. \;\; & \mathbf{f}_{RF} \in \{\mathcal{F}, 0\}^{N_t} \\ & \|\mathbf{f}_{RF}\|_0 = M \end{aligned}$$

- Divide range $\left[0, \frac{2\pi}{2^B}\right]$ into K sectors and obtain optimal phase which gives highest gain $h_i^* f_i$ for each antenna
- Order $\alpha_i^k = h_i^* \overline{f}_{RF,i}^k$ and select M largest ones
- Do for each k and choose the one with the highest objective G_k



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Input: $\mathbf{h}, B, M, N_t, K$.
Output: $\mathbf{f}_{\mathrm{RF}}^{\mathrm{alg}}$.
Set $w_k$, $k = 1, \ldots, K$, as (16).
for $k = 1 : K$ do
    for $i = 1 : N_\mathrm{t}$ do
        Find the optimal phase $\bar{f}_{\mathrm{RF},i}^k$ as (17).
        Calculate $\alpha_i^k$ as (18).
    end for
    Obtain selected antenna set $\mathcal{S}_k$ based on $\alpha_i^k$ as (19).
    Obtain $G_k$ as (20).
end for
Select $k^\star$ as (21).
Obtain $\mathbf{f}_{\mathrm{RF}}^{\mathrm{alg}}$ by (22).
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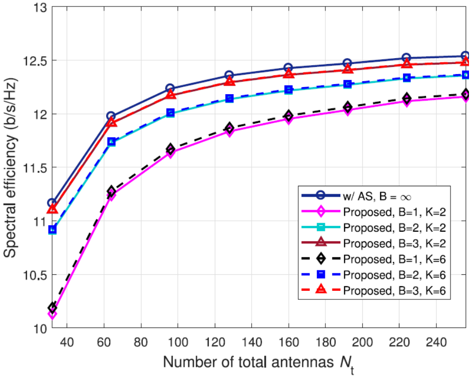
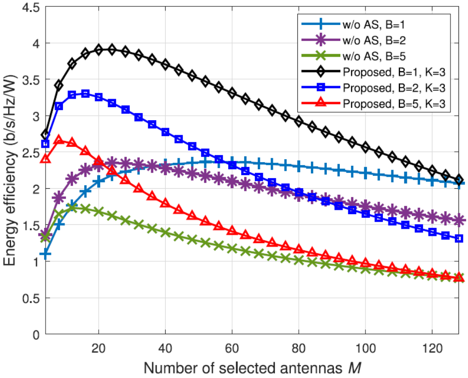

Spectral efficiency (b/s/Hz)
13
12.5
12
11.5
11
10.5
10
40
60
80
100
120
140
160
180
200
220
240
Number of total antennas N_t
w/ AS, B = ∞
Proposed, B=1, K=2
Proposed, B=2, K=2
Proposed, B=3, K=2
Proposed, B=1, K=6
Proposed, B=2, K=6
Proposed, B=3, K=6


Energy efficiency (b/s/Hz/W)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
20
40
60
80
100
120
Number of selected antennas M
w/o AS, B=1
w/o AS, B=2
w/o AS, B=5
Proposed, B=1, K=3
Proposed, B=2, K=3
Proposed, B=5, K=3

Other Interesting Papers

1. Prediction of Time-Varying Multi-User MIMO Channels Based on DOA Estimation Using Compressed Sensing
2. Joint Antenna Selection and User Scheduling for Massive Multiuser MIMO Systems With Low-Resolution ADCs
3. Low Complexity Hybrid Precoding for Multiuser Millimeter Wave Systems Over Frequency Selective Channels
4. Energy-Efficient Resource Allocation for Energy Harvesting-Based Device-to-Device Communication
5. Deep Learning-Inspired Message Passing Algorithm for Efficient Resource Allocation in Cognitive Radio Networks
6. Minimum Error Entropy Criterion Based Channel Estimation for Massive-MIMO in VLC