Joint Iterative Beamforming and Channel Allocation for Multiple Antenna Ad Hoc Networks

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Introduction:

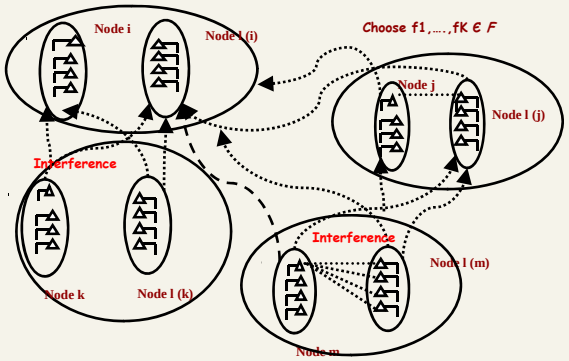
Objective:

In an ad hoc networks with no centralized controllers,

- Choose the best of K available channels,
- Use beamforming on M antennas,

in order to

- Maximize received SINR on every link,
- Constant transmit power on every link.



Non-cooperative beamforming and channel selection

- User strategies:
- MAC layer → channel selection
- PHY layer → spatial beamforming
- Can the users make their minds up or will they keep arguing? **Will the game converge?**

System Model and Concepts:

- Every node has M antennas and a unit-norm receive/ transmit beamformer pair (wi, gi) .
- K orthogonal channels $f_1, f_2, \ldots\ldots, f_K$ to choose from.
- Nodes on the same frequency interfere.

The resulting SINR at node l(i) is:

$$\Gamma_{l(i)} = \frac{P_i \mid w_{l(i)}^H H_{l(i),i} g_i \mid^2}{\sum_{m \neq i, l(i)} P_m \mid w_{l(i)}^H H_{l(i),m} g_m \mid^2 I(f_m, f_i) + 1}$$

$$\| g_i \|^2 = 1 \qquad \| w_i \|^2 = 1 \qquad I(f_m, f_i) = \begin{cases} 1 & same \quad freq. \\ 0 & diff \quad freq. \end{cases}$$

- Objective function:

Minimize $-\Gamma_{l(i)}$ subject to $\sum_{i=1}^{N} \| \sqrt{P_i}\, g_i \|^2 = C'$

- The corresponding Lagrangian is:

$$L(g) = -\sum_{i=1}^{N} P_i g_i^H H_{l(i),i}^H R_{l(i)}^{-1} H_{l(i),i} g_i + \sum_{i=1}^{N} \lambda_i \left(\| \sqrt{P_i} g_i \|^2 - C' \right)$$

$$R_{l(i)} = \sum_{m \neq i, l(i)} P_m H_{l(i),m} g_m g_m^H H_{l(i),m}^H I(m, l(i)) + I$$

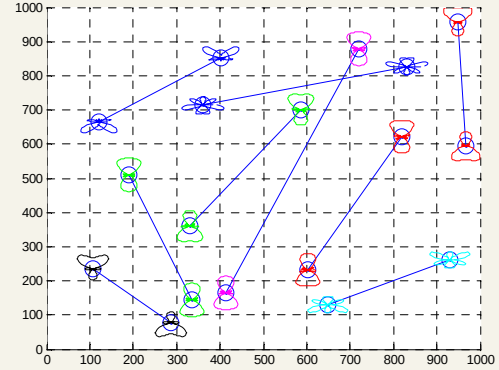
- The optimal transmit beamformer is:

$$g_i = \arg\max_g \frac{g^H H_{l(i),i}^H R_{l(i)}^{-1} H_{l(i),i} g}{g^H R_i^* g}$$

- The greedy transmit beamformer is:

$$g_i = \arg\max_g g^H H_{l(i),i}^H R_{l(i)}^{-1} H_{l(i),i} g$$

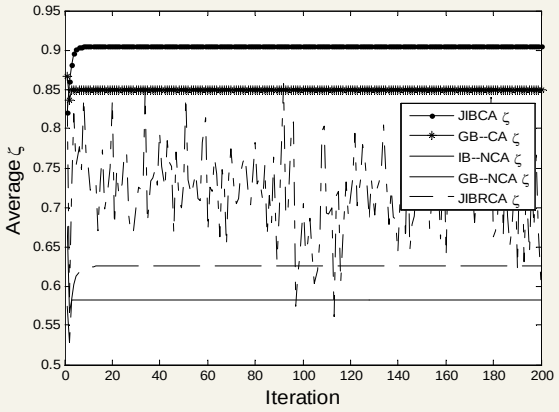
Scenario:



SINR efficiency

$$\zeta_{l(i)}^n = \frac{\Gamma_{l(i)}^n}{\Gamma_{l(i)}^{su}} = \frac{\Gamma_{l(i)}^n}{P_i \lambda_{\max}\left(H_{l(i),i}^H H_{l(i),i} \right)}$$

Simulation Comparisons:



JIBCA: Joint Iterative Beamforming and Channel Allocation

GB-CA: Greedy beamforming and Channel Allocation

JIBRCA: Joint Iterative Beamforming and Random Channel Allocation