Optimal Resource Allocation in Downlink of a two cell OFDMA network

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Background

- resource allocation in OFDMA
  - subcarriers
  - power
- resource allocation in a single cell
  - disjoint resource allocation
  - joint resource allocation [Seong:06]
- multi cell networks
  - inter cell interference limits independent resource allocation
    - fixed frequency reuse
    - Random frequency reuse [Kiani:06]
- we propose joint resource allocation in the network
$K_1$ users in cellA and $K_2$ users in cellB

$N$ subcarriers in each cell

$p_{kn}^{(1)}, p_{jn}^{(2)}$ are powers allocated to user $k$ in cellA and to user $j$ in cellB respectively
Network Model (2)

- $h_{kn}^{(11)}, h_{jn}^{(22)}$ are direct channel gain in cellA and cellB respectively.
- $h_{kn}^{(21)}, h_{jn}^{(12)}$ are interference channel gains in cellA and cellB respectively.
- $r_{kn}^{(1)}, r_{jn}^{(2)}$ are rates of user $k$ in cellA and user $j$ in cellB respectively.
Problem formulation

- **Objective:** Maximise sum rate of two cells with power constraints.
  \[
  \max \sum_{n=1}^{N} \left( \sum_{k=1}^{K_1} r_{kn}^{(1)} + \sum_{j=1}^{K_2} r_{jn}^{(2)} \right)
  \]

- **Subject to**
  - OFDMA constraints: Each subcarrier is allocated to a single user in a cell \( p_{in}^{(1)} p_{jn}^{(1)} = 0 \forall i \neq j \) and also \( p_{in}^{(2)} p_{jn}^{(2)} = 0 \)
  - Total power constraints
    - power allocated in cell A is less than the \( P_{tot} \)
    - power allocated in cell B is less than the \( P_{tot} \)
Application of Lagrange dual theory

- **Primal objective function**
  \[
  \max \sum_{n=1}^{N} \left( \sum_{k=1}^{K_1} r_{kn}^{(1)} + \sum_{j=1}^{K_2} r_{jn}^{(2)} \right)
  \]

- **Constraints**
  - Each subcarrier in a cell should be used by a single user
  - Total power allocated in each cell is less than the \( P_{\text{tot}} \)

- Construct the Lagrangian with Lagrange multipliers
- Dual objective is unconstrained maximum of the Lagrangian is \( g(\alpha_1, \alpha_2) \)
- Minimise Dual objective \( g(\alpha_1, \alpha_2) \) and \( \alpha_1 > 0, \alpha_2 > 0 \)
Algorithm

- Initialise $\alpha_1, \alpha_2$ to large value.
- while ((power consumed in cell1 < total power) and (power consumed in cell2 < total power))
  - For all the subcarriers
    - Choose the best user combination among of $K_1 * K_2$
  - end
- Minimise dual objective $g(\alpha_1, \alpha_2)$ with gradient search method.
Simulation setting

- Frequency non selective Rayleigh fading
- \( K1=2; K2=2; N=8 \)
- Standard deviation of channel coefficients: \( h11=1; h22=1; h12=0.1; h21=0.1 \)
Profile of the lagrangian for a subcarrier

Shape of the lagrangian for a tone in high interference condition

Shape of the lagrangian for a tone in low interference condition
Comparison of power allocation for different schemes for N=8 and N=16

Figure: Comparison of power allocation for different schemes for N=8 and N=16
Numerical Results (3)

Figure: Comparison of sum rate for different schemes for N=8 and N=16
Figure: Comparison of sum rate for different schemes in a pathloss model
Conclusions

- Proposed scheme shows significant gains compared to fixed frequency reuse
- Soft frequency reuse
- Distributed schemes should be explored
