Adaptive CDMA Cell Sectorization with Linear Multiuser Detection

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MOTIVATION

- Conventional sectorization (equal angular region) may not perform well especially in nonuniform terminal distribution.
- Adaptive sectorization in response to terminal locations in conjunction with linear multiuser detection can improve uplink CDMA capacity

System Model

- We consider a synchronous uplink CDMA system with K users and processing gain G .
- The cell is sectorized to N sectors
- Perfect directional antenna, i.e., no intersector interference is assumed

Problem Statement

- Assuming base station is employing linear multiuser detections, we minimize the total uplink transmit power, while each user satisfies minimum quality of service (SIR) at the base station
- We formulate the total transmit power optimization problem as a function of the sectorization arrangement, the transmit power levels, and the receiver filters at the base station.

$$\min_{\theta,p} \sum_{k=1}^{N} \sum_{i\in g_k(\theta)} p_i \qquad (1)$$

$$\text{s.t.} \quad \gamma_i = \frac{p_i h_i (c_i^T s_i)^2}{\sum_{j\neq i, j\in g_k(\theta)} p_j h_j (c_i^T s_j)^2 + \sigma^2 (c_i^T c_i)^2} \geq \gamma^* \qquad (2)$$

p_i	transmit power for user i
h_i	channel gain
γ_i	Signal to noise ratio (SIR)
c_i	Receiver filter
s_i	signature
γ^*	target SIR
σ^2	Noise power
$g_k(\theta)$	Set of users that resides in sector k

Note: minimum total power is achieved when (2) is satisfied with equality.

We can show that, **when the squared cross correlations are equal**, minimum power is achieved at equal received power in a sector, Then, (1) is expressed as

$$\min_{\theta,p} \sum_{k=1}^{N} q_k^* \sum_{i\in g_k(\theta)} \frac{1}{h_i} \qquad (3)$$

which can be transformed into a graph partitioning problem and solved by a shortest path algorithm.
We consider two such cases (equal cross correlation):

Case I Random-sequences (large system analysis)

Case II M-sequences

Parameters for Numerical Results

sectors: N=6

Noise power: $\sigma^2 = 10^{-13}$

target SIR: $\gamma^* = 5$

K=60 users, processing gain G=64 (Case I)

K=36 users, processing gain G=7 (Case II)

Numerical Results

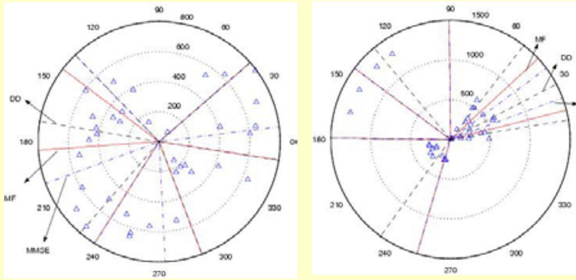
Optimum Transmit Power [WATTS] with Random-sequences

User Distribution	Uniform	Non uniform
MF	11.46	17.02
DD	4.04	9.70
MMSE	3.92	9.62

Optimum Transmit Power [WATTS] with M-sequences

User Distribution	Uniform	Non uniform
MF	3.20	6.03
DD	2.18	5.06
MMSE	1.89	4.80

Note: MF(Matched Filter), DD(Decorrelator), MMSE(MMSE Detecotr)



(a) (b)

Sector boundary of uniform distribution (a), non uniform distribution (b) with M-sequences

Conclusion

- MMSE detector has 65% (nonuniform), 43% (uniform) power saving over MF (Random sequence).
- MMSE detector has 40% (nonuniform), 20% (uniform) power saving over MF (M-sequence).
- Incorporation of a better receiver structure provides significant power savings, and user capacity can be improved by employing linear multiuser receivers in conjunction with adaptive sectorization.