

Inter-Cell Interference Mitigation in Cellular Networks Applying Grids of Beams



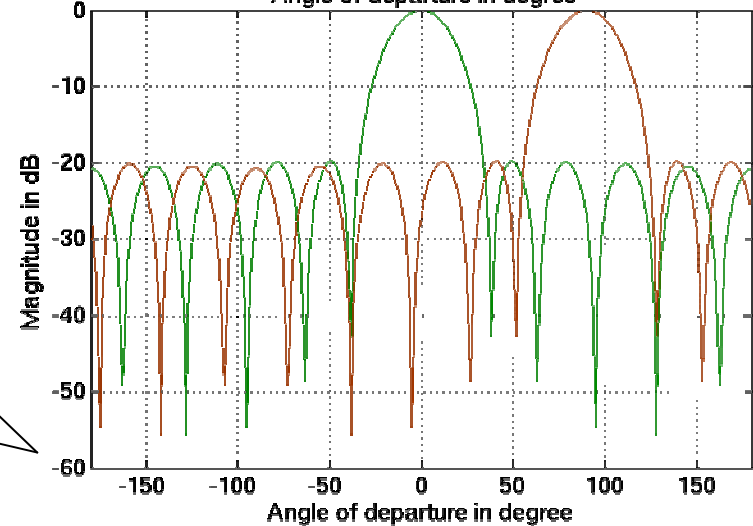
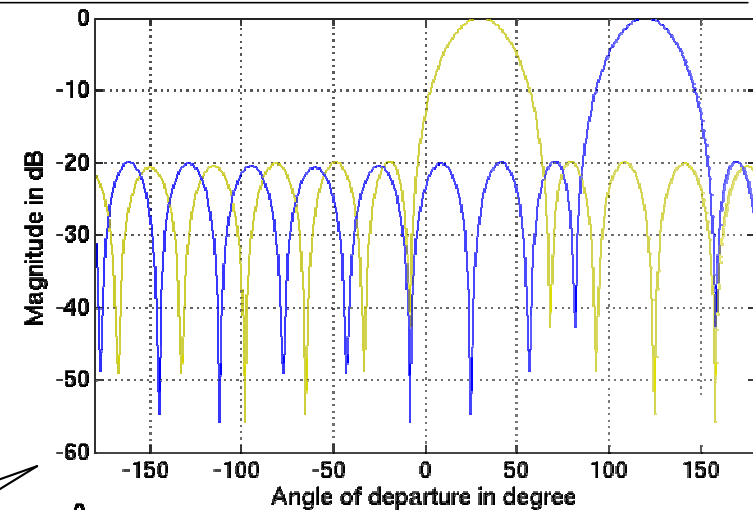
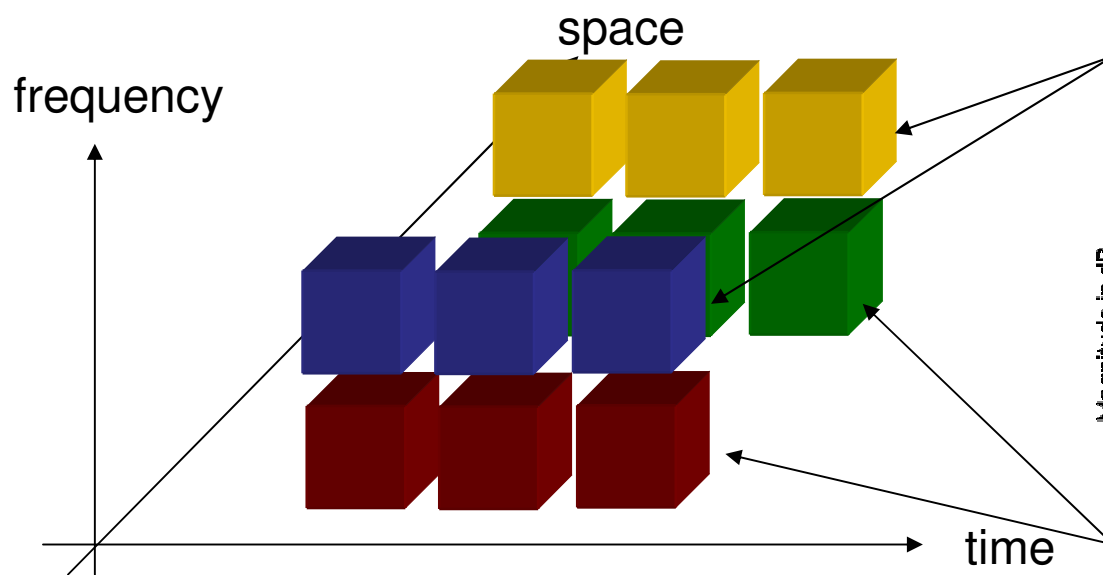
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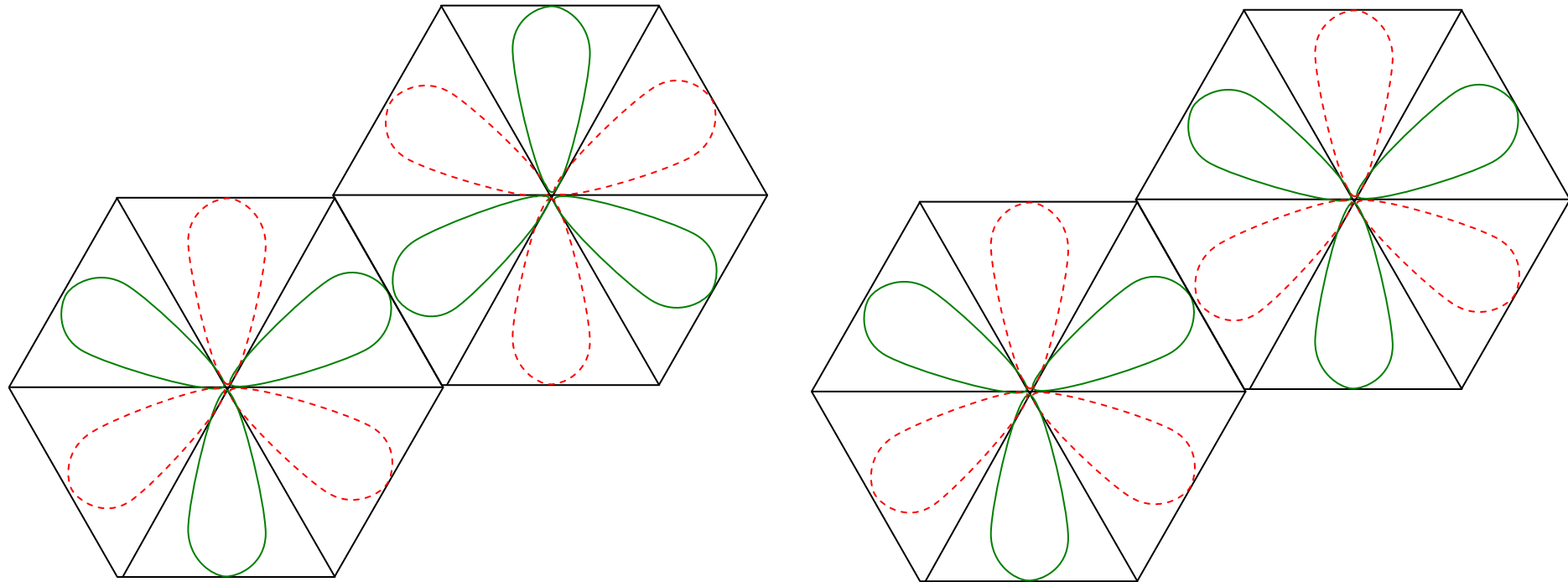
The Talk was given at the meeting of ITG Fachgruppe “Angewandte Informationstheorie“, Berlin, Germany, Oct. 2008.

Resource Blocks

- downlink of OFDMA-based cellular network
- multiple antenna at transmitter
- single antenna at receiver
- beamforming without channel state information → grids of beams



Motivation



— beam of time-frequency unit A
- - - beam of time-frequency unit B

Which beams shall be used on a time-frequency unit?

Overview

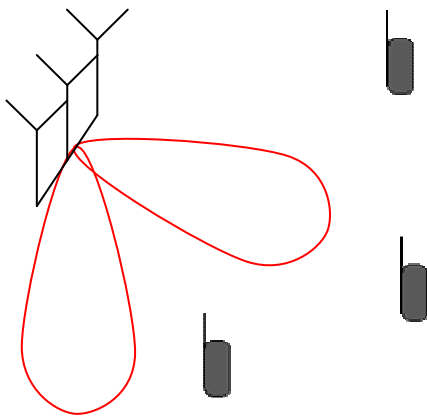


- System concept: grids of beams in cellular network
- Design of grids of beams
 - Problem of interference mitigation: objective function and constraints
 - Low complex algorithm for interference mitigation
- Simulation results
- Conclusion

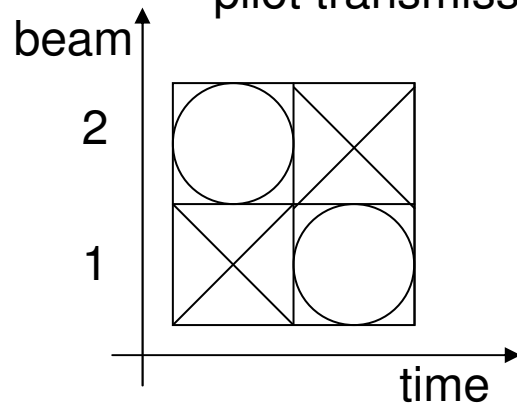
System Concept



preamble phase



pilot transmission



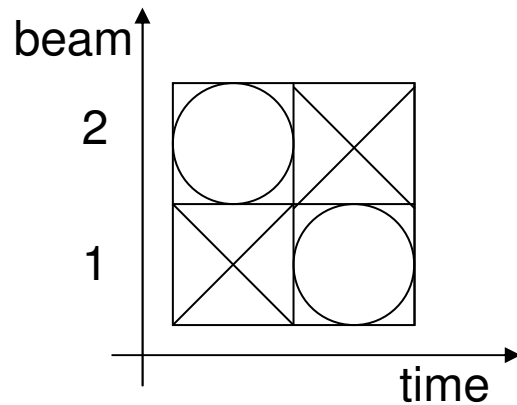
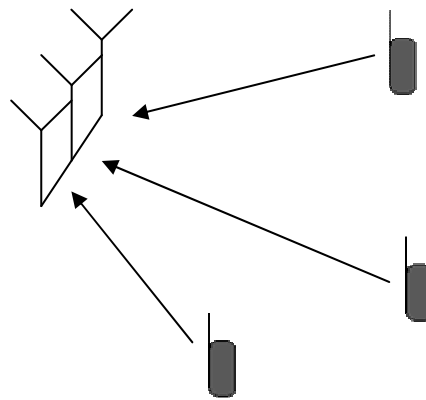
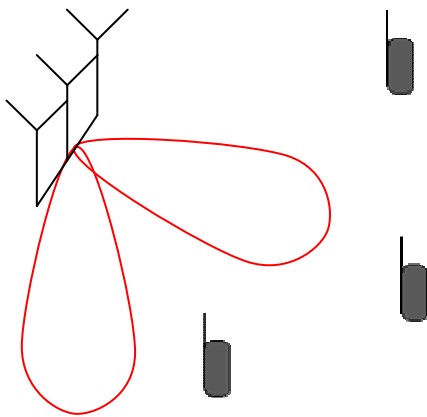
R. Grünheid, H. Rohling, K.Brüninghaus, "Self-Organized Beamforming and Opportunistic Scheduling in an OFDM-based Cellular Network", Proc. VTC 2006, Melbourne Australia, April 2006.

System Concept



preamble phase

feedback phase



SINR values:

- each resource block
- each user

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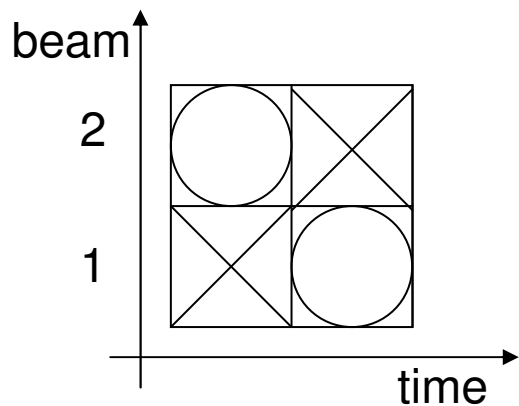
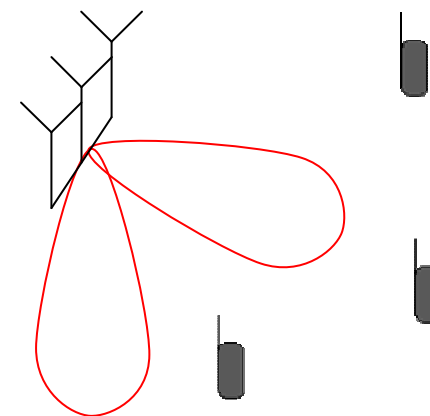
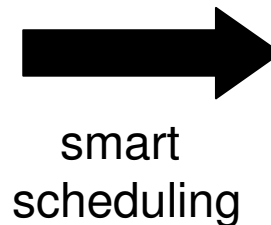
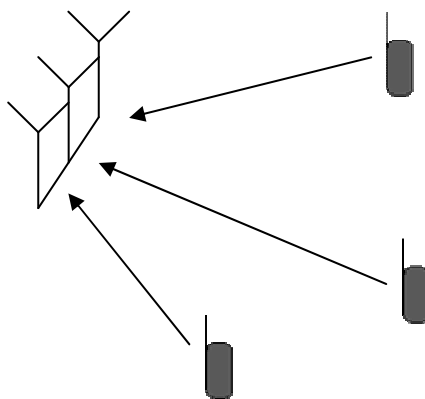
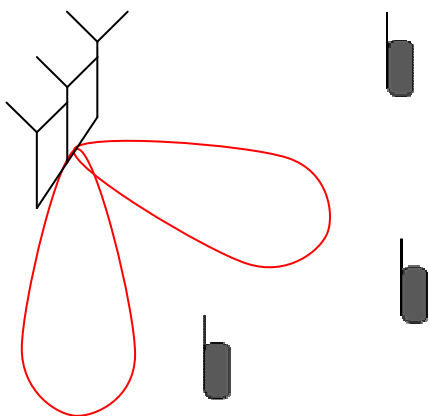
System Concept



preamble phase

feedback phase

signaling and payload phase



SINR values:

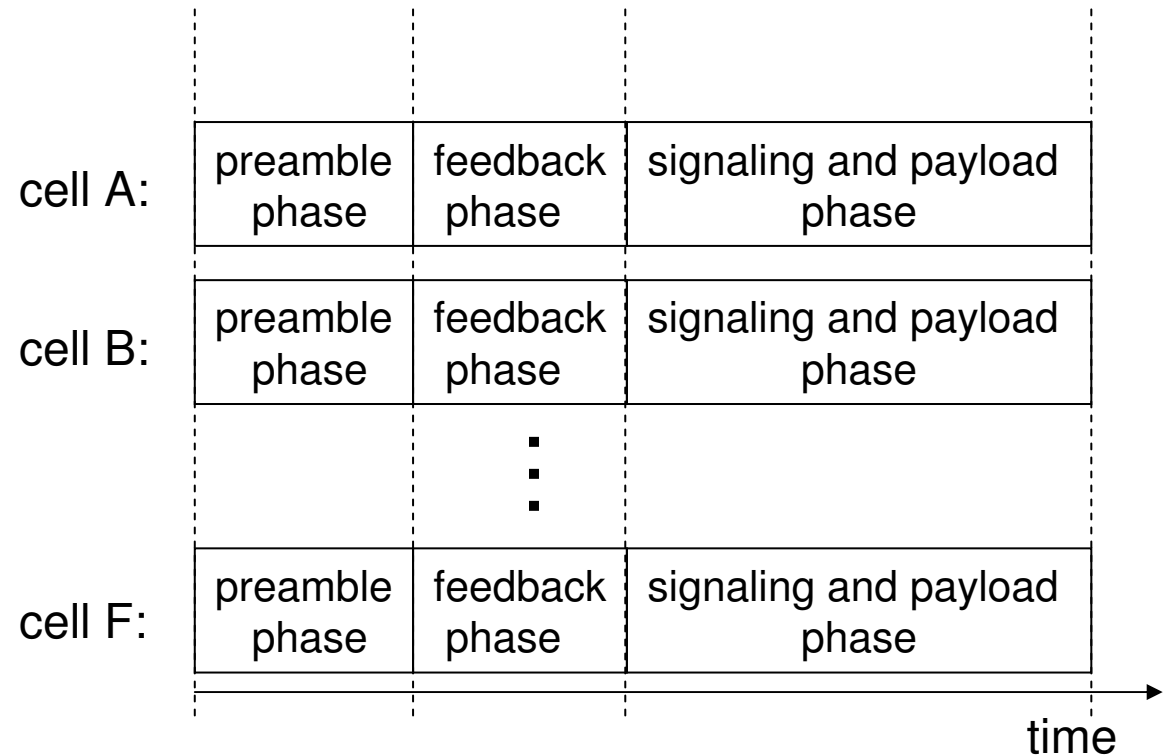
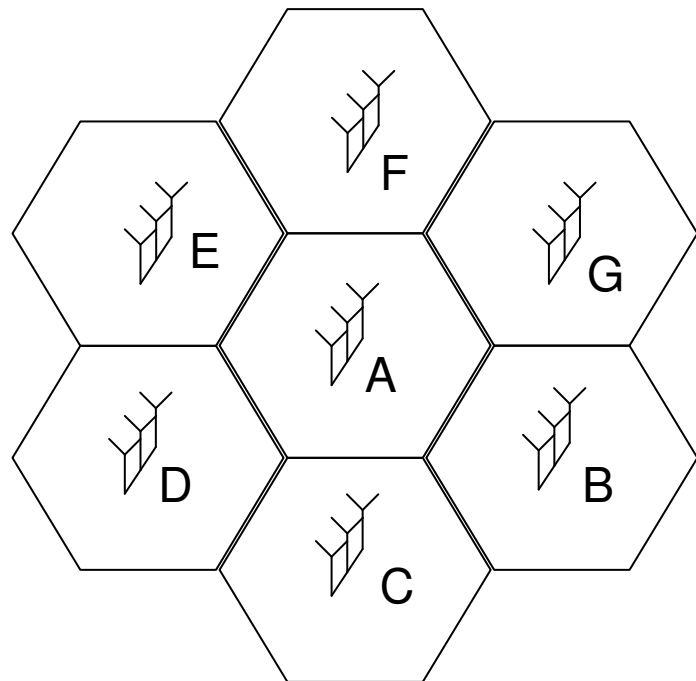
- each resource block
- each user

like in preamble phase:

- same beams
- same power

R. Grünheid, H. Rohling, K.Brüninghaus, "Self-Organized Beamforming and Opportunistic Scheduling in an OFDM-based Cellular Network", Proc. VTC 2006, Melbourne Australia, April 2006.

Multi-Cell Environment



synchronous in time precise SINR values

Design of Grids of Beams

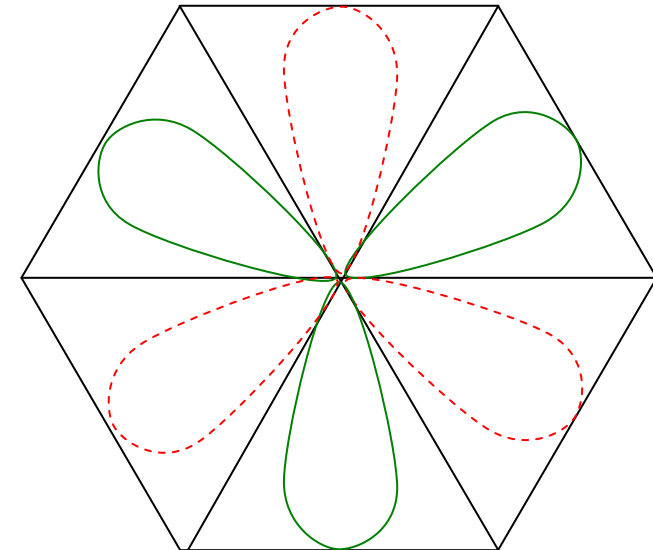


approach in literature:

- filter design
- group beams such that inter-beam interference is avoided → comb-like manner
- use grid of beams serving more users more often

idea:

- design grid of beams for each time-frequency resource such that
 - inter-cell interference is avoided
 - beams serving more users are applied more often

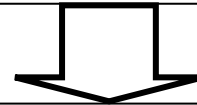


Problem Formulation



assumptions:

- set of time-frequency units
- set of beams



input:

- **demand** for a beam
- **interference** generated by a beam



optimization problem:

minimize interference in network



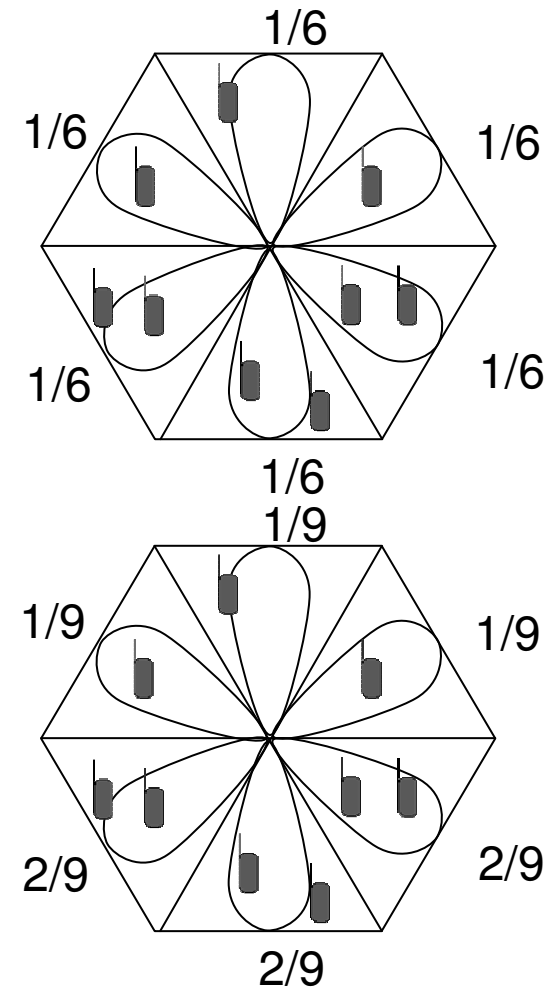
result:

beams used on time-frequency units

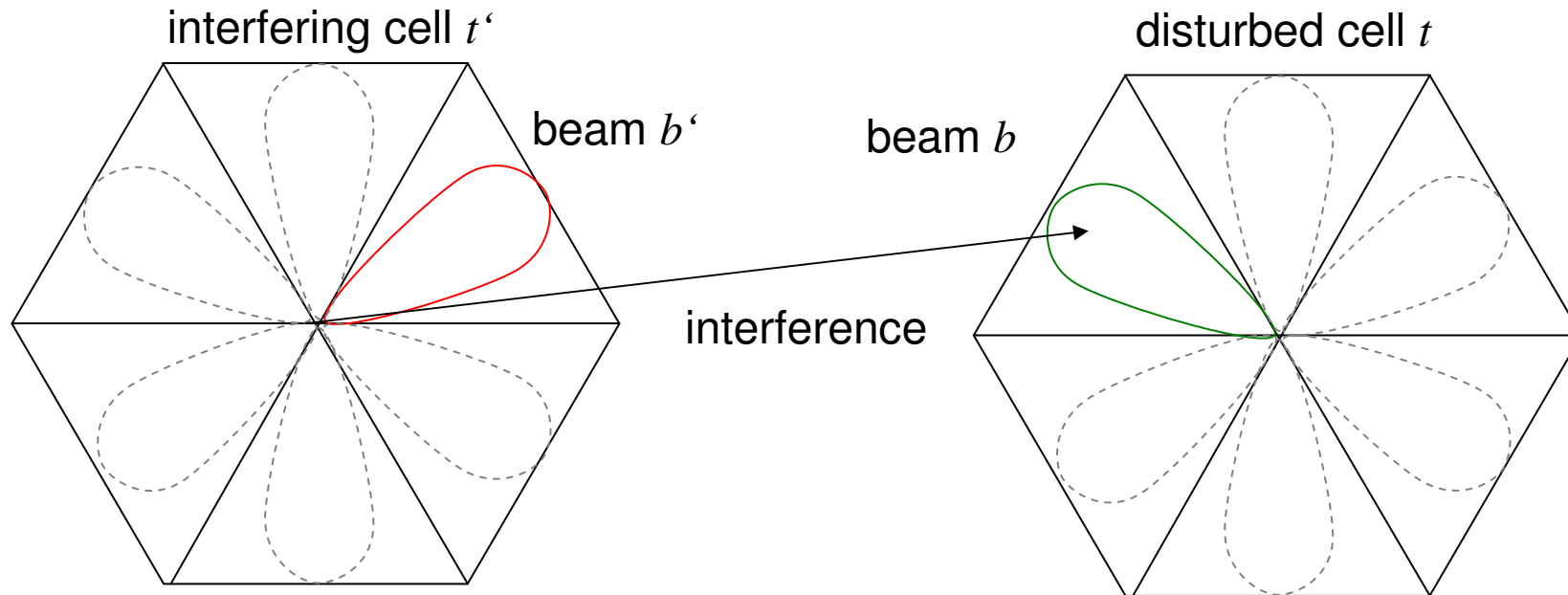


Demand of Beams

- preference:
 - from estimation of angle of arrival or
 - from tracking SINR values
- aims at
 - good coverage
 - high signal power at receiver
- sum of demands is given by number of time-frequency units and beams in a grid of beams
- no preference known
 - use each beam same often
- preference known
 - use beam proportional to traffic in its direction
- demand of a beam is time-variant



Interference of a Beam



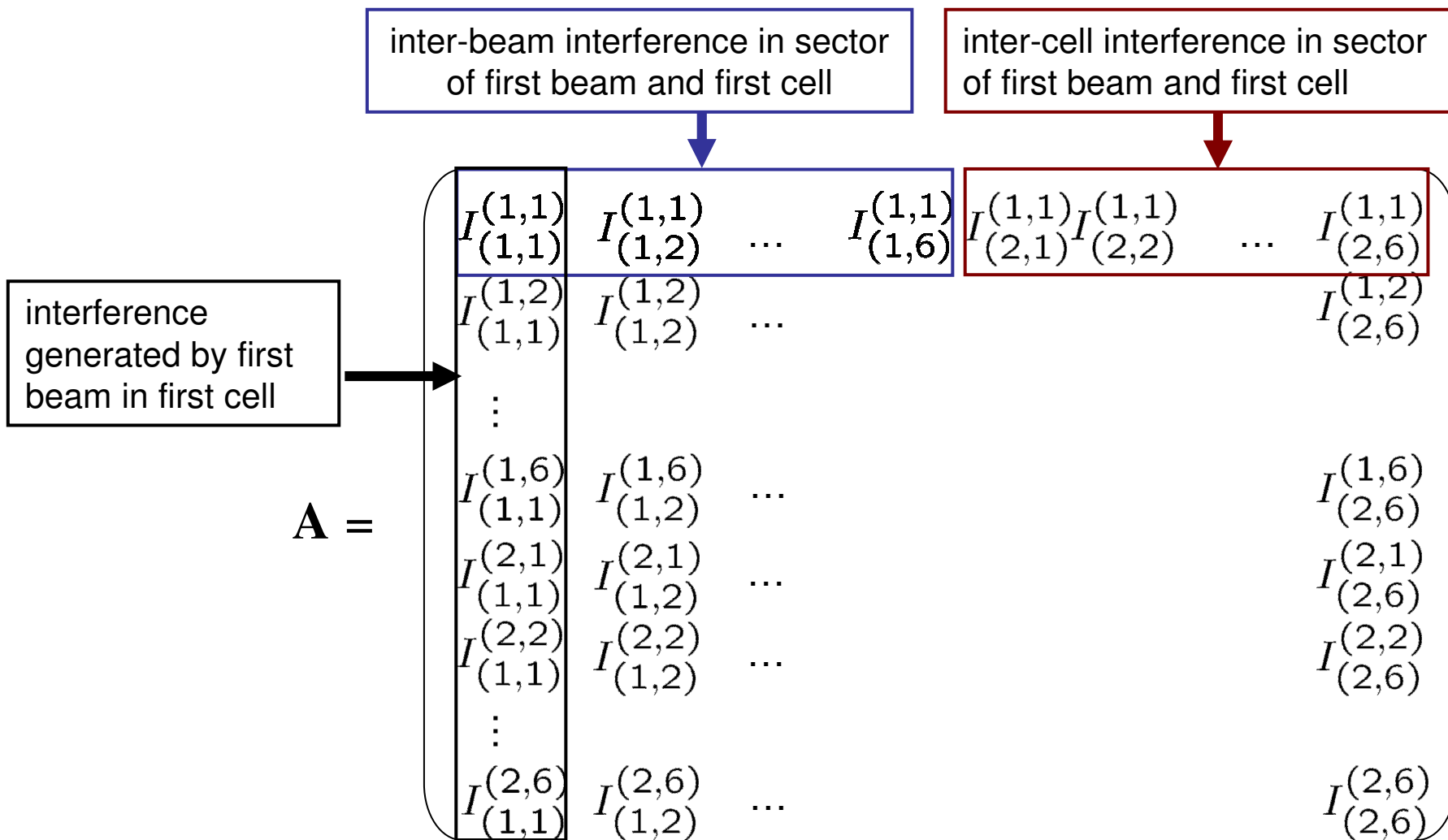
for each pair of beams:

average interference $I_{(t',b')}^{(t,b)}$ in sector depending on

- path loss
- antenna pattern
- user distribution (probability density function)

Note: Average interference is quasi time-invariant.

Interference Matrix



Optimization Problem

objective: $\min_{\mathbf{u}} \mathbf{u}^T$

$$\begin{pmatrix} \mathbf{A} & \mathbf{0} & \mathbf{0} & \dots & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{A} & \mathbf{0} & \dots & \mathbf{0} & \mathbf{0} \\ & & & \ddots & & \\ \mathbf{0} & \mathbf{0} & & \dots & \mathbf{A} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & & \dots & \mathbf{0} & \mathbf{A} \end{pmatrix}$$

extension of \mathbf{A} : consider
each time-frequency unit

\mathbf{u}

assignment variable

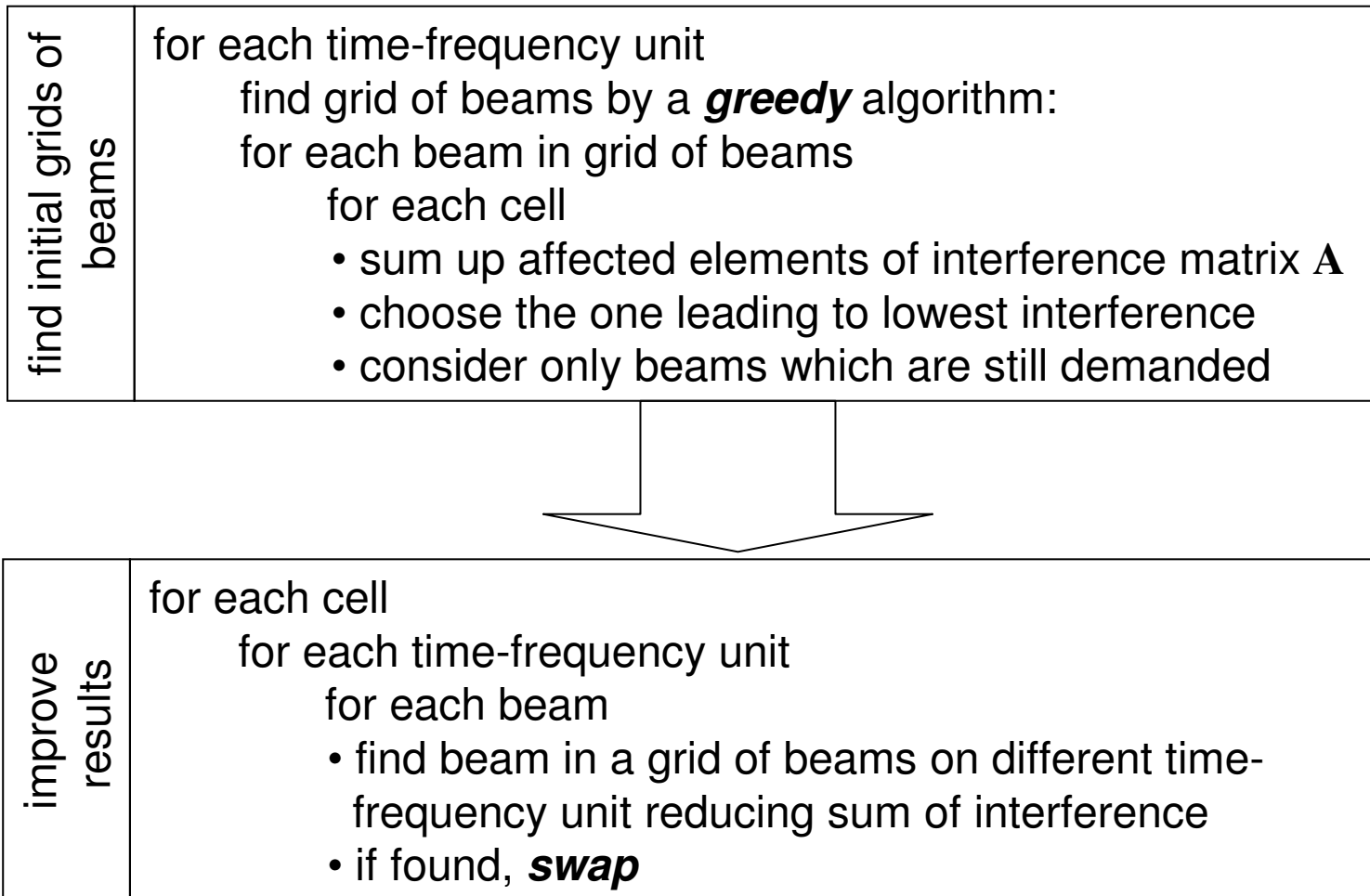
- for each time-frequency unit
- for each cell
- for each beam

constraints:

- each grid of beams consists of same number of beams
- each beam is used as often as demanded
- elements of \mathbf{u} are equal to 0 or 1

→ integer program which is NP-hard

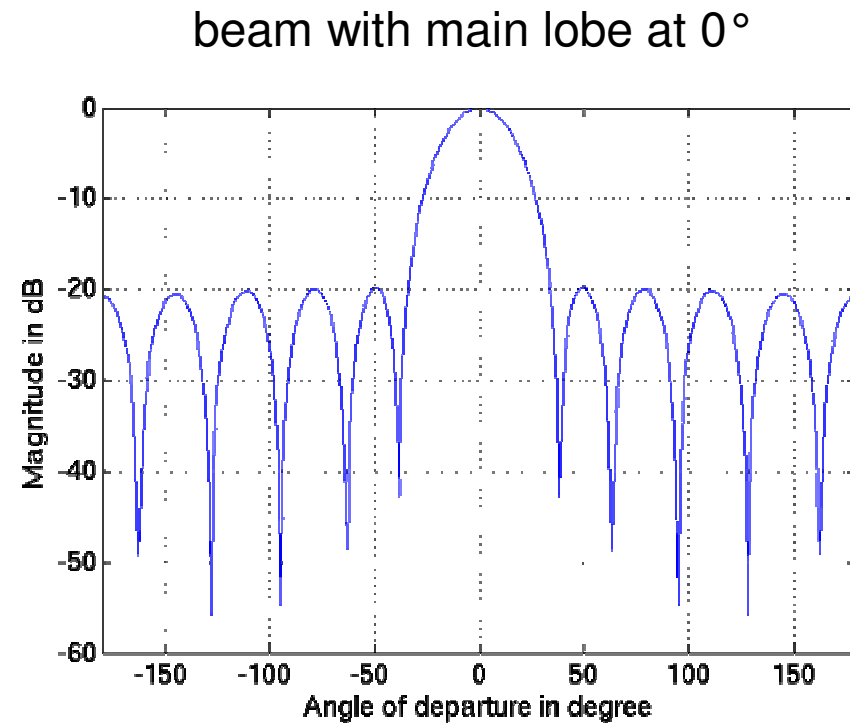
Dynamic Design of Grids of Beams



Evaluation Parameters



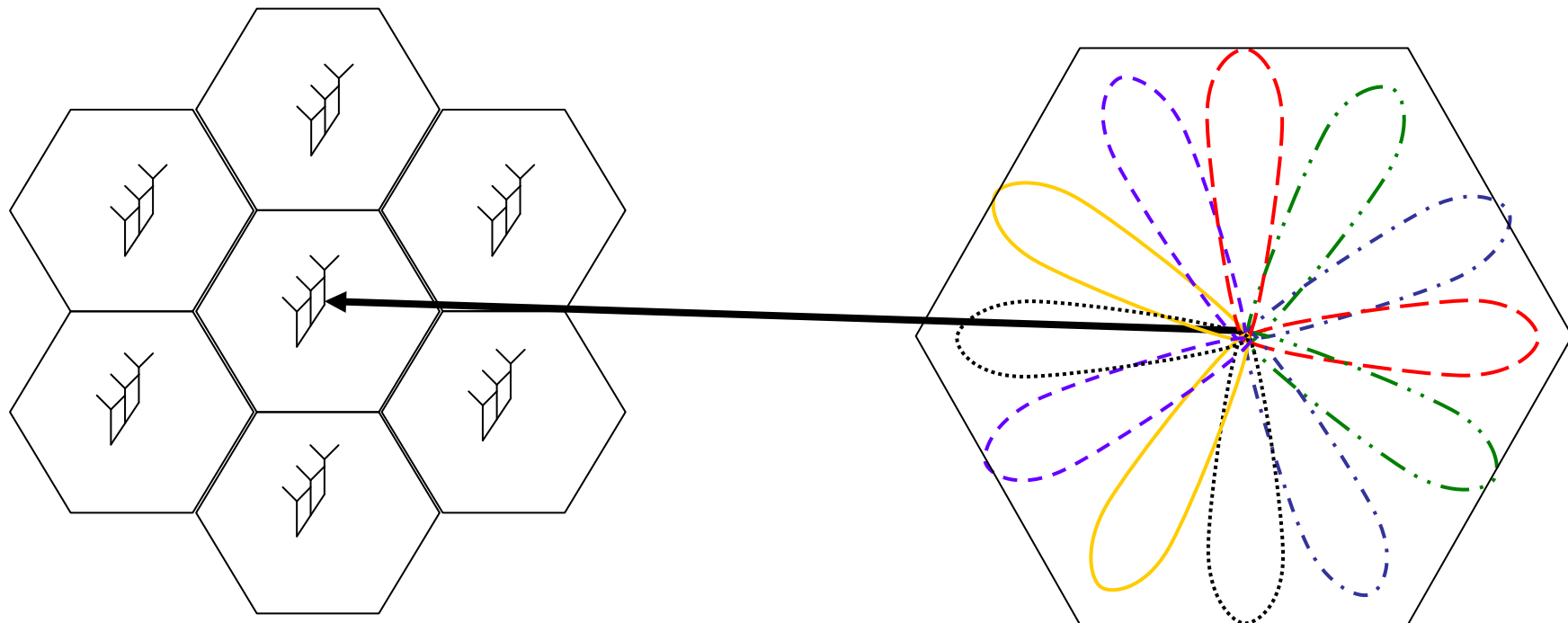
Parameter	Value
bandwidth	5 MHz
number of subcarriers	128
power BS	35dBm
noise power	-102 dBm
antennas BS	uniform circular array, 12 elements
main lobe direction	0°, 30°, 60°, ..., 330°
beam type	Chebyshev, 20 dB side lobe attenuation
size of grid of beams	2
channel model	Winner Channel Model C2 NLOS
number of cells	7
cell radius	200m
scheduler	Max-Min



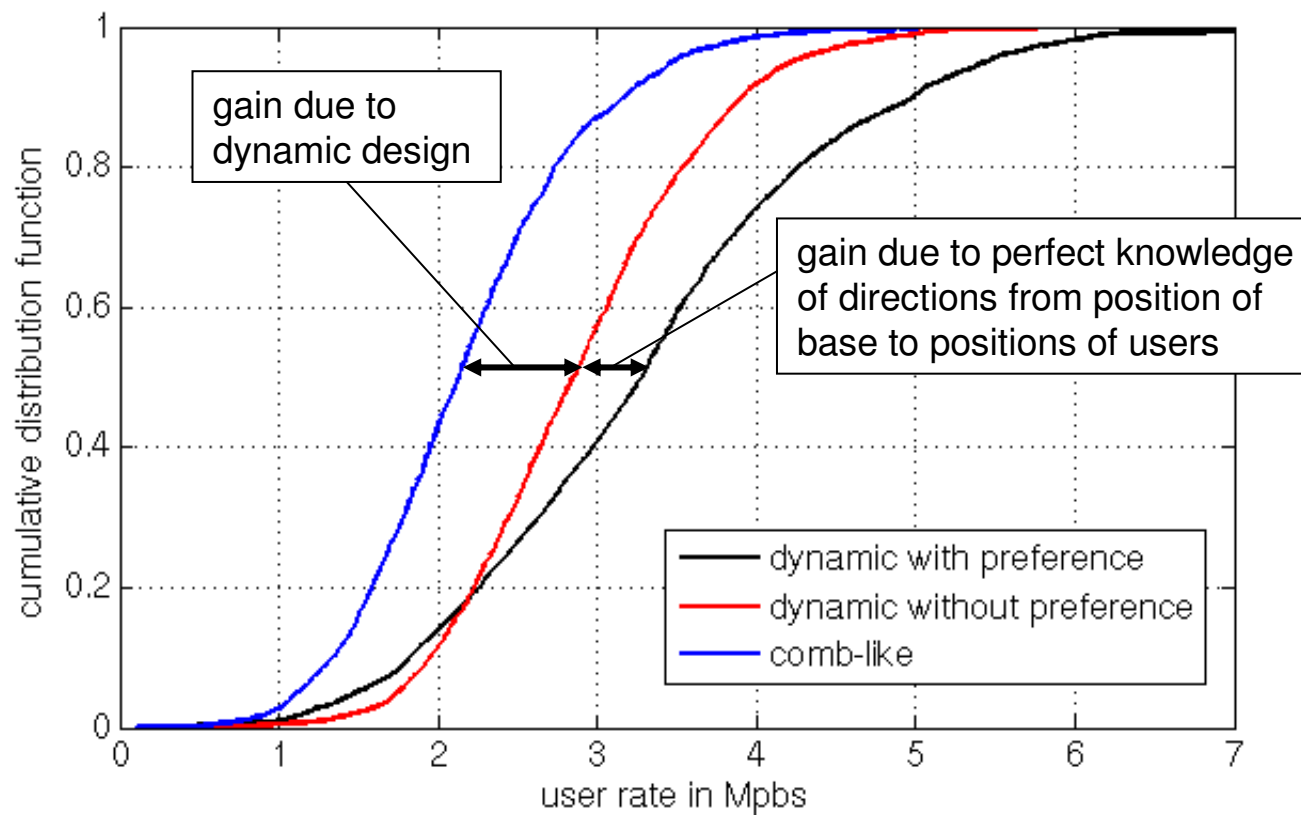
Benchmark Method

comb-like manner of grid of beams:

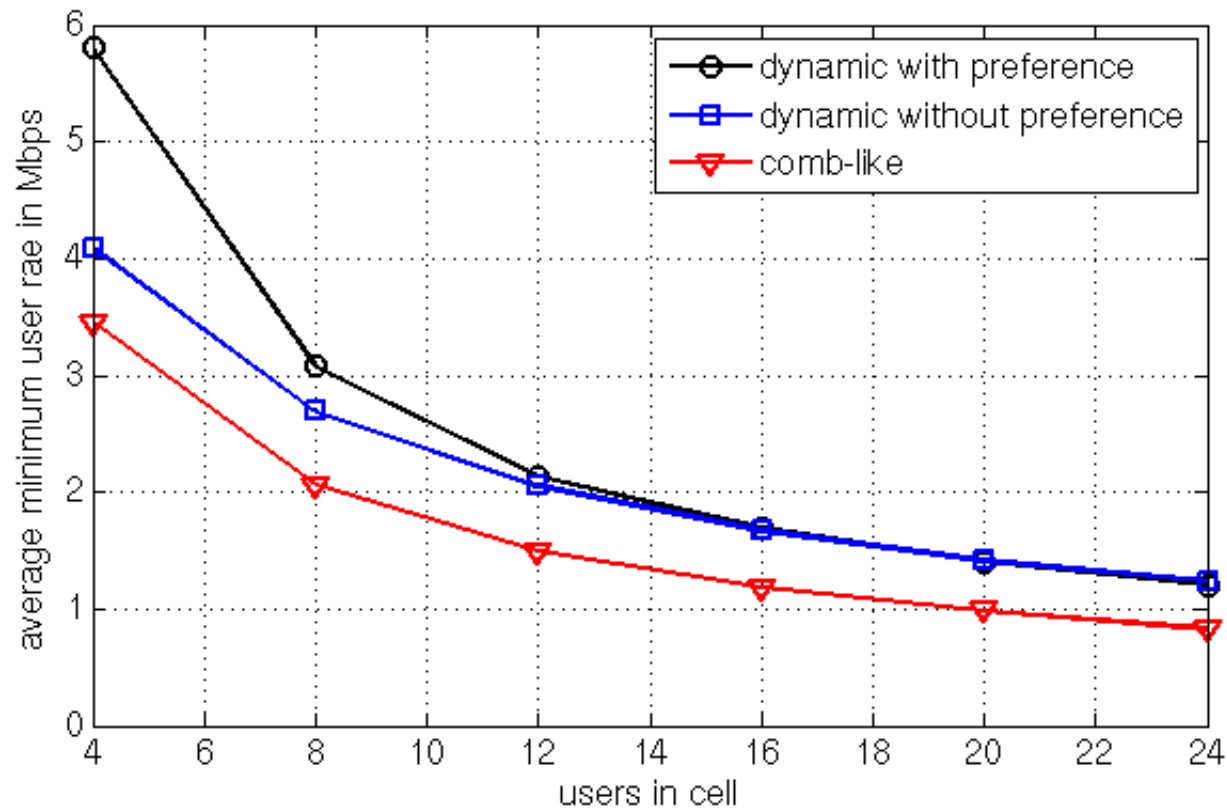
subcarrier	1	2	3	4	5	6	7	...
1st beam	0°	30°	60°	120°	150°	180°	0°	...
2nd beam	90°	300°	330°	210°	270°	300°	90°	...



Data Rate of User for 8 Users in Cell



Minimum Data Rate of User in Cell



Conclusion



- grid of beams as a robust alternative to beamforming requiring full channel state information
- dynamic design of grids of beams considering
 - demand of a beam
 - inter-cell interference
- formulation of optimization problem including definition of an objective function
- presentation of an algorithm improving performance of a network by dynamic design of grids of beams