DPS AND COORDINATED MUTING

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- Techniques for cell-edge rate improvement
  - Dynamic point selection (DPS)
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Introduction

- Every cell serves its users by allocating various resource blocks to them over time
- Schedulers have different objectives
  - Max-rate scheduler
  - Max-min fair scheduler
    - Equal rates for all the users
  - Proportionally fair (PF) scheduler
    - Equi-partition of time and resource blocks

$$\max \sum_i R_i$$

$$\max \min_i R_i$$

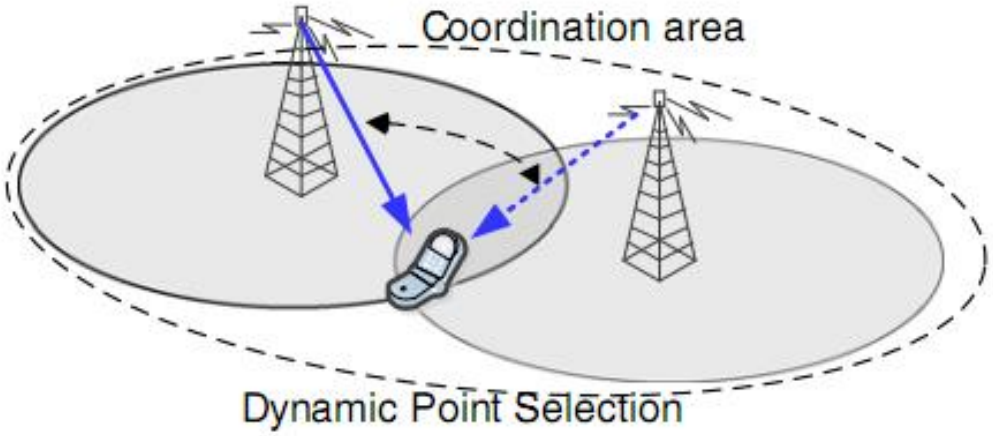
$$\max \sum_i \log R_i$$

Motivation

- Cell-edge users have higher path loss than the cell-centre users and hence lower signal strengths
- Proximity to neighboring cells causes higher interference
- Lower SINR values imply lower rates
- Cell-edge users form a bottleneck
- To improve the cell-edge performance
  - DPS
  - Coordinated muting

Dynamic Point Selection

- Cell-edge user could be served by a neighboring cell if that channel is better
- Heavily loaded cell can offload some cell-edge users to its neighbor



Coordinated Muting

- Muting the neighboring cell removes the dominant interferer and boosts SINR
- Improvement in rates is higher for edge users
- Lightly loaded can be muted often for fairness across cells
- Muting patterns could be different for different resource blocks (RB)

Comparison of Schedulers

Non-CoMP system

- No coordination among cells
- Independent proportionally fair (PF) schedulers
- Scheduled user is

$$i^* = \arg\max_{i \in U} \frac{r_i}{R_i}$$

- Here
  - i^* is the scheduled user
  - U is the set of all users in the cell
  - r_i and R_i are the instantaneous and average rates of $i\text{th}$ user

Coordinated Muting

- Muting decision and the scheduling decision are taken simultaneously
- For scheduling two coordinating cells, the joint PF scheduler-

$$\{i^*, j^*\} = \underset{i \in U_1,\, j \in U_2}{\arg\max} \begin{cases} \frac{r_i}{R_i} + \frac{r_j}{R_j} & \text{Both cells 'on'} \\ 0 + \frac{\tilde{r}_j}{R_j} & \text{Cell-1 'muted'} \\ \frac{\tilde{r}_i}{R_i} + 0 & \text{Cell-2 'muted'} \end{cases}$$

- Here
  - $\tilde{r}_i$ and $\tilde{r}_j$ are the boosted instantaneous rates due to muting of the other cell

DPS

- User association and the scheduling decisions are taken simultaneously at every TTI
- The 2-cell joint PF scheduler:

$$\{i^*, j^*\} = \underset{i,\, j \in (U_1 \cup U_2)}{\arg\max} \left\{ \frac{r_{i,1}}{R_i} + \frac{r_{j,2}}{R_j} \right\}$$

- When $i^* = j^* = k$, conflict is resolved as follows:

$$\{i^*, j^*\} = \underset{i,\, j}{\arg\max} \begin{cases} \underset{i \in (U1 \cup U2 \setminus k)}{\max} \left\{ \frac{r_i}{R_i} \right\} + \frac{r_k}{R_k} \\ \frac{r_k}{R_k} + \underset{j \in (U1 \cup U2 \setminus k)}{\max} \left\{ \frac{r_j}{R_j} \right\} \end{cases}$$

DPS with Coordinated Muting

- User association, muting and scheduling decisions taken all at once
- Joint scheduler is:

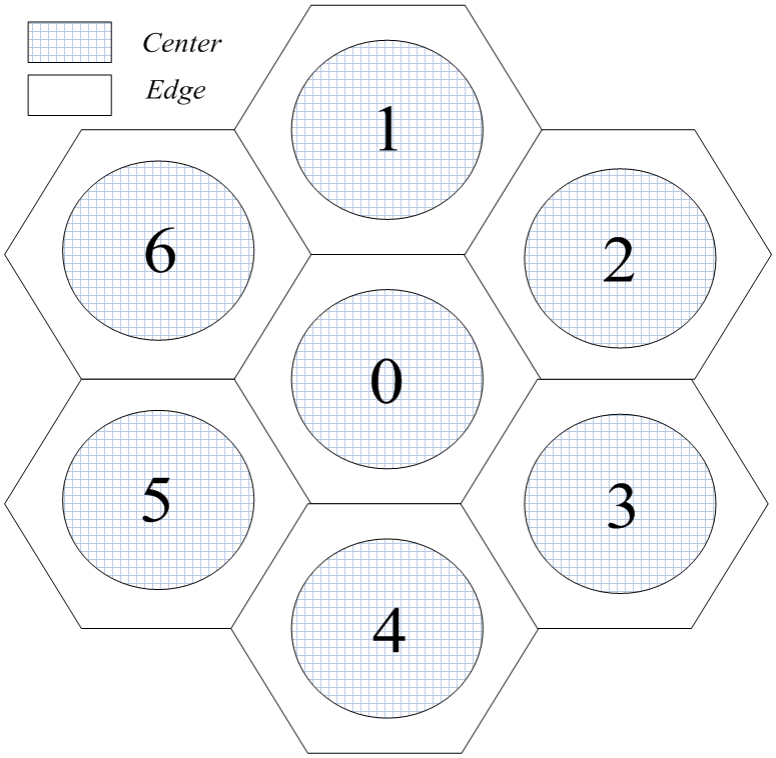
$$\{i^*, j^*\} = \arg\max_{i,j} \begin{cases} \frac{r_{i^*_{DPS}}}{R_{i^*_{DPS}}} + \frac{r_{j^*_{DPS}}}{R_{j^*_{DPS}}} & \text{Both cells 'on'} \\ 0 + \max\limits_{j \in (U_1 \cup U_2)} \frac{\tilde{r}_j}{R_j} & \text{Cell-1 'muted'} \\ \max\limits_{i \in (U_1 \cup U_2)} \frac{\tilde{r}_i}{R_i} + 0 & \text{Cell-2 'muted'} \end{cases}$$

Simulation Parameters

Parameter	Value
Cells	19
ISD	500 m
Noise PSD	-174 dBm/Hz
Tx power	46 dBm
Channel realizations	1000
User drops	50
Path loss model (dB)	128.1 + 37.6 * log(d (km))

Cluster Design

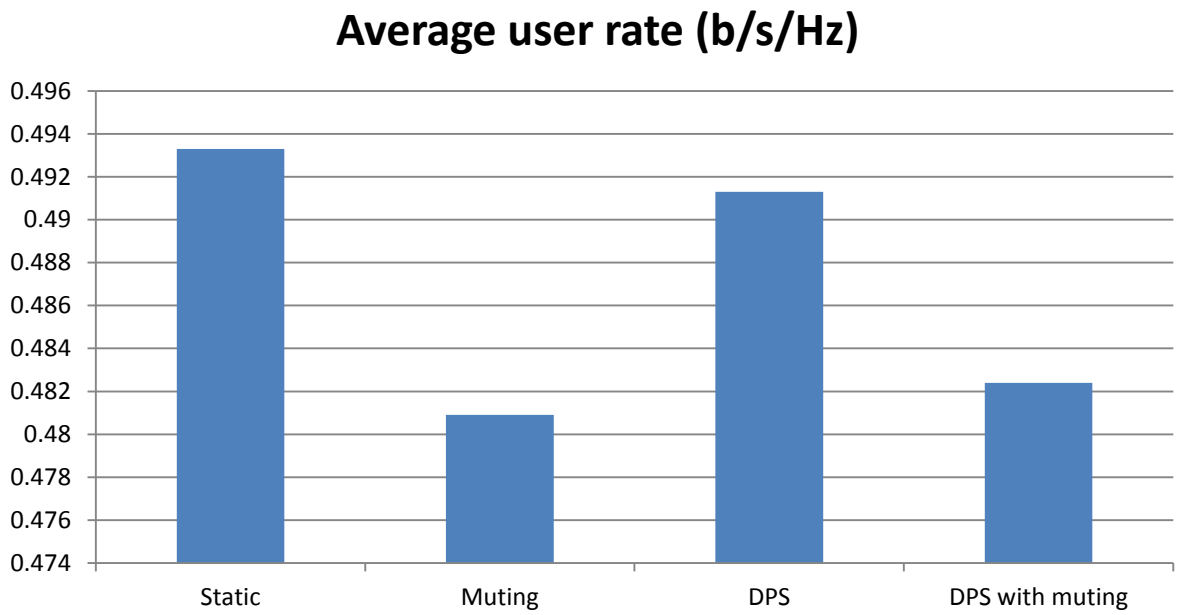
- 19 cell cluster consisting of
  - Tier-0: 1 cell
  - Tier-I: 6 cells
  - Tier-II: 12 cells
- Rates analyzed for tier-0 and tier-I cells
- Tier-II cells used for modeling interference



Case 1 - Imbalanced Load

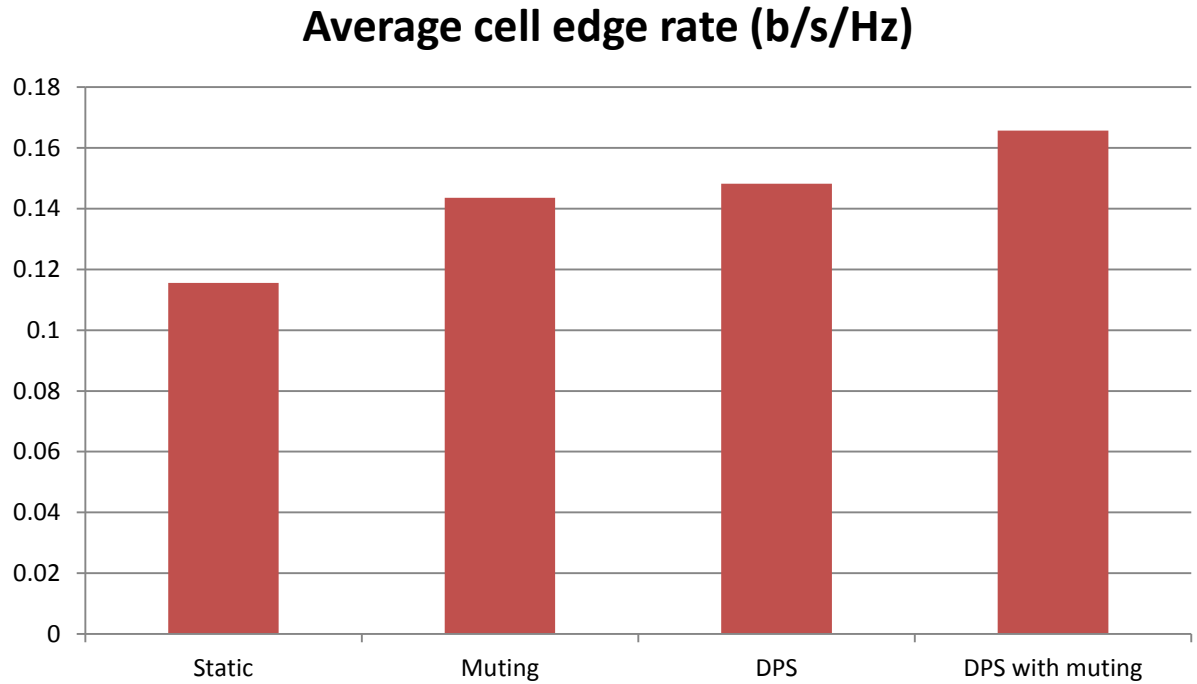
- 0^{th} cell
  - 10 centre users
  - 4 edge users
- Tier-I and tier-II cells
  - 10 centre users

Average Rates



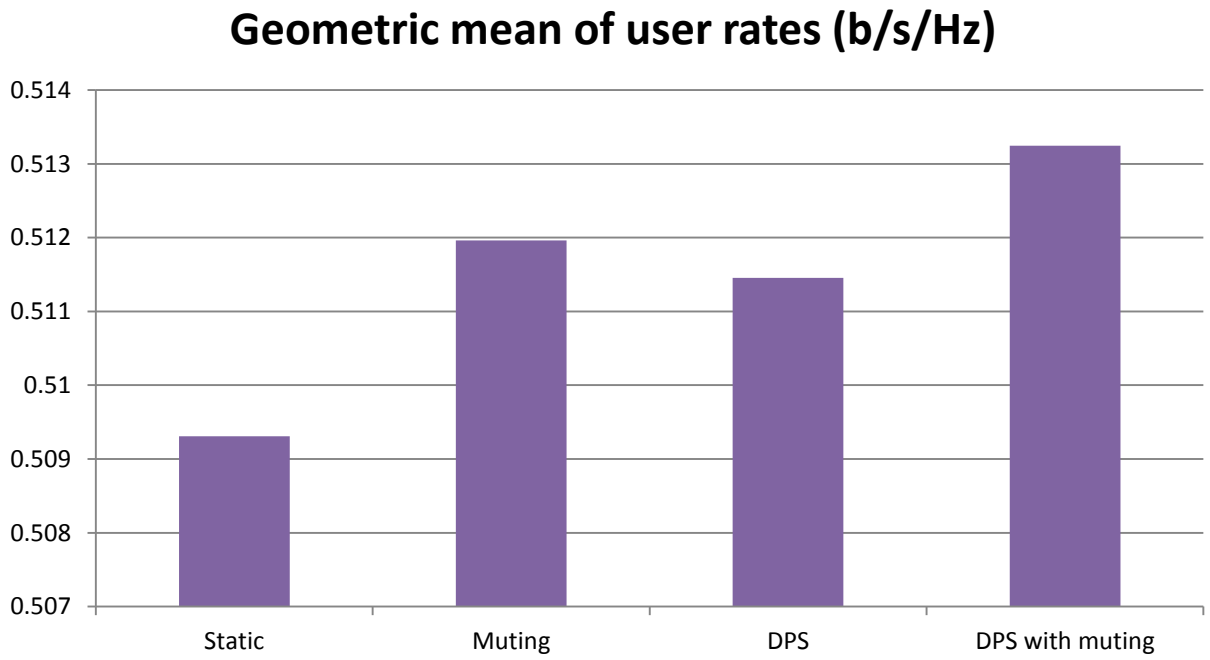
- Assigning the RBs according to max-PF criterion and not the max-rate criterion decreases average rate
- 2.2% decrease from static to DPS with muting

Cell Edge User Rates



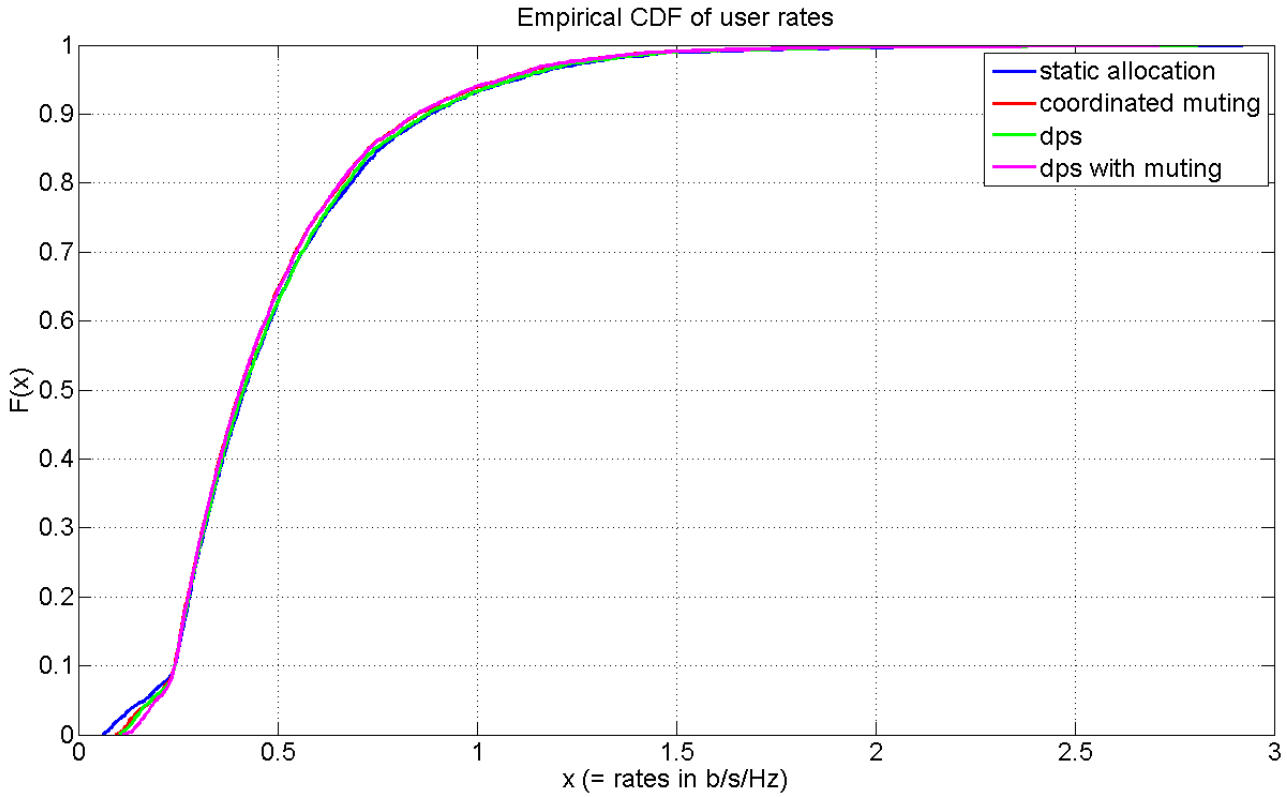
- Improved rates for the intended beneficiaries, i.e. the cell-edge users
- 43.3% improvement in rate for the cell-edge users

Geometric Mean of the Rates



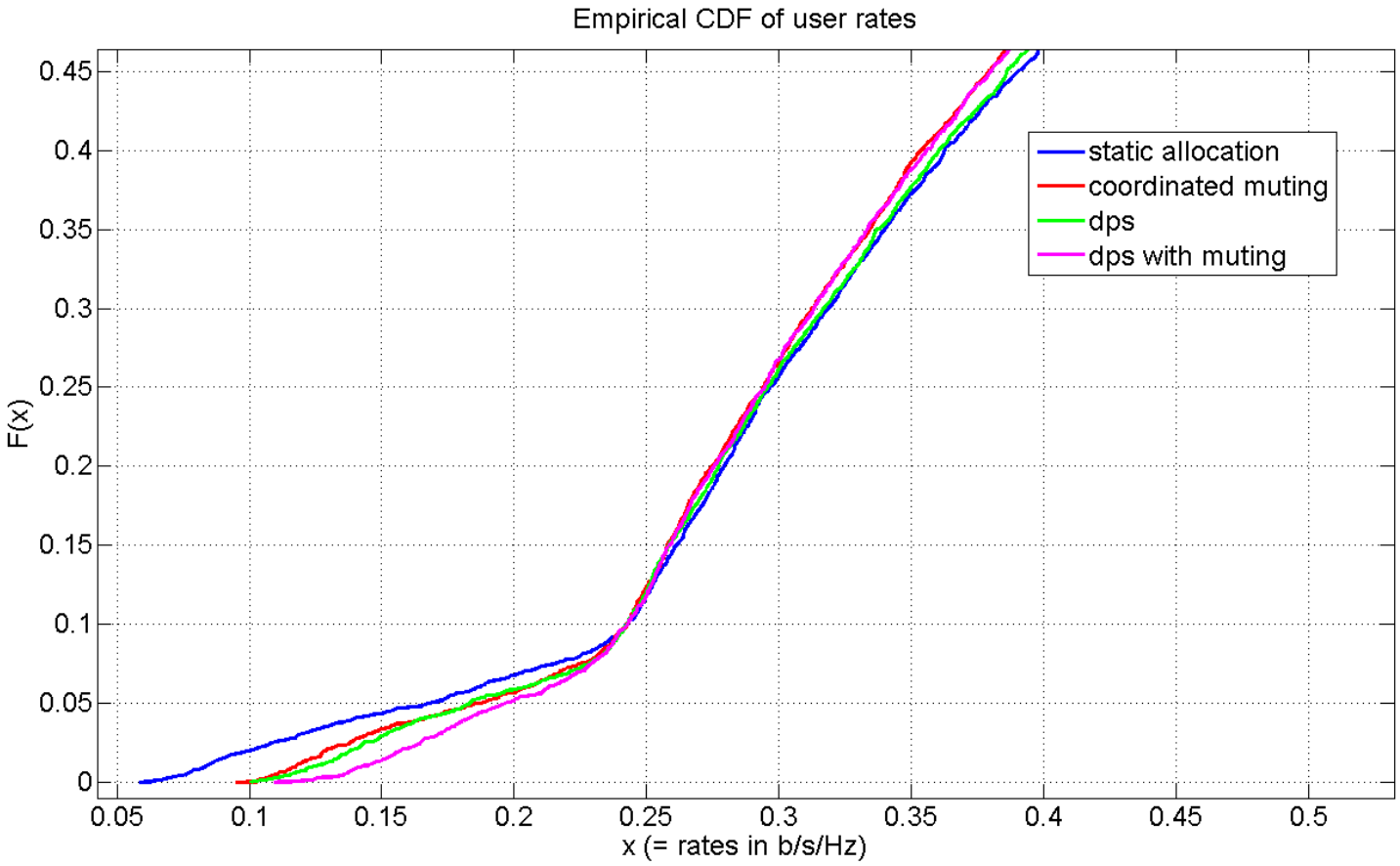
- Maximization of the geometric mean (GM) of the rates is equivalent to maximization of sum-PF metric
- Muting techniques benefit from the rate-boosts in tier-II cells

Empirical CDFs



- Low-rate users are critical
- Any improvement in rate for these users is significant

Empirical CDFs - Zoomed

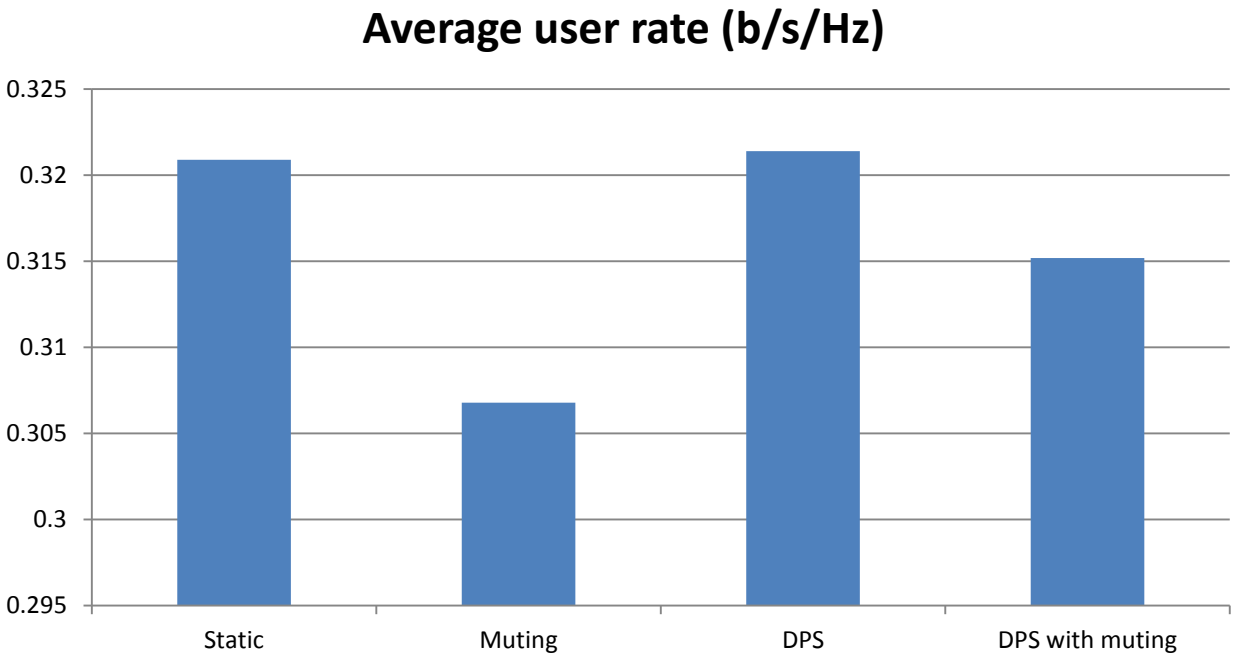


Case 2 - Balanced Load

All Cells have

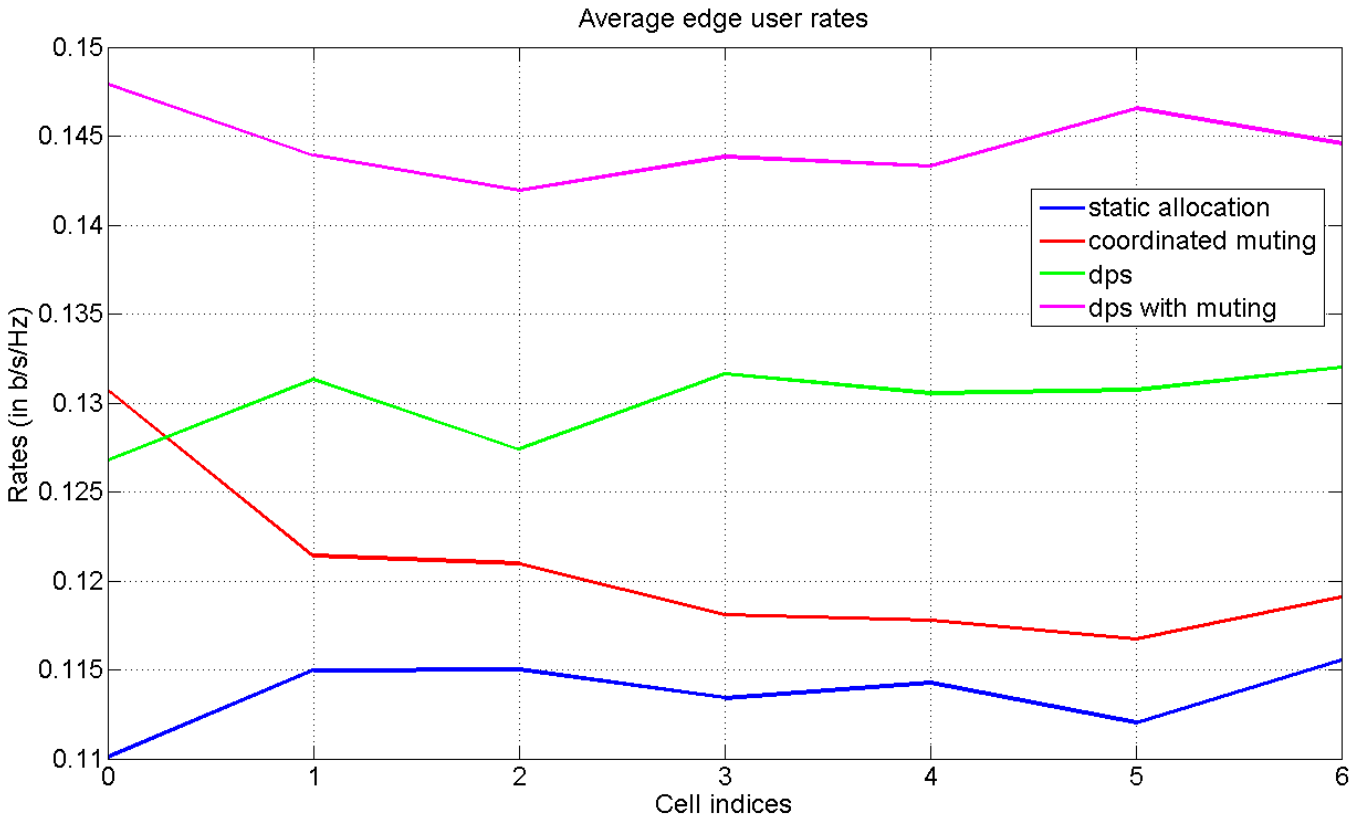
- 10 centre users
- 4 edge users

Average Rates



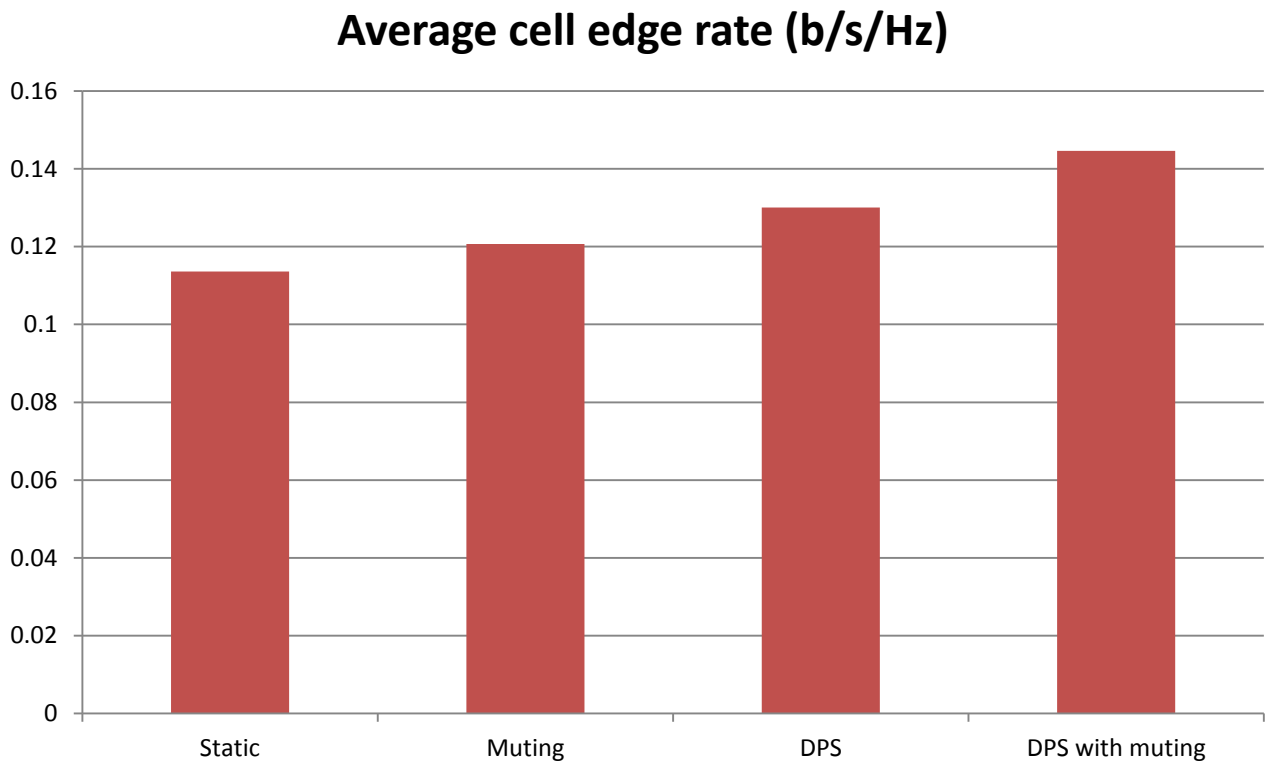
- DPS benefits from contributions from tier-II cells
- 1.8% decrease from static to DPS with muting

Cell Edge User Rates



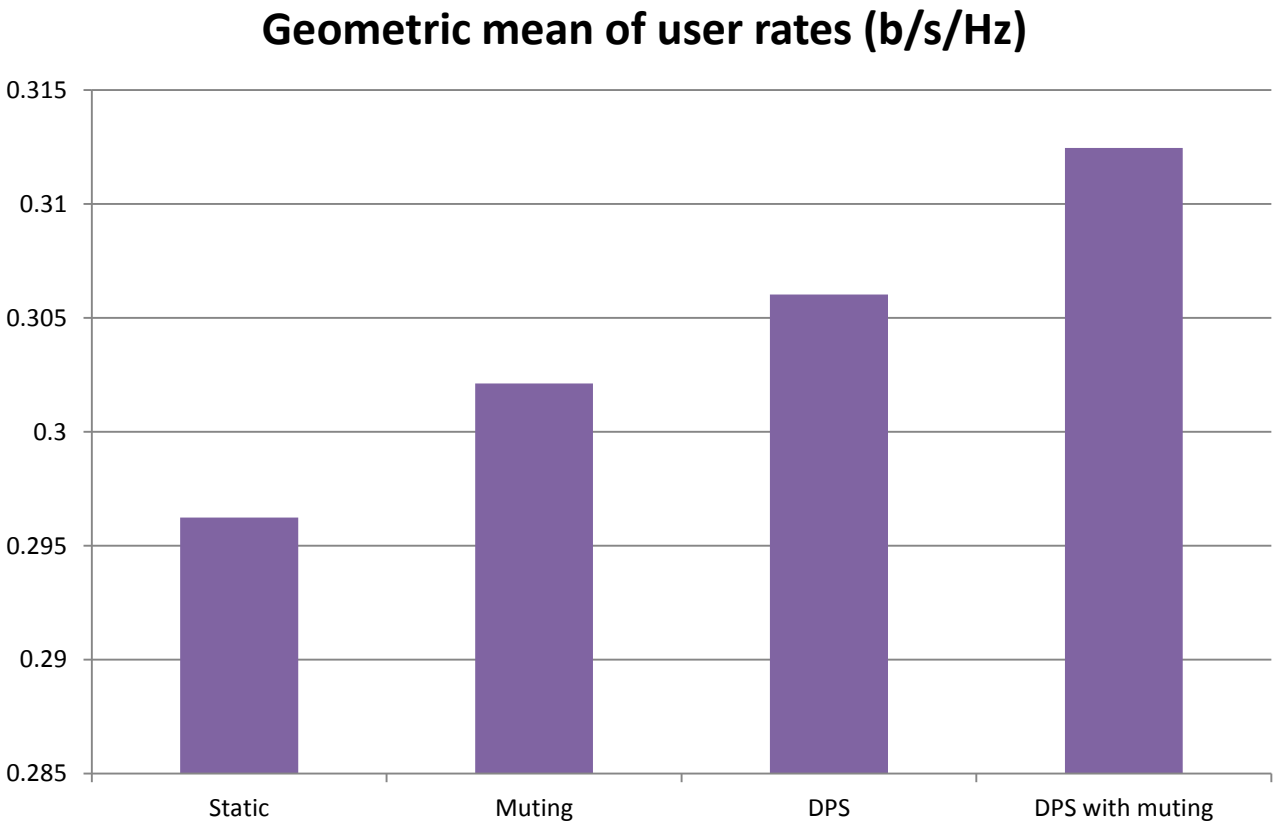
- Increase in cell-edge rates seen for all the cells

Cell Edge User Rates



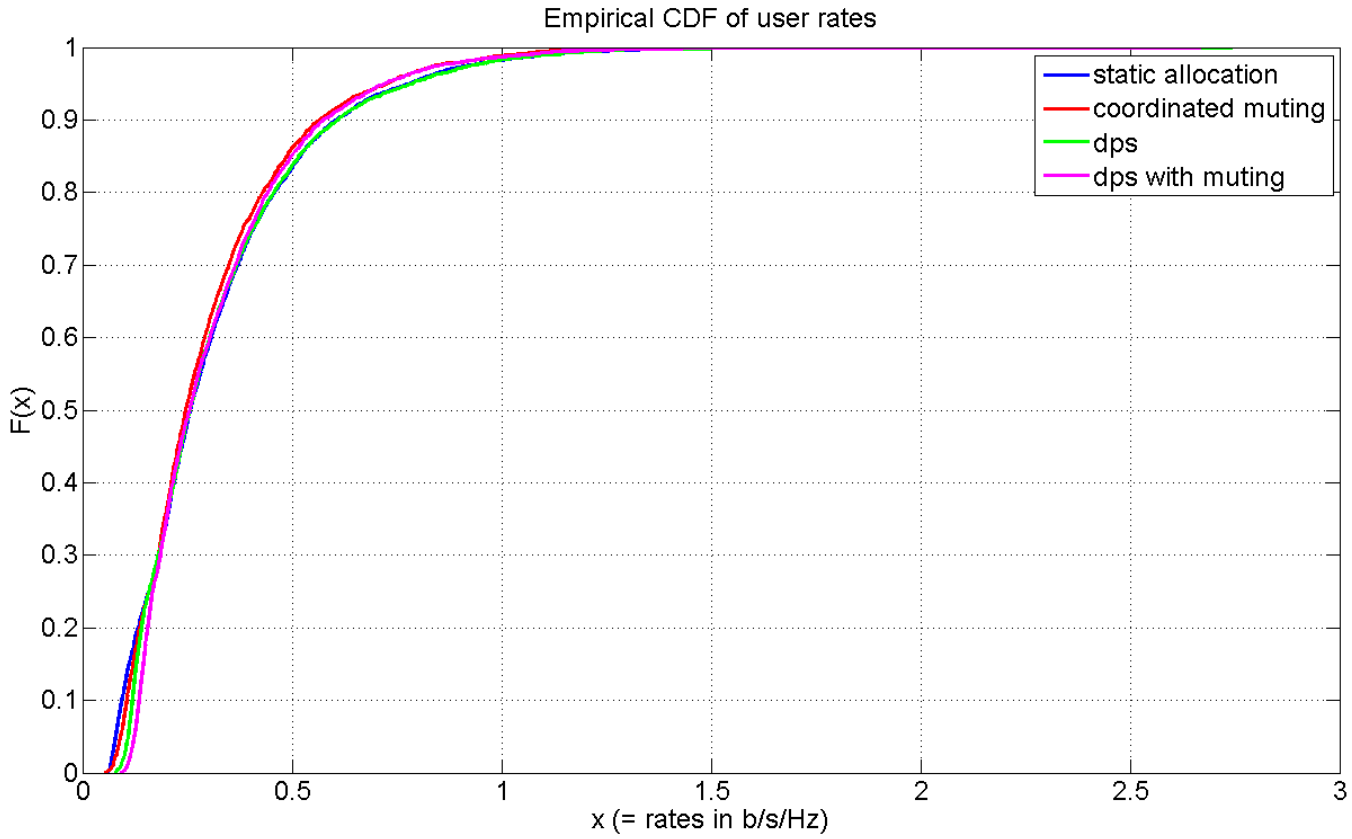
- 27.3 % increase from static to DPS with muting

Geometric Mean of the Rates



- 5.5 % increase from static to DPS with muting

Empirical CDFs



- Improvement in the rates in the critical region
- Gains not pronounced due to edge-users in all cells

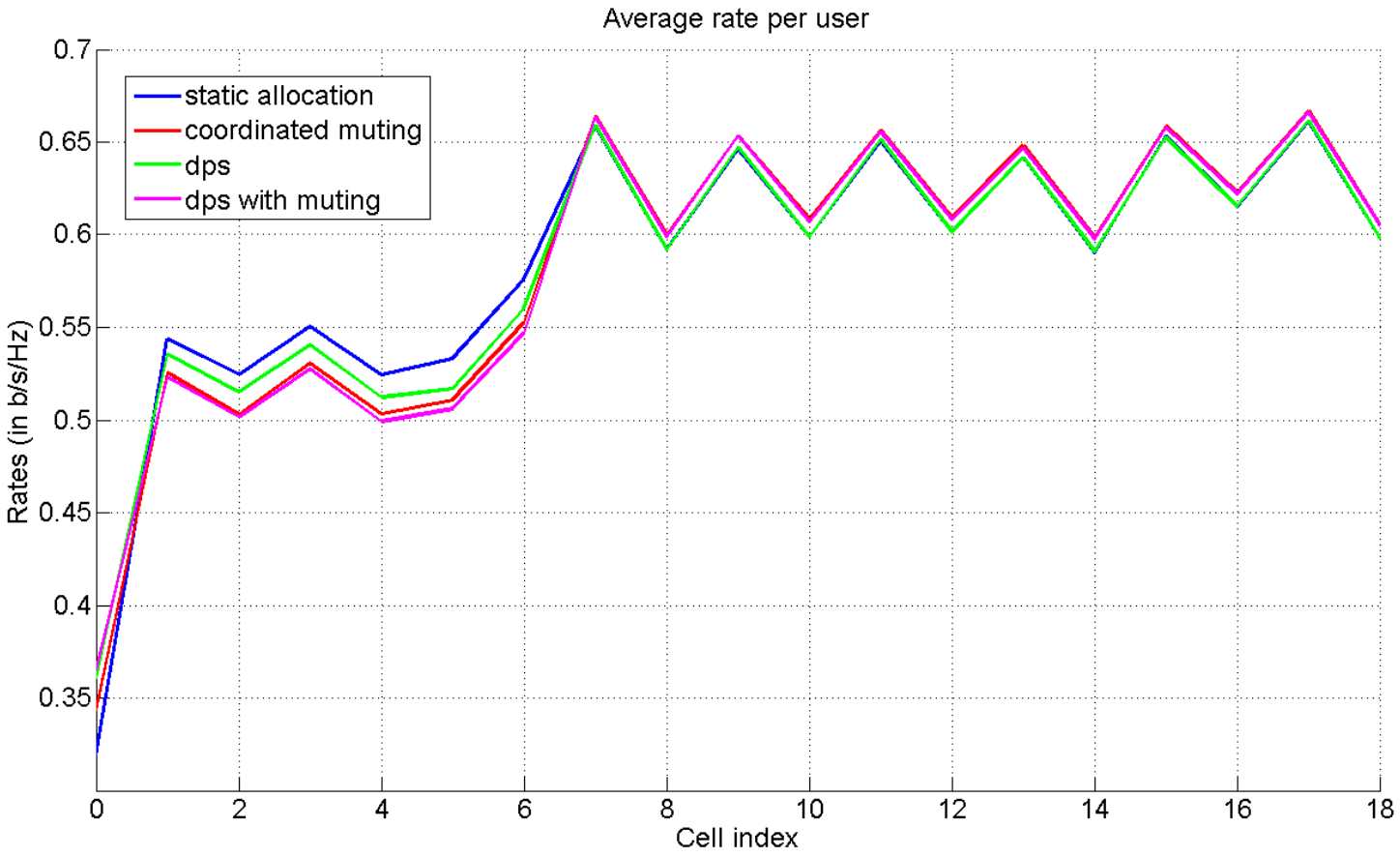
Conclusion

- DPS and coordinated muting independently improve the cell-edge user rates substantially
- DPS and muting can be combined to improve the cell-edge rates further
- Gains for joint scheme are still less than the sum of the individual gains

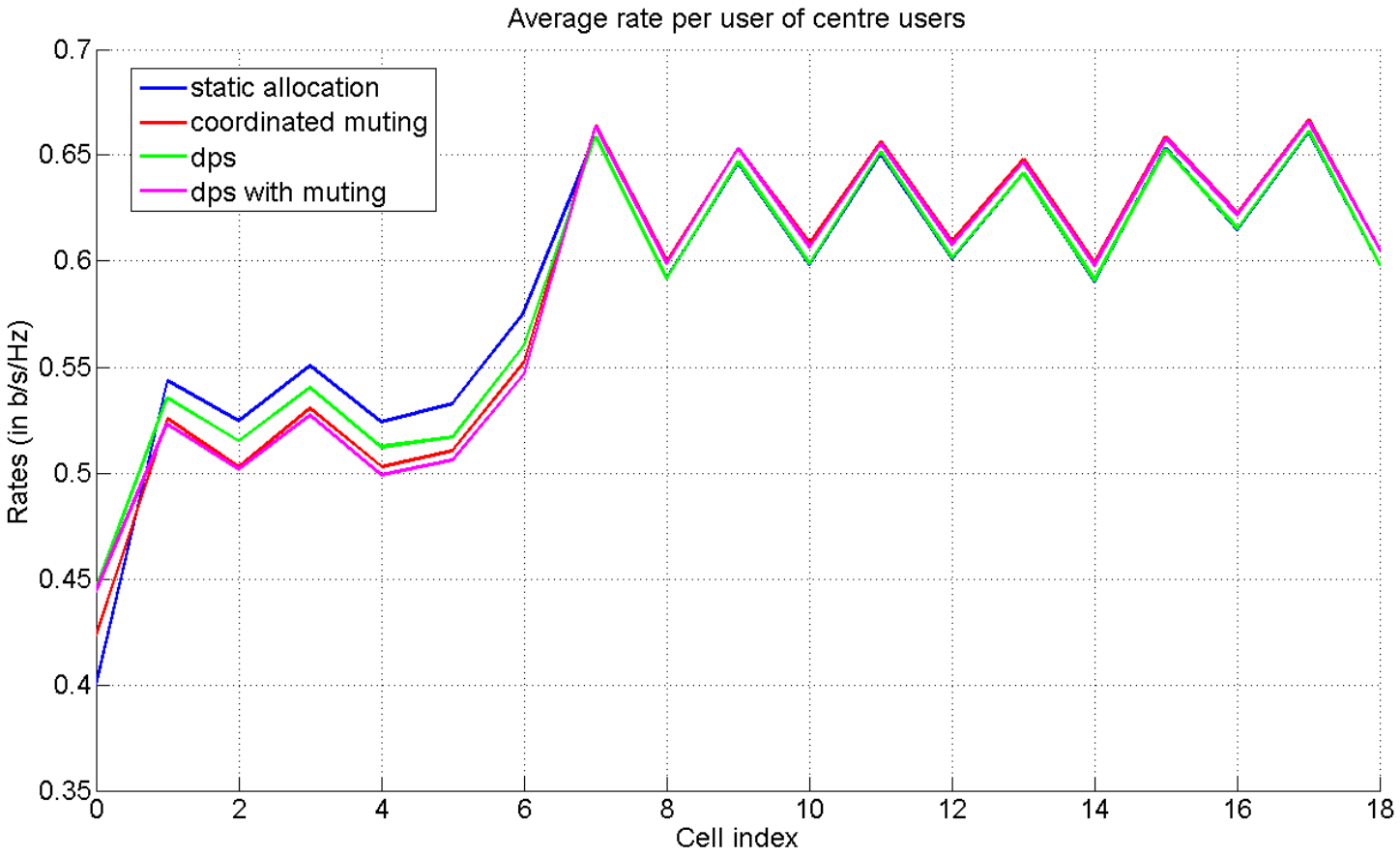
Questions?

Backup Slides

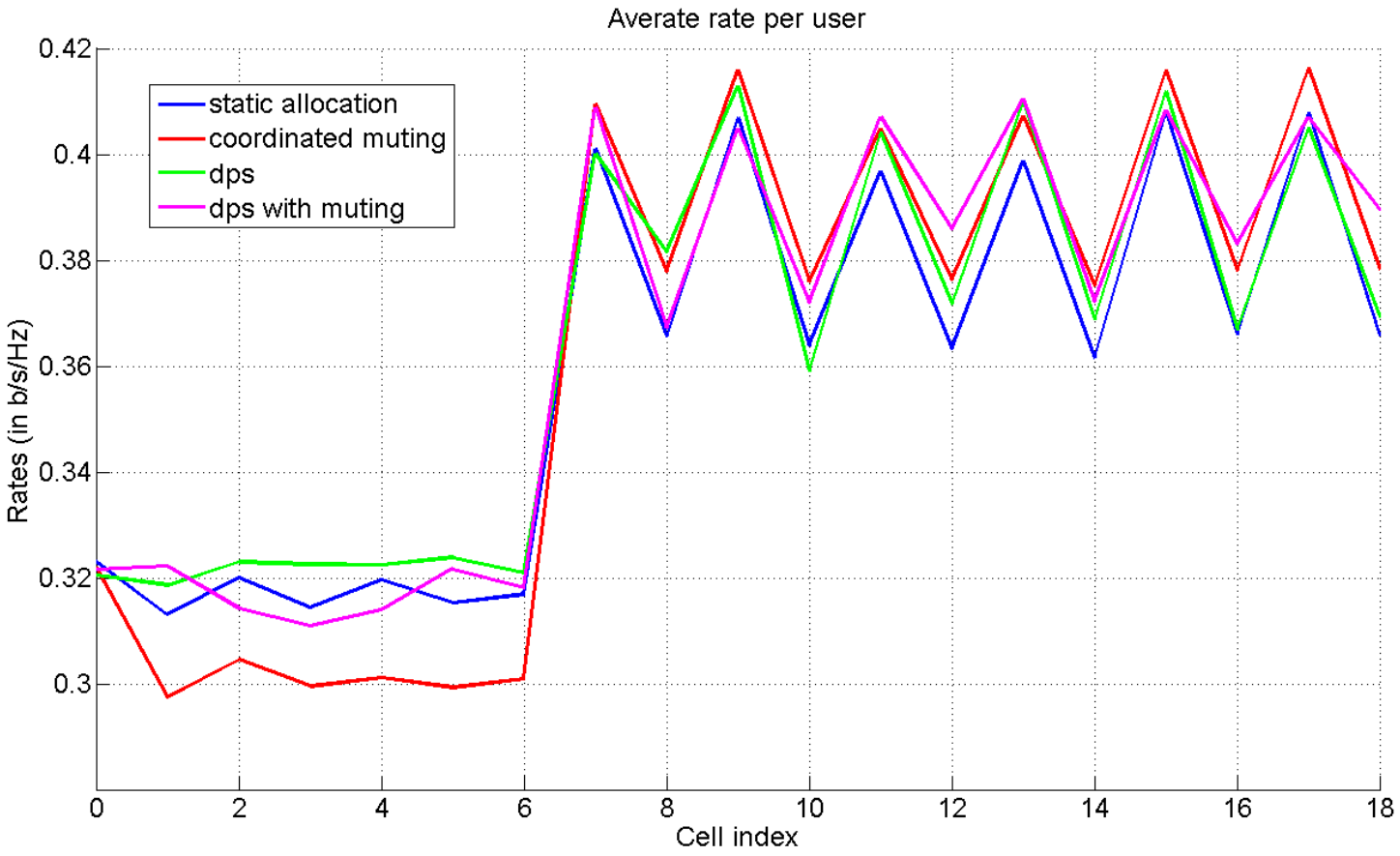
Case 1


Average rate per user
static allocation
coordinated muting
dps
dps with muting
Rates (in b/s/Hz)
Cell index
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0
2
4
6
8
10
12
14
16
18

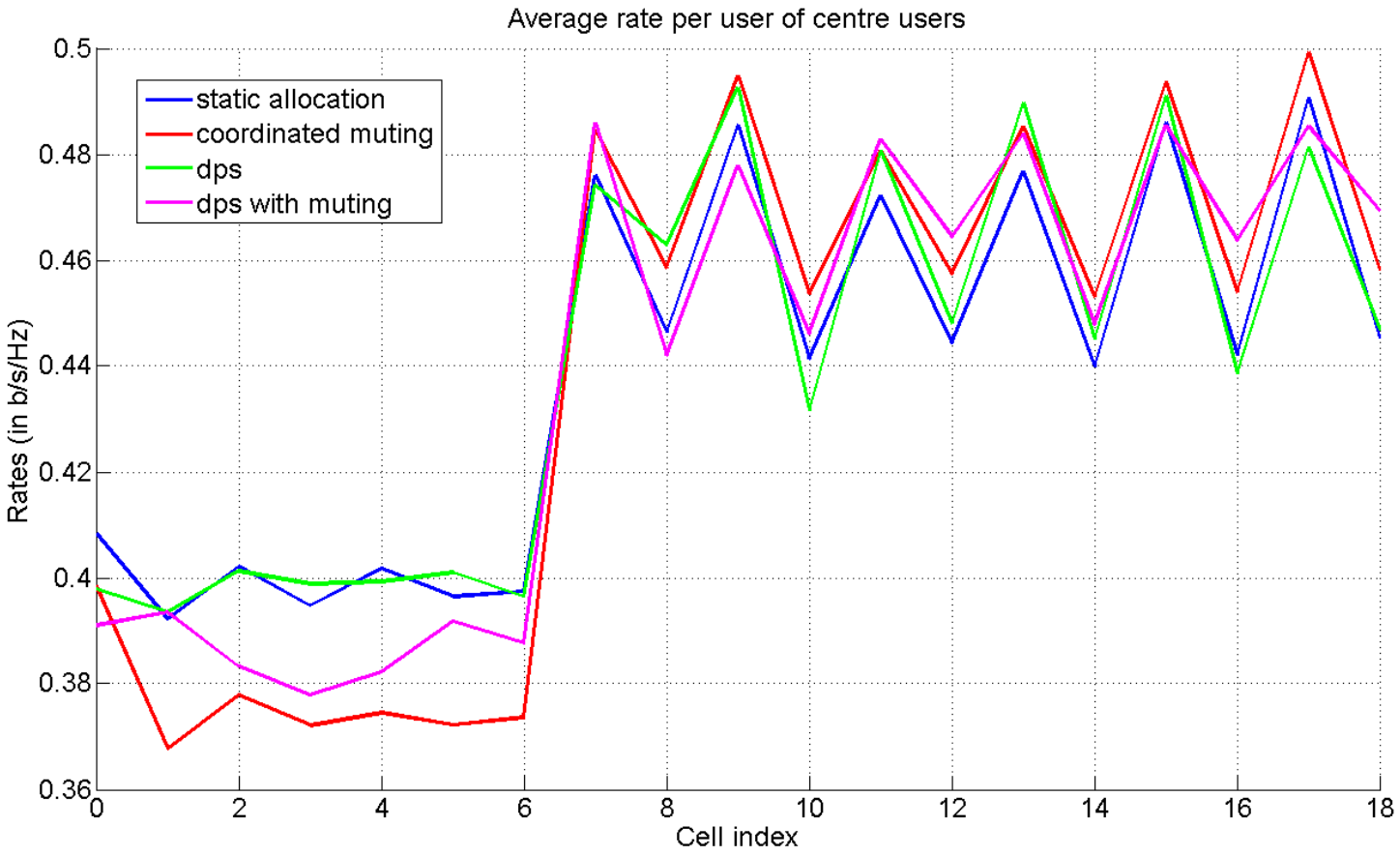
Case 1


Average rate per user of centre users
static allocation
coordinated muting
dps
dps with muting
Rates (in b/s/Hz)
Cell index
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0
2
4
6
8
10
12
14
16
18

Case 2


Averate rate per user
static allocation
coordinated muting
dps
dps with muting
Rates (in b/s/Hz)
Cell index
0.42
0.4
0.38
0.36
0.34
0.32
0.3
0
2
4
6
8
10
12
14
16
18

Case 2


Average rate per user of centre users
static allocation
coordinated muting
dps
dps with muting
Rates (in b/s/Hz)
Cell index
0.5
0.48
0.46
0.44
0.42
0.4
0.38
0.36
0
2
4
6
8
10
12
14
16
18