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Soft Frequency Reuse in Next Generation OFDMA Networks

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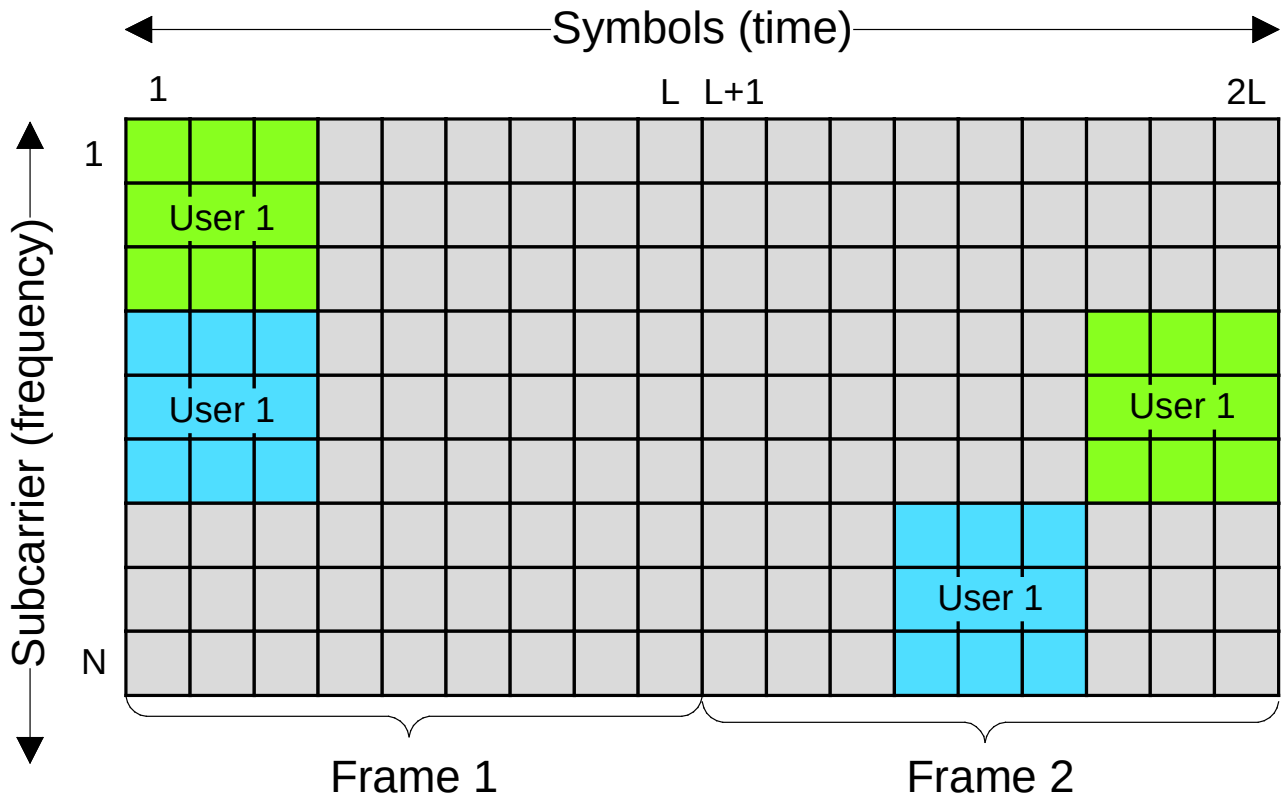
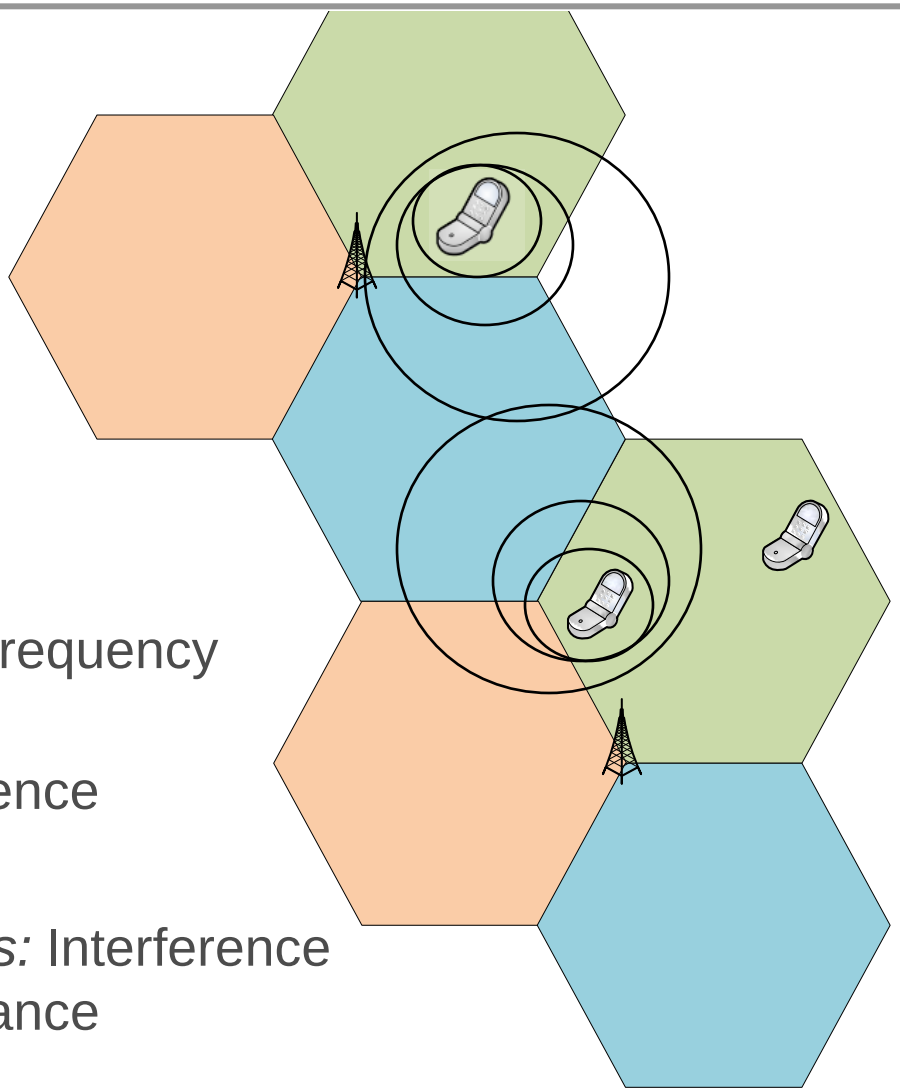
Orthogonal Frequency Division Multiple Access



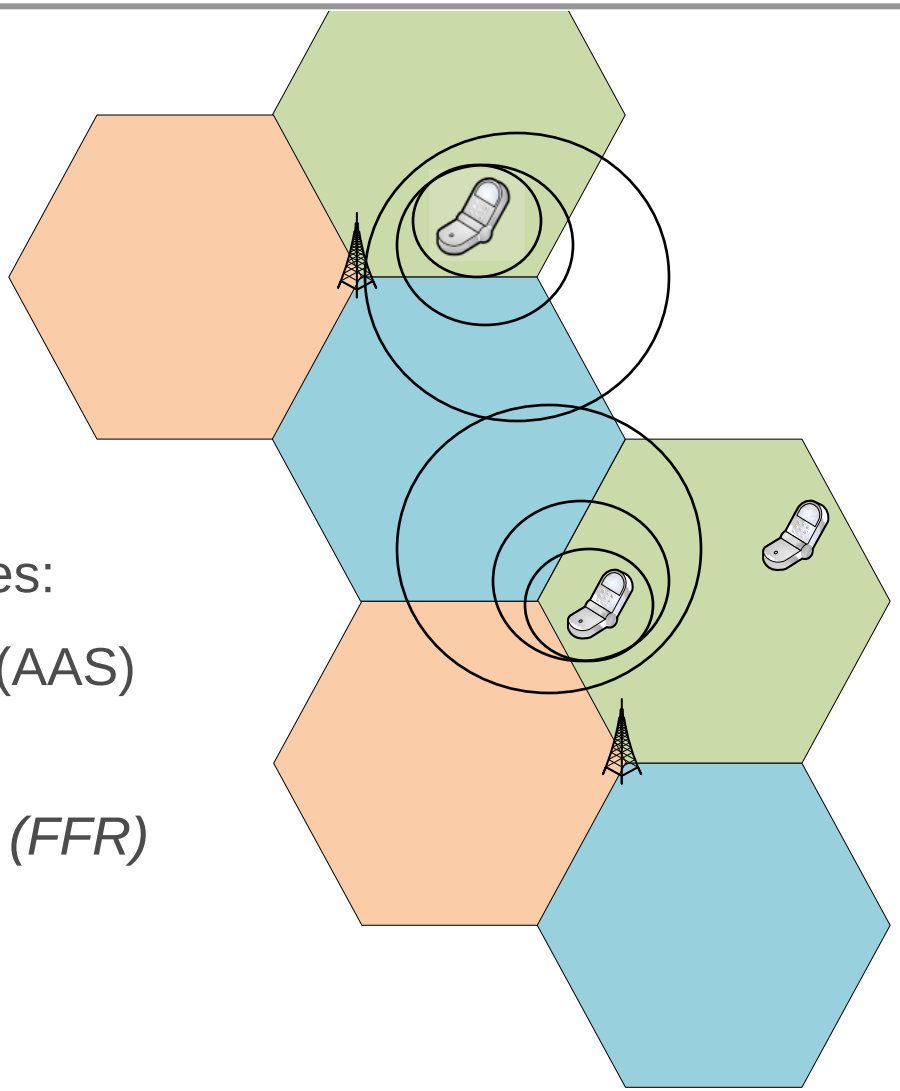
- Used in modern communication standards
  - 3GPP LTE
  - IEEE 802.16e

Inter-cell Interference



- *2G wireless systems*: Complex frequency planning
- *3G systems:* Full reuse, Interference averaging
- *Next generation mobile networks:* Interference coordination, interference avoidance

Inter-cell Interference



- *WiMAX 802.16m*

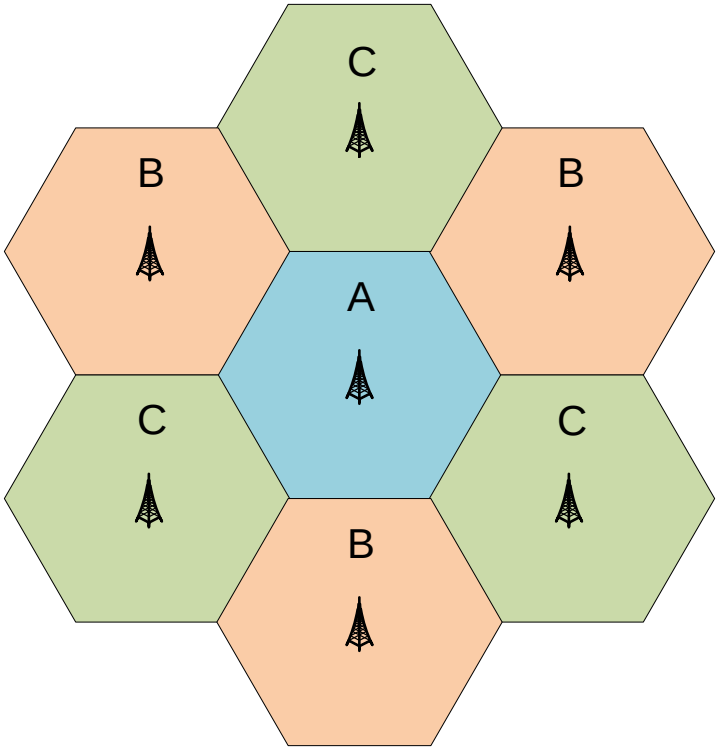
  Interference mitigation techniques:

  - Advanced antenna systems (AAS)
  - Beamforming techniques
  - *Fractional Frequency Reuse (FFR)*

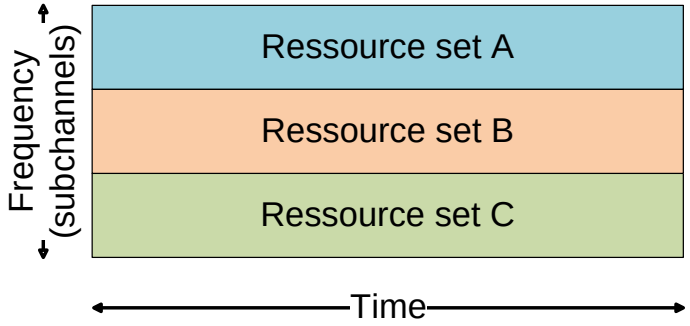
Description of Fractional Frequency Reuse and Soft Frequency Reuse

TECHNICAL BACKGROUND

Frequency Reuse 3



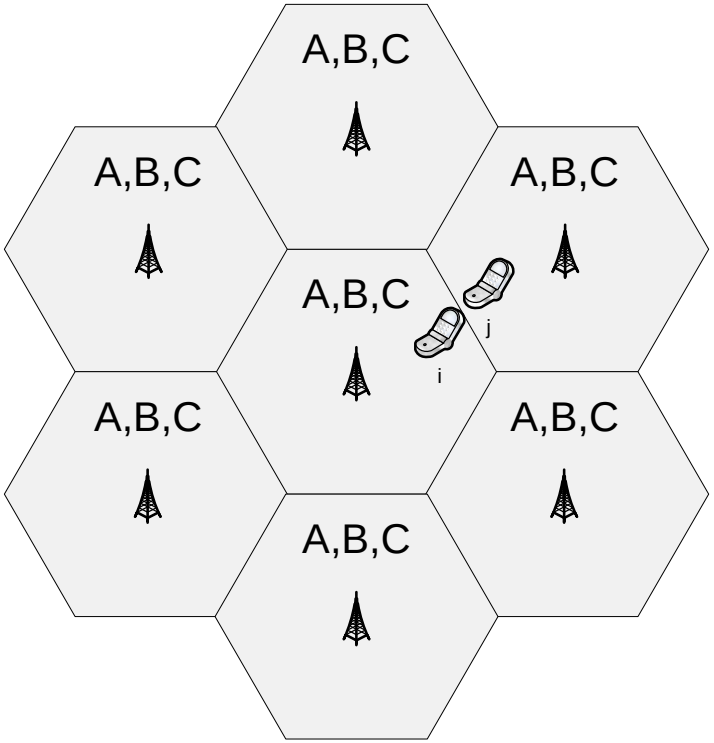
- Frequency partitioning
- Adjacent cells on different bands



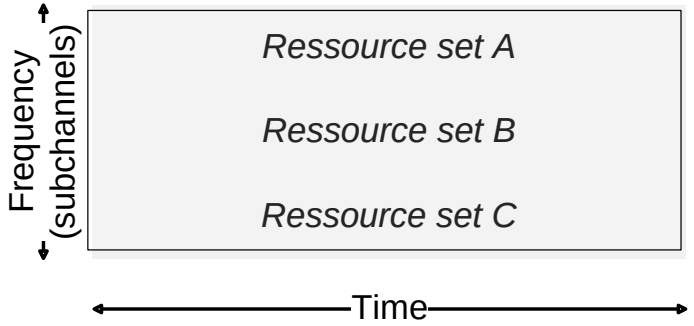
\+ Low inter-cell interference

– Inefficient frequency use

Frequency Reuse 1

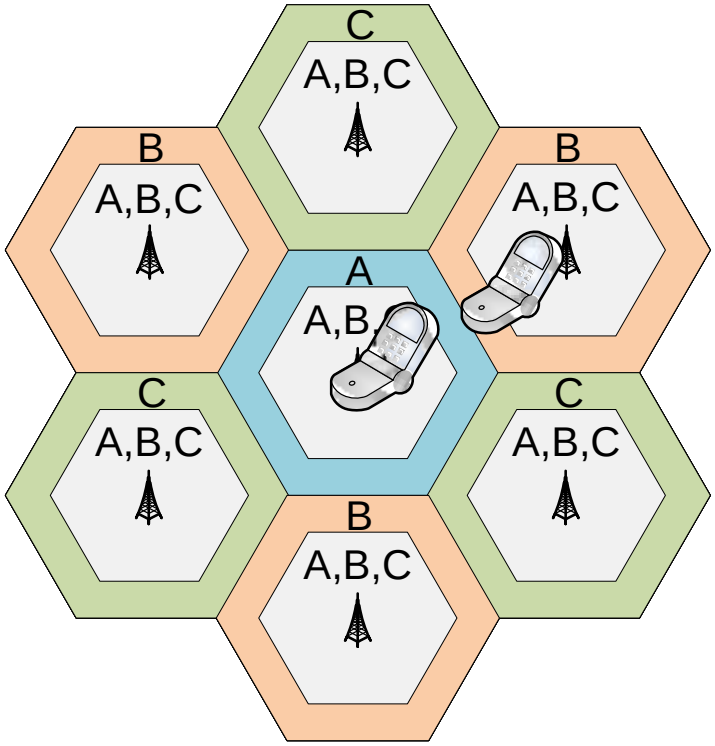


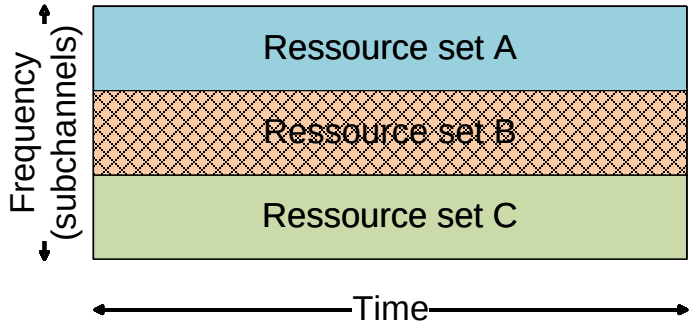
- Frequency universally reused



+ High spectral efficiency
– Requires power control or sophisticated mitigation techniques

Fractional Frequency Reuse





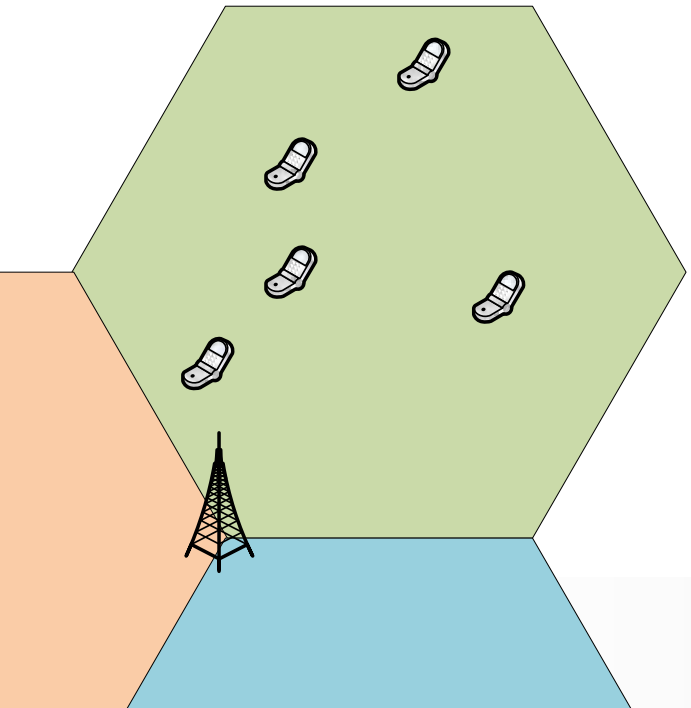
- Best of both worlds?
  - FFR has proved to be successful in the downlink
- Why does the downlink differ from the uplink?

Problem Formulation and Description of the Simulation

EVALUATION

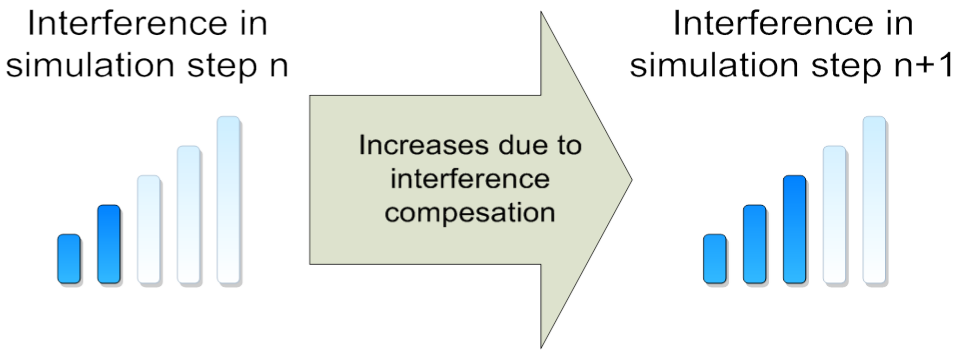
Problem Formulation

- Which users belong to the cell center/edge?
- How many users for the cell center?
- How much resources and which transmit power?



- Modulation and Coding Scheme
  - Channel quality
  - Efficiency (bits/symbol)

Iterative Monte-Carlo Simulation



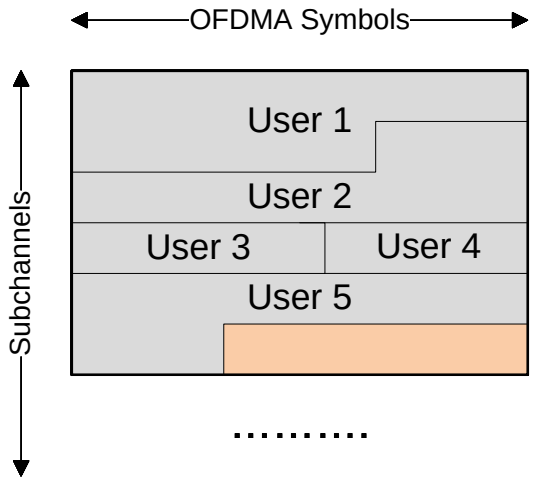
1. Allocate resources
2. ~~Time-invariant~~ Derive resulting interference
3. Repeat

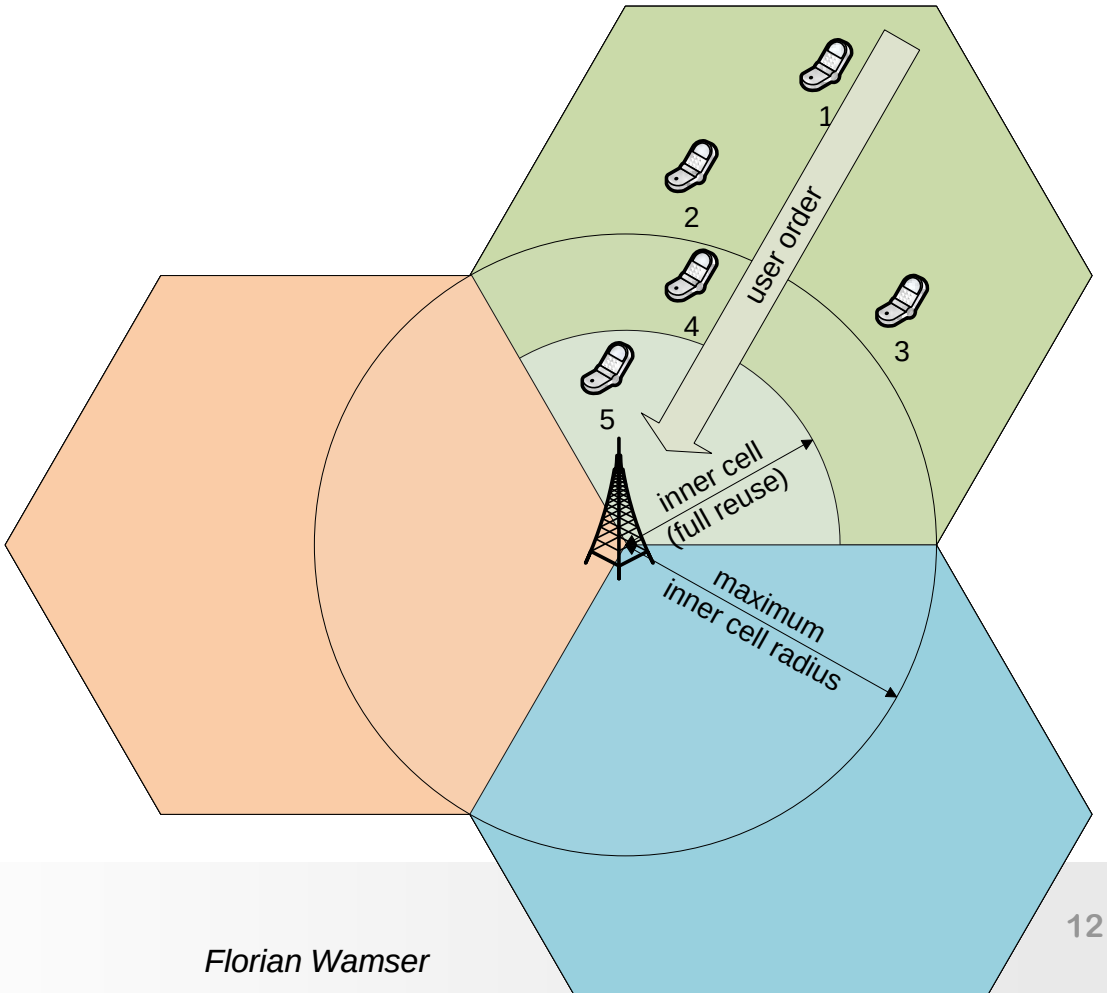
instead

- Focus on
  - different user distributions
  - *resource allocation*
  - power control

Structure of the Resource Allocation Algorithm

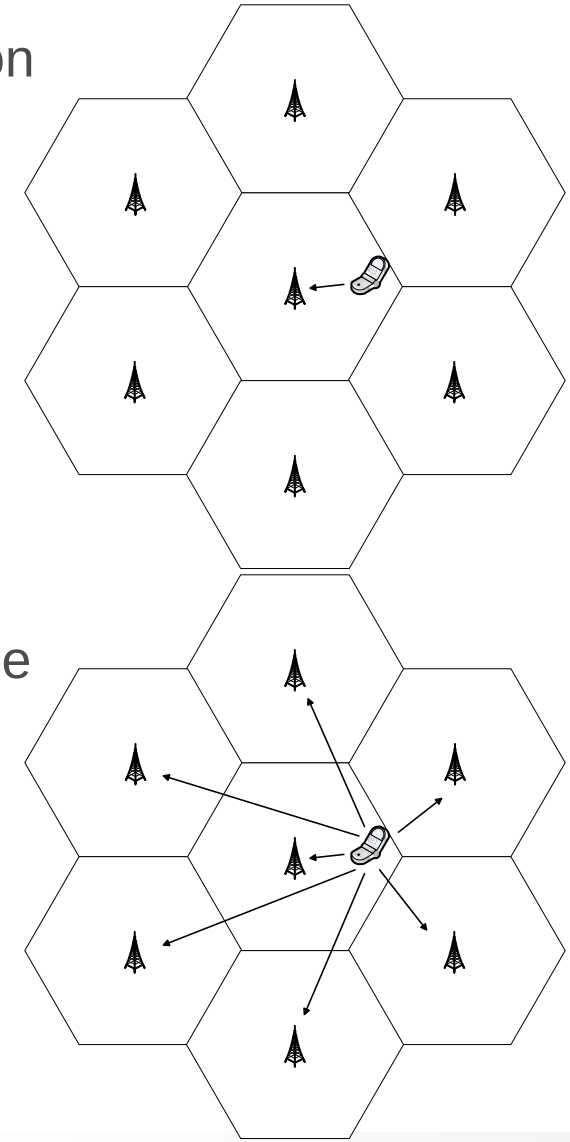
1. User order metrics
2. Home-band allocation
3. Side-band allocation
4. Outage selection

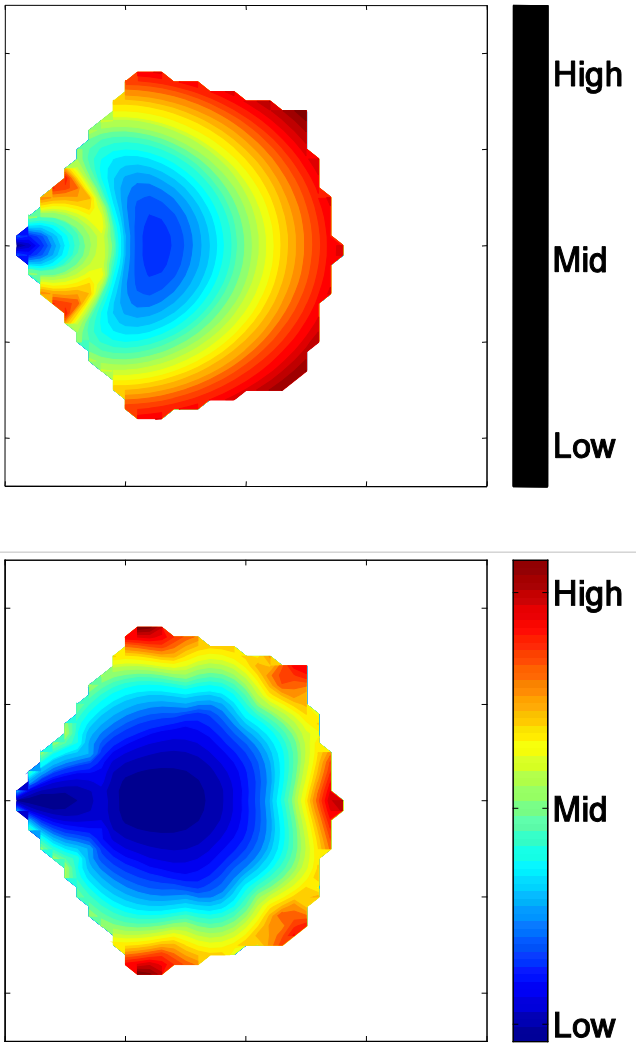




User Order Metric

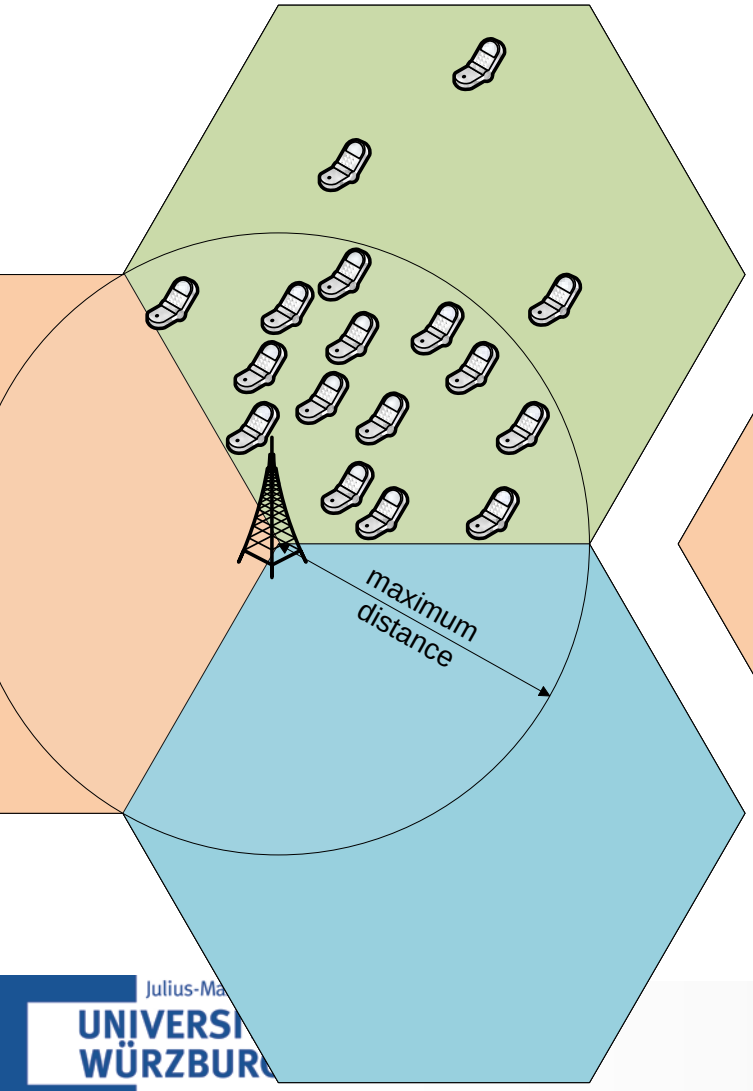
- Propagation loss
- Interference sum



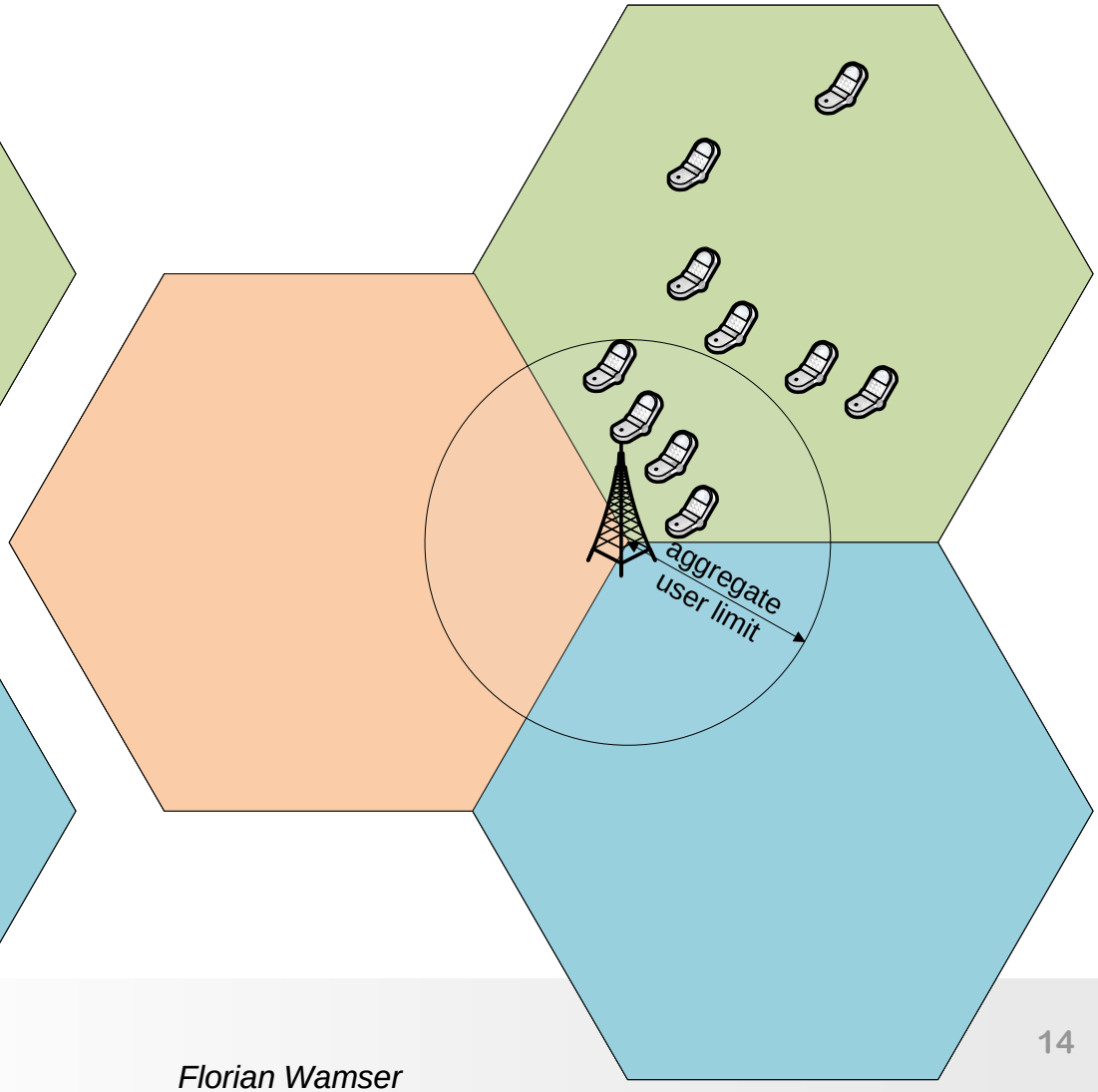


Limitation of the Inner Cell

- Individual limitation



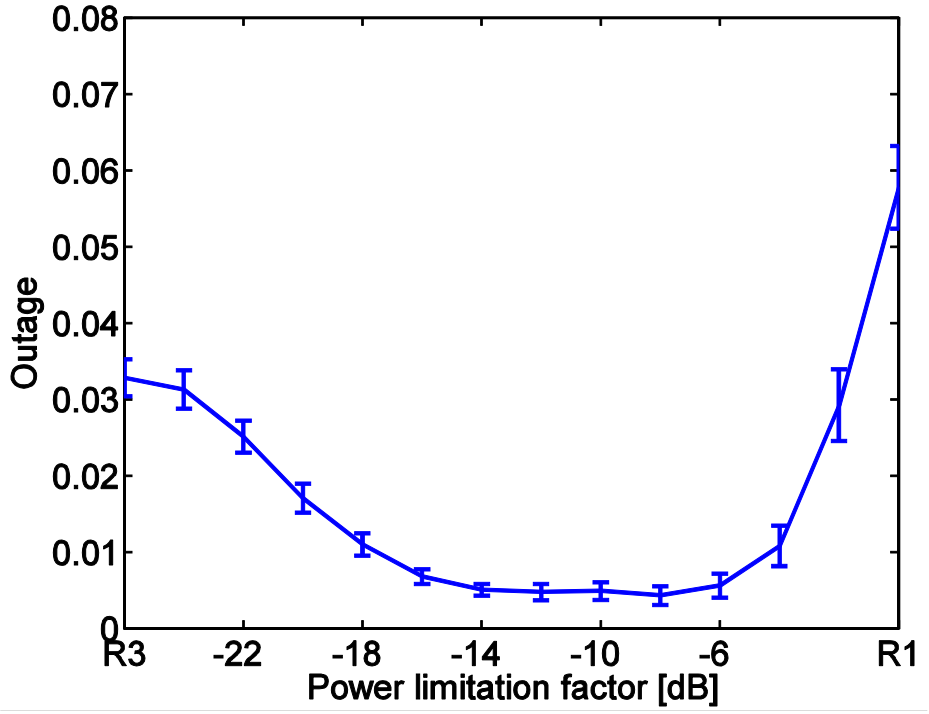
- Aggregate limitation

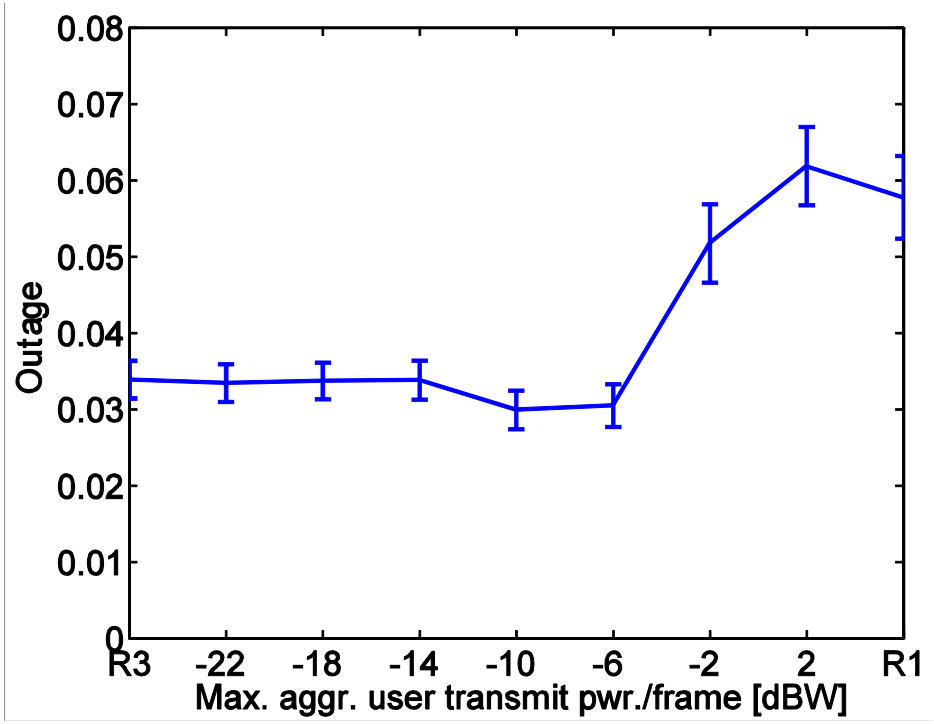


Remarkable Outcome and Findings

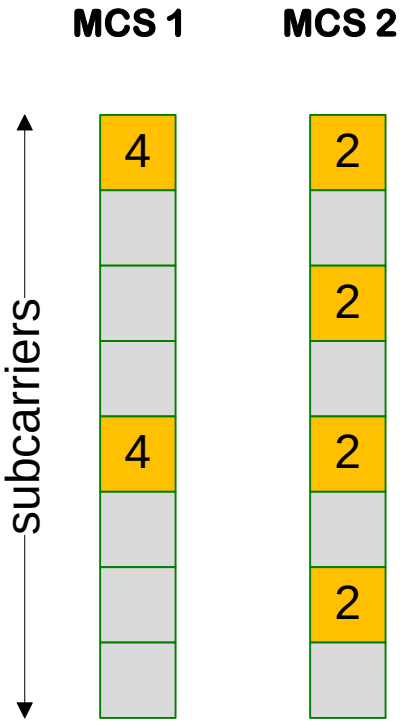
RESULTS

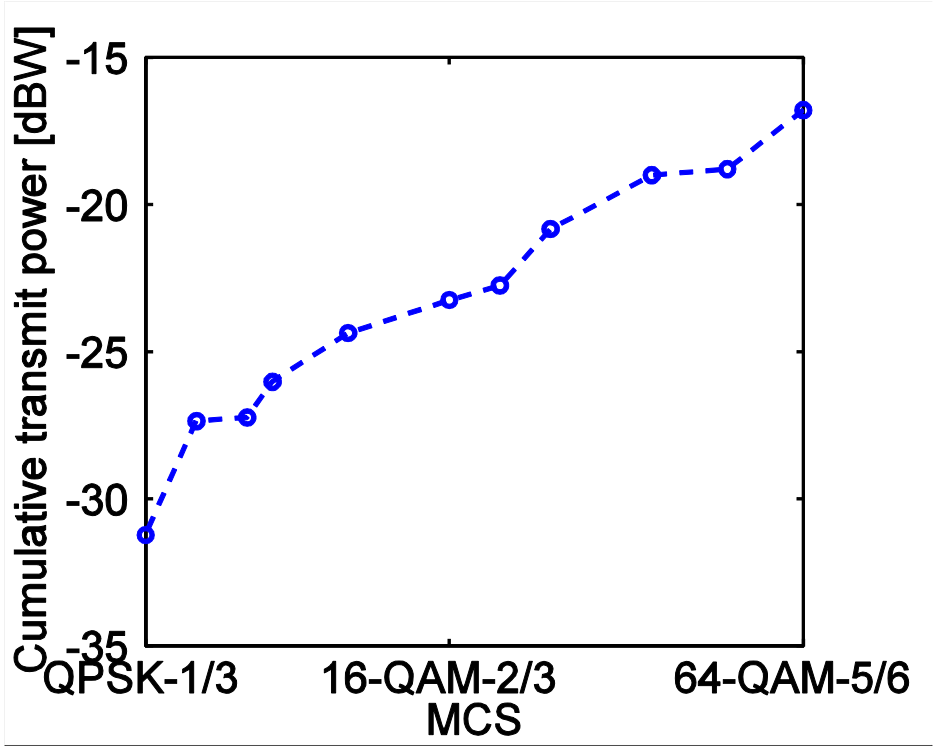
Limitation of the Inner Cell





MCS Optimization

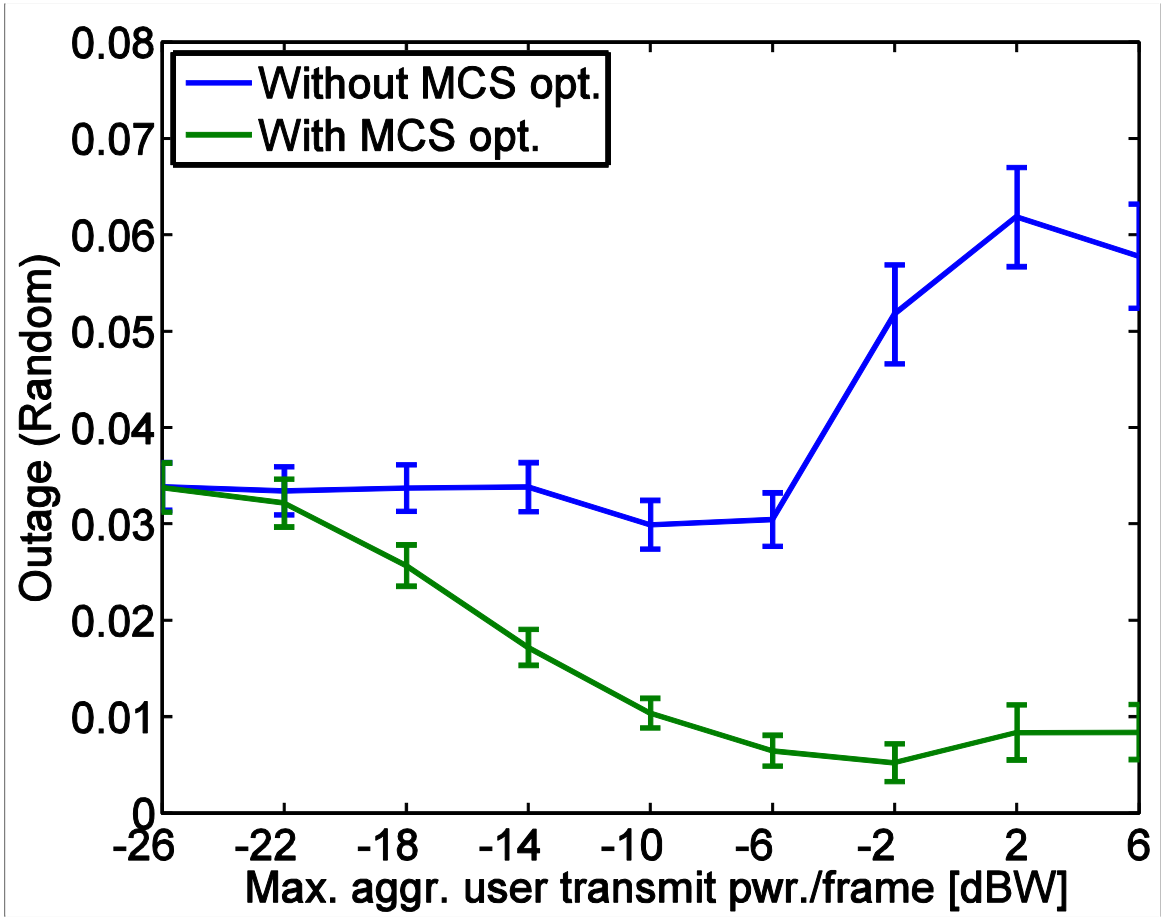




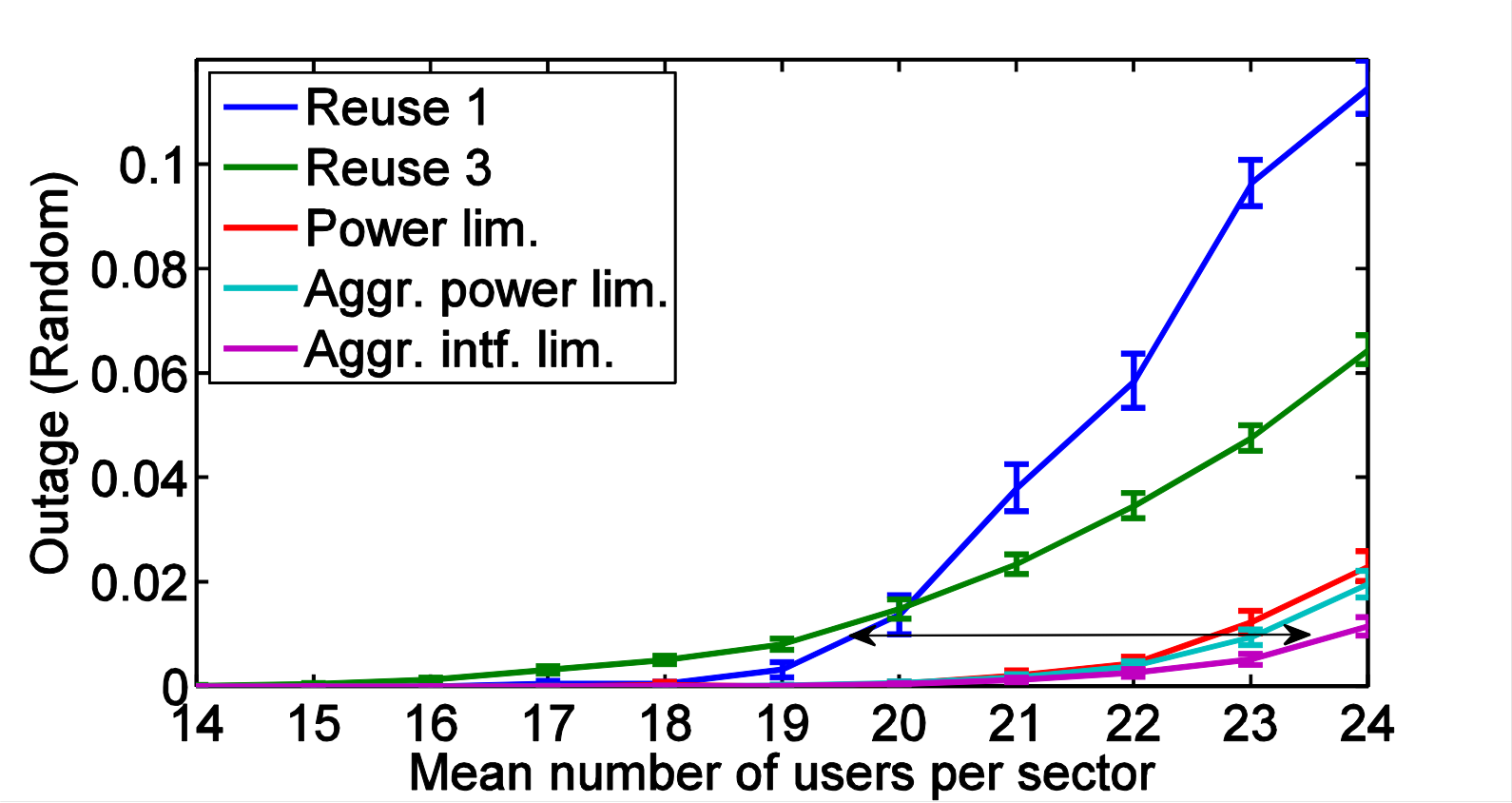
$$P_1 > P_2$$

$$C = \frac{1}{2}\log_2\left(1+\frac{S}{N}\right)$$

Results (1)


Without MCS opt.
With MCS opt.
Outage (Random)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-26
-22
-18
-14
-10
-6
-2
2
6
Max. aggr. user transmit pwr./frame [dBW]

Results (2)


Reuse 1
Reuse 3
Power lim.
Aggr. power lim.
Aggr. intf. lim.
Outage (Random)
0
0.02
0.04
0.06
0.08
0.1
14
15
16
17
18
19
20
21
22
23
24
Mean number of users per sector

Conclusion

- Introduction to inter-cell interference and Fractional Frequency Reuse in the Uplink

- Time-invariant Monte-Carlo simulation
- Evaluation of different resource allocation algorithms

- Trade-off between resource efficiency and interference
- Fractional Frequency Reuse can provide a high capacity gain

- Open fields of research
  - Clustered user distributions
  - Partial reuse
  - Time dynamic

Questions

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