4G LTE CoMP, Coordinated Multipoint

4th Semester Institute Project

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Motivation

- CoMP: optimizing performance by sending and receiving data to and from User Entities from several points
- Especially important on cell edges
- Aim: improving quality for user, optimum capacity of network
- CoMP still in development (not included in LTE Rel. 10)

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Background

- Papers on LTE-A, Joint Transmission, Beamforming and CoMP in general
- Reference: MATLAB-based down- link physical-layer simulator for LTE (Mehlführer, C., 2009)
  - MATLAB-based downlink physical-layer simulator for LTE
  - covering Multi-Cell Multi-User simulation scenarios -> most realistic

Scheduling

- assignment of resource blocks (RB) to each user
- i.e. Round Robin (timeslots divided equally between users)
- dynamic scheduling: mapping RBs to users based on different criteria

SINR

- signal-to-interference-plus-noise ratio

$$\frac{S}{I+N} \tag{1}$$

  - S = power of signal
  - I = power of interference
  - N = power of noise
- used to determine signal quality

CQI and channel modulation

- Channel Quality Indicator
- determines modulation
  - transfer block size (TBS)
  - resource blocks for users
- depends on SINR
- Best CQI scheduling: maximation of rate, but unfair (only UEs with very good channels get scheduled at all) -> "fair" modulation necessary

CoMP - overview

- LTE Advanced: major enhancement of the LTE standard
- CoMP: Coordinate MultiPoint operation
  - refers to wide range of techniques
  - dynamic coordination or transmission and reception with multiple geographically separated eNBs (base stations)
  - goal: enhancing overall system performance, more effective use of resources, improved end user service quality (especially at the cell edges)

CoMP: major categories

Joint Processing (JP)

- Joint Transmission (JT)
- Dynamic Point Selection (DPS)
  - with muting
  - without muting

Coordinated Scheduling (CS) / Coordinated Beamforming (CB)

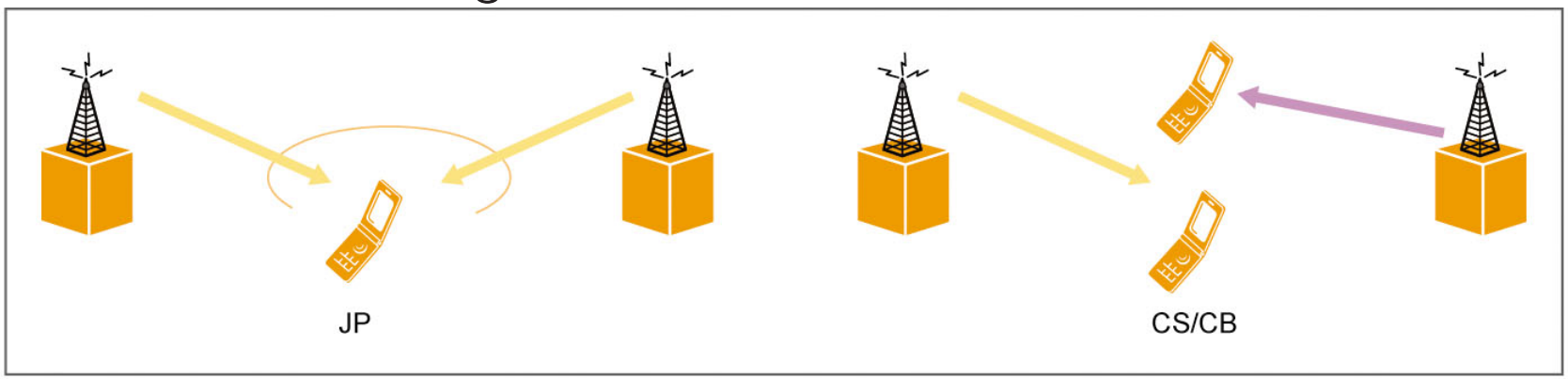

Figure 4. Principle of CoMP.

Coordinated Scheduling (CS)

- data available at one node
- transfered packets do not overlap in time
- TODO insert graphic: timesteps

Background - Dynamic Point Selection

Dynamic Point Selection (DPS)

- data usually available at several nodes
- user decides per packet which base station is best
- TODO insert graphic: timesteps

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System Model - Assumptions

- UE Location is known
- UE does not move so no Dopplereffect or similar effects
- CQI, PMI, RI are randomly generated
  - PMI depends on generated CQI
- Fixed number of UEs in a simulation
- Mean values of the Rayleigh distribution (provided from 3GPP)
- Basestations are created in a hexagonal layout

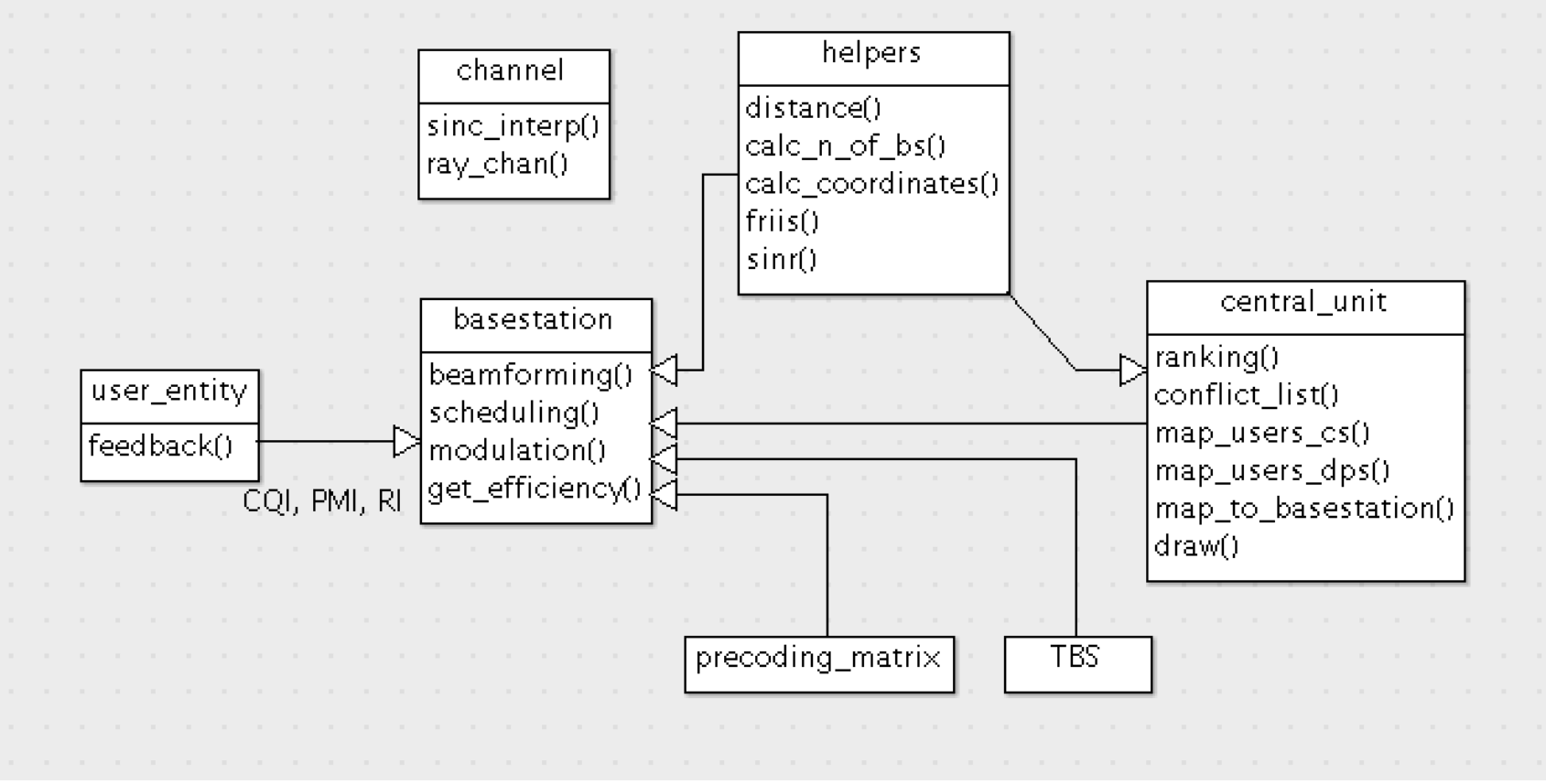
System Model - Programming

- Classes providing main functionality: Central Unit, Base Station, User Entity, Channel
- Classes providing background data and auxiliary functions: TBS, helpers, params, precoding matrix

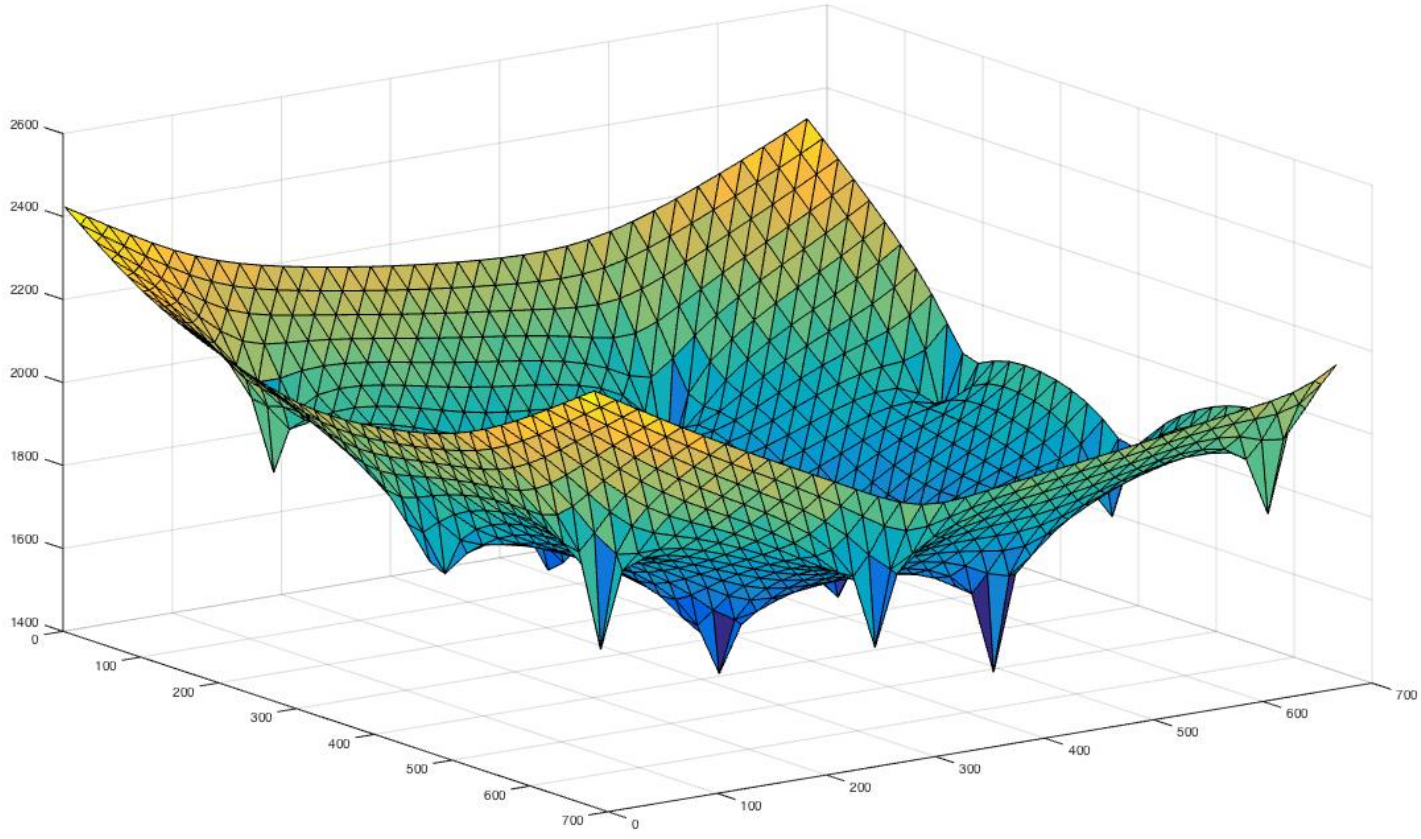
System Model - Classes providing main functionality

- Central Unit
  - Coordinates all base stations
- Base Station
  - Matches subcarriers to connected users, calculates modulation
- User Entity
  - Returns feedback to each base station
- Channel
  - Certain frequency and amount of subcarriers
  - Friis equation for calculation of path loss
  - Model - Rayleigh channel

Class Overview



SINR Profile



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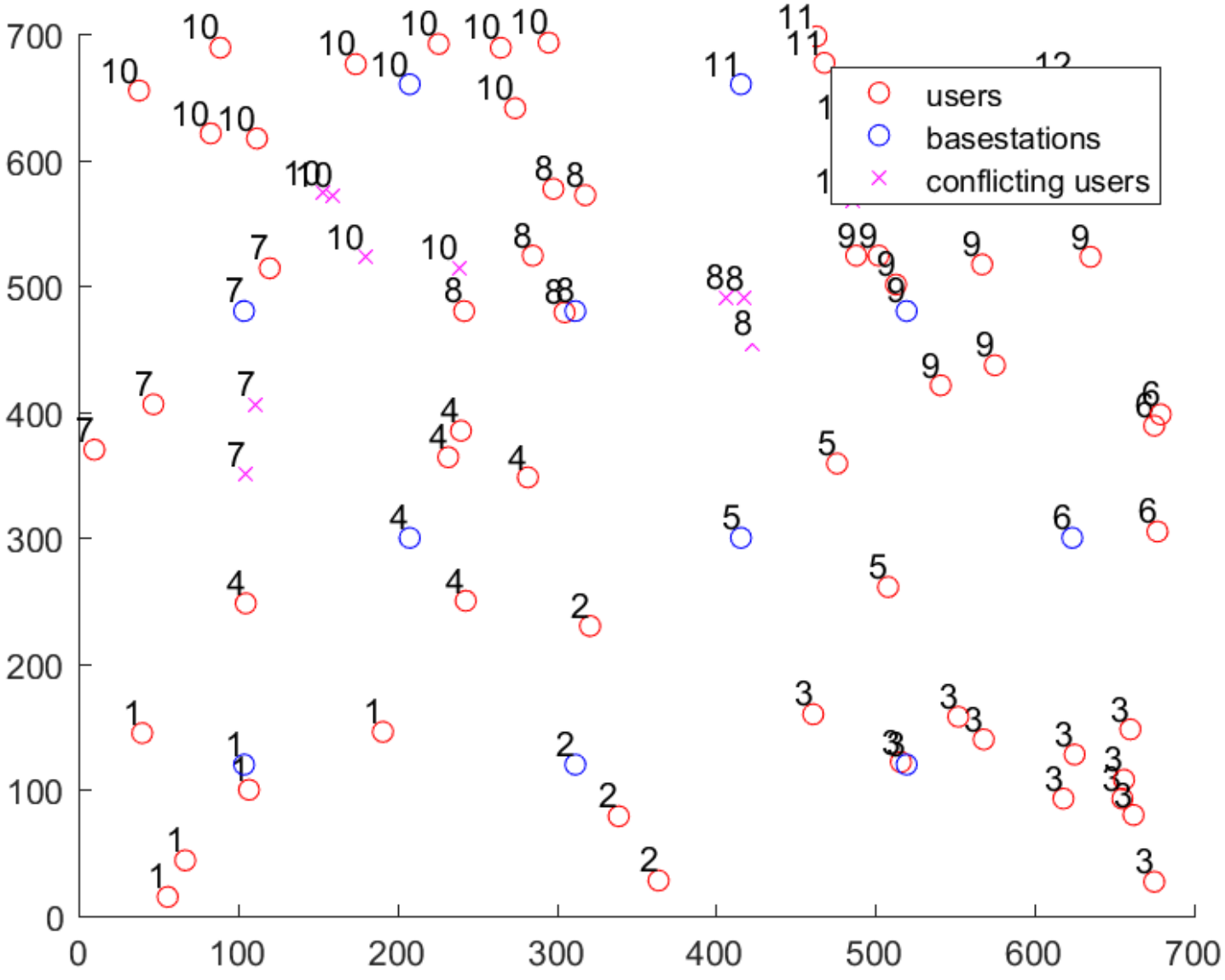
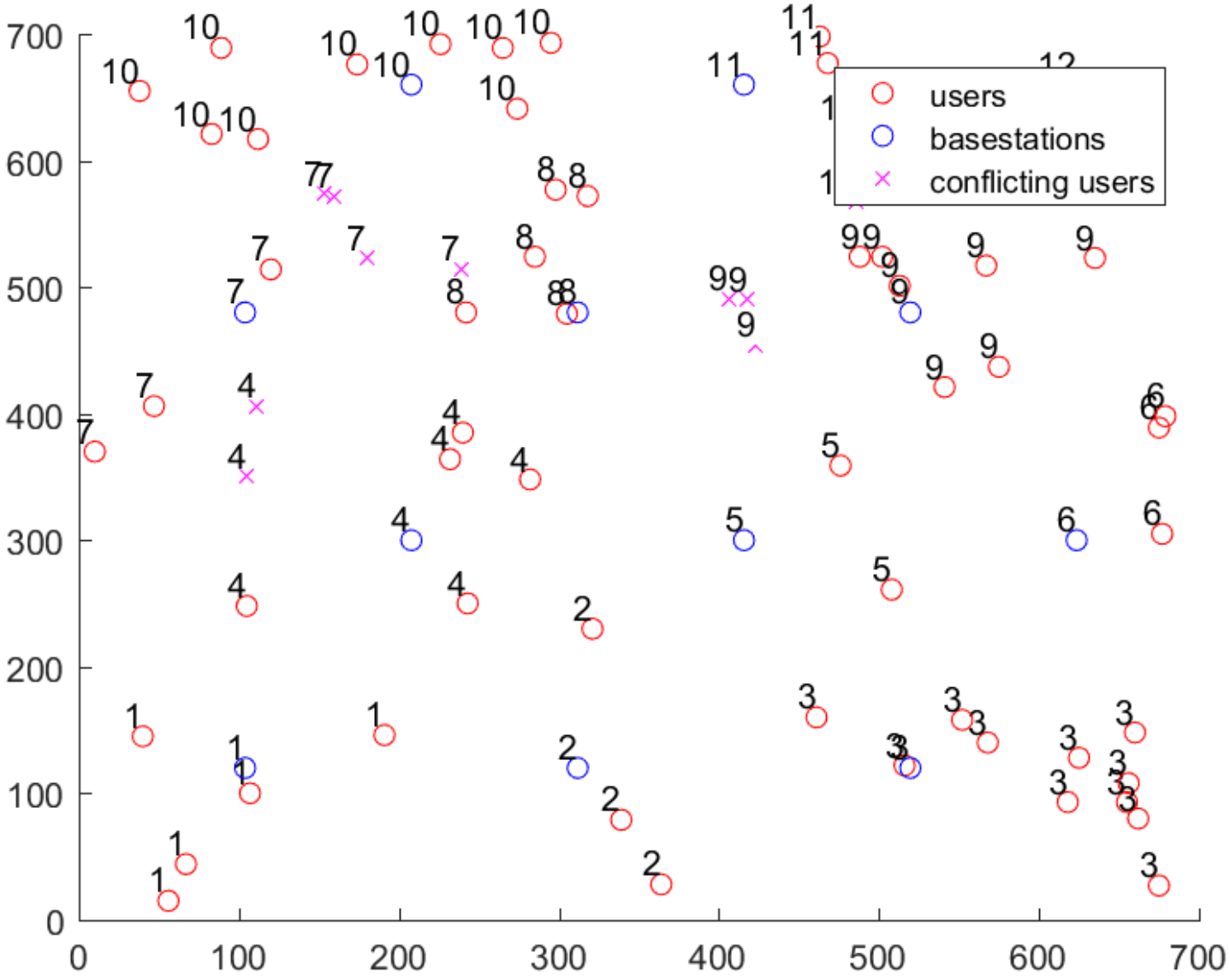
Simulation - main characteristics

- Flexibility
- Simulation Process
  - Initialization
  - Simulation Cycle
    - mapping of users to basestations
    - assignment of recourceblocks to users
    - calculation of the best modulation and coding scheme

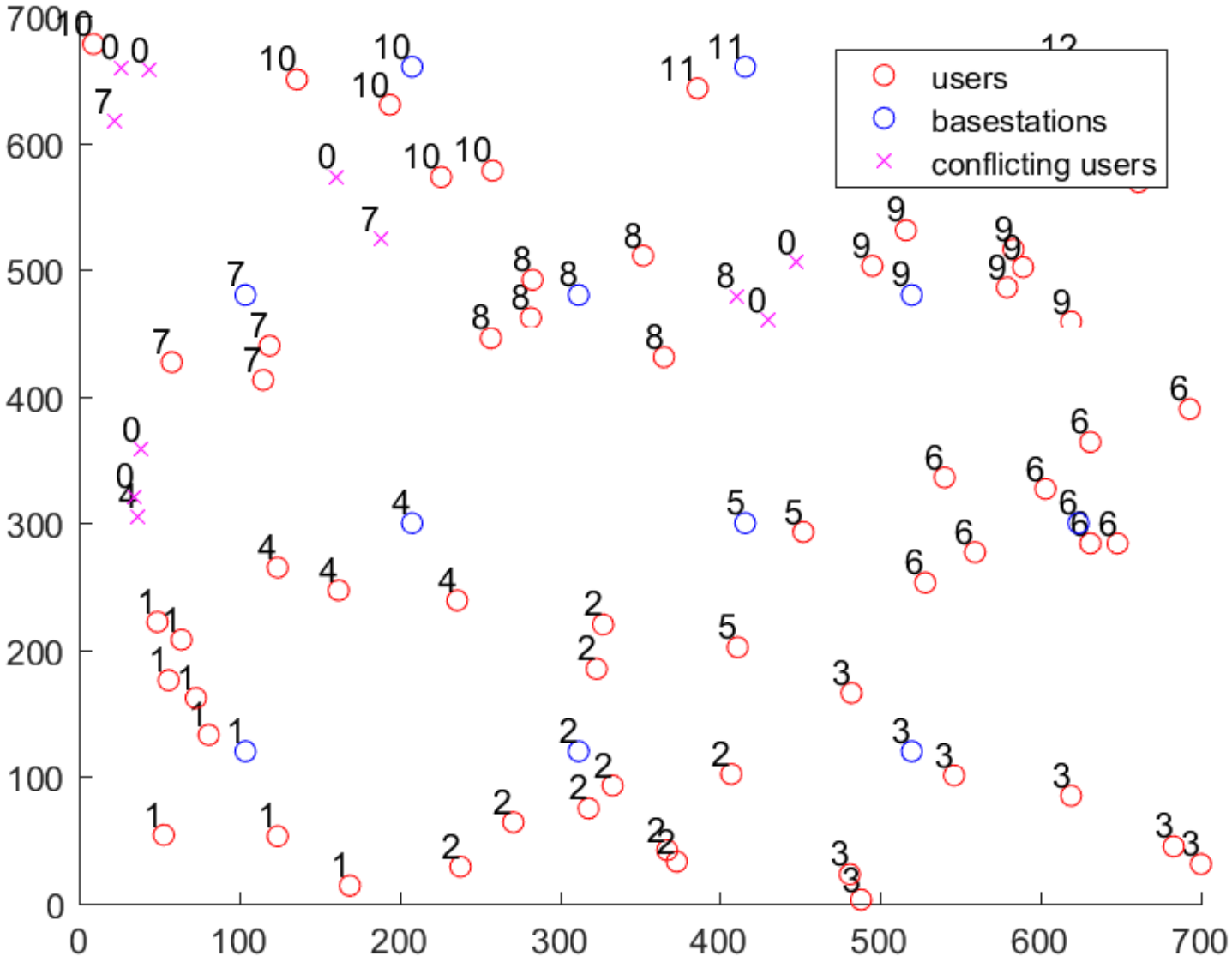
Simulation DPS I



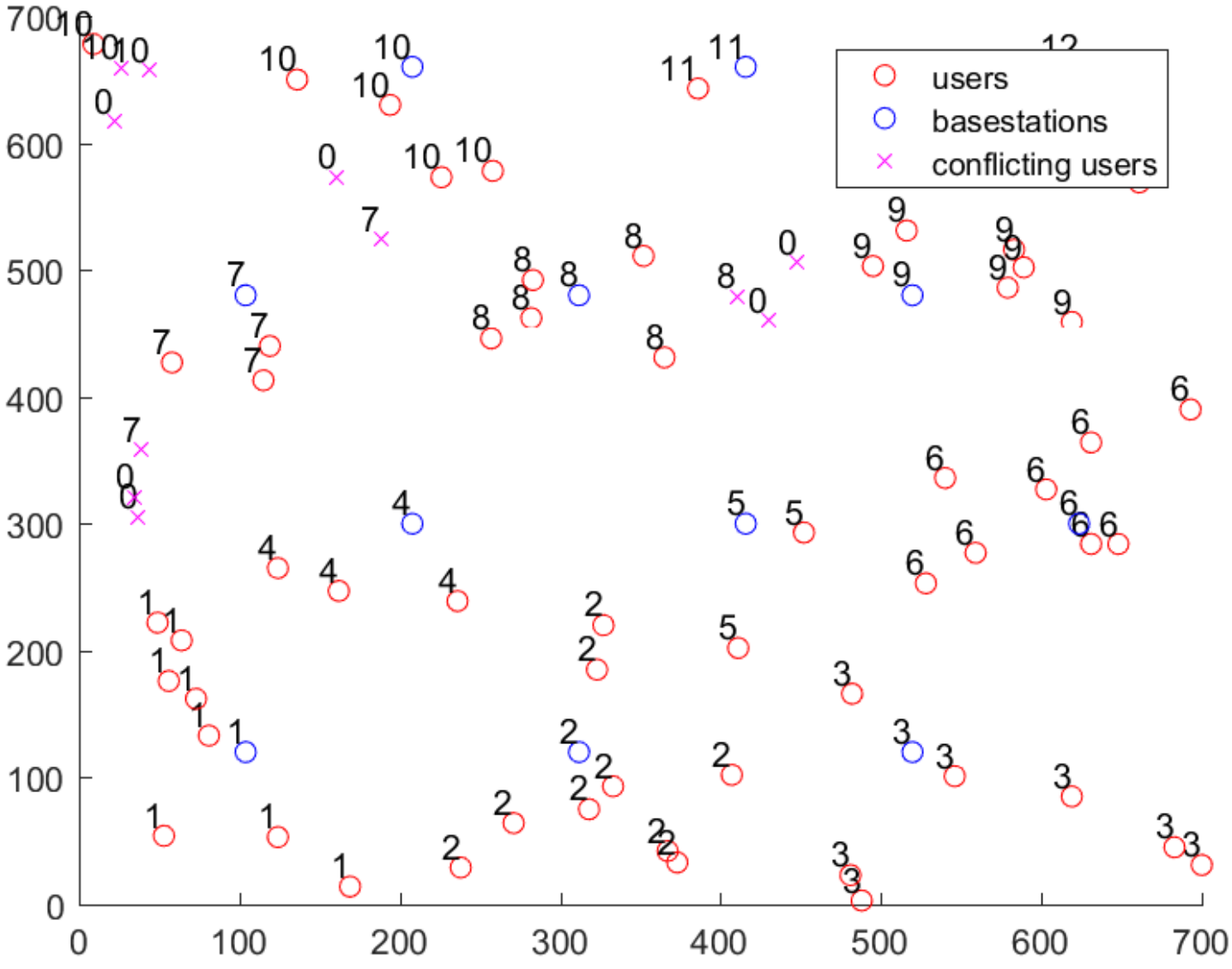
Simulation DPS II



Simulation CS I



Simulation CS II



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Evaluation

- Cost = additional backhaul
- Use = less interference at cell edges
- (I need graphics for the following slides)

Advantages

- CoMP allows better allocation for users at cell edges –> more receiving power
- Utilization of different subcarriers inside conflict zones avoids interference

Disadvantages

- Computational power and time loss
- Bigger signaling overhead between users and base stations
- More frequent communication with the CU –> bigger backhaul needed

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Conclusion

- Main functionalities for a LTE-Advanced simulator implemented
  - Implementation of **Coordinated Scheduling** and **Dynamic Point Selection**
  - Comparison with system behaviour without CoMP
- Advantages of CoMP mainly for users at cell edges
  - Profitability vs backhaul/signaling trade-offs should be evaluated on a case-by-case basis
  - Possible solution: activating Coordinated Multipoint only as a certain conflict density in the simulated environment is reached

Project goals reached

- Analysis of behaviour of frequency flat, slow fading channels
- Differences between SISO and MIMO channel models and their implications
- Criteria for estabishling a state of conflict between different user entities
- Choice of channel modulation based upon generated feedback
- Allocating users to base stations according to selected CoMP scheme

Learning goals reached

Programming

- **Object-oriented programming** on MATLAB
- Graphical representation of simulation results
- Working with parameter files/external files (e.g. precoding matrix) and already existing MATLAB libraries
- Defining model simplifications while still mantaining a degree of correctness

Learning goals reached

Soft skills

- Collection of preliminary informations through approach to English language scientific literature
- Teamwork: weekly meetings and frequent contacts with the project supervisors
  - Task division in the team according to current needs and time availability
- Debugging and version control on GitHub
- LaTeXbasics for the final presentation

What comes next?

- Implementation of other CoMP schemes, e.g. coordinated beamforming
- Different channel models (e.g. *fast fading* channels)
- Further optimization of CU/BS
  - Different allocation of implementation stages between CU and BS
  - More refined scheduling patterns (currently implemented: Round Robin)
- Implementation of different environment setups and parameters

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References

- Mehlführer, C. et al, 2009. Simulating The Long Term Evolution Physical Layer. Proc. 17th European Signal Processing Conference (EUSIPCO 2009), [online]
- Davydov, A. et al, 2013. Evaluation of Joint Transmission CoMP in C-RAN based LTE-A HetNets with Large Coordination Areas. Globecom 2013 Workshop.
- Hong, M. et al, 2012. Joint Base Station Clustering and Beamformer Design for Partial Coordinated Transmission in Heterogeneous Networks.
- Sawahashi, M. et al, 2010. Coordinated Multipoint Transmission/Reception Techniques For LTE-Advanced.

Thank you for your attention!