4G LTE CoMP, Coordinated Multipoint

4th Semester Institute Project

Leonhard Hetz Philipp Braun Carmine Bianco Alissa Wenzel Matthis Dirksen

Institute for Theoretical Information Technology
Prof. Dr. Rudolf Mathar
RWTH Aachen University

July 21, 2016

Content

Content

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)

Content

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:
- 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

Coordinated Scheduling (CS) /
Coordinated Beamforming (CB)

Joint Processing (JP)

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

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

Content

System Model - Assumptions

- it is always known where a UE is
- UE does not move so no Dopplereffect or similar effects
- CQI, PMI, RI are randomly generated
- fixed number of UEs in a simulation
- using mean value of the Rayleigh distribution (provided from 3GPP)
- basestations are always in a hexagonal layout

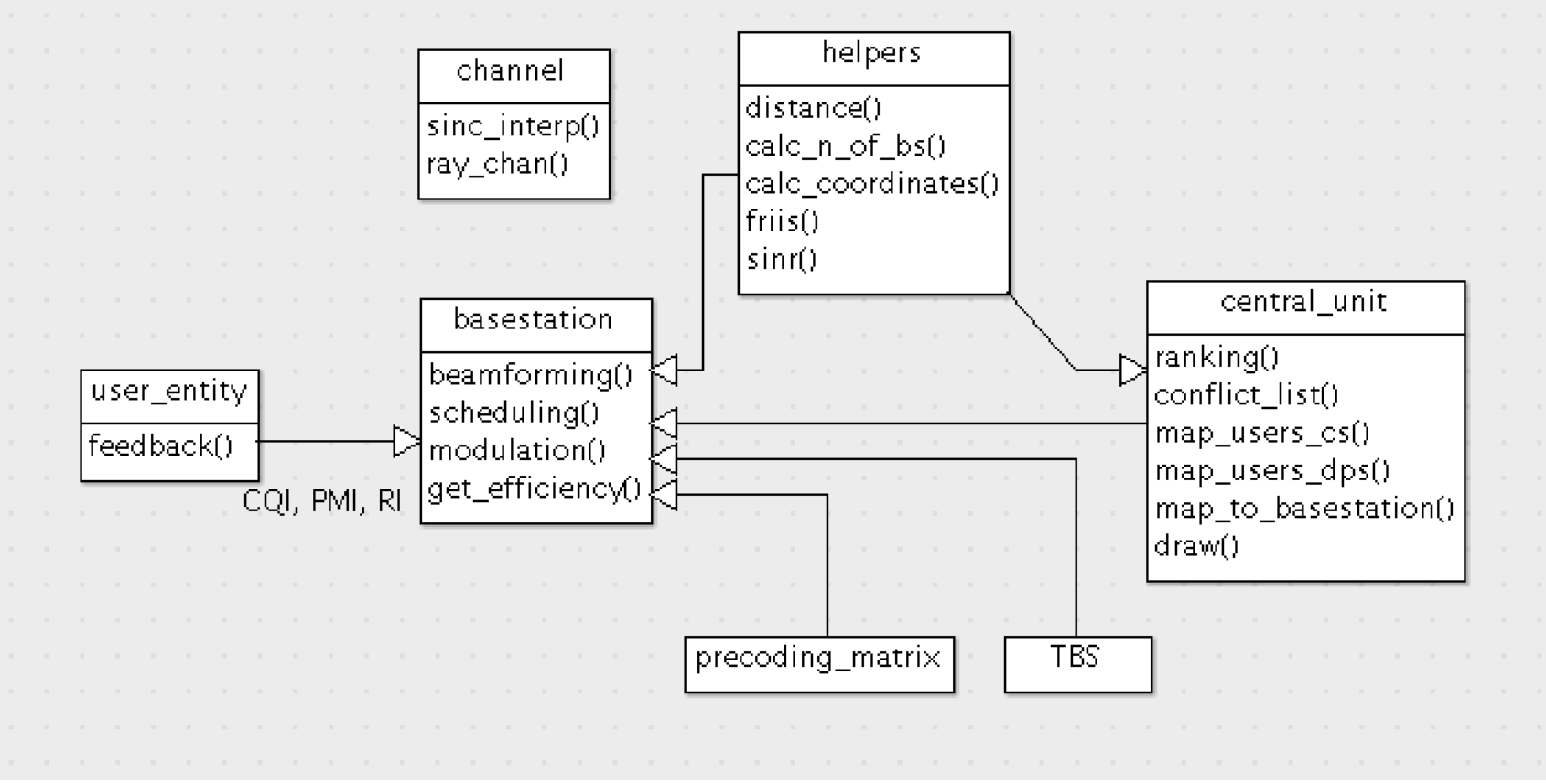
System Model - Programming

- 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
  - one CU per simulation
- Base Station: matches subcarriers to connected users, calculates modulation
- User Entity: returns feedback to the base station
- Channel: has a certain frequency and amount of subcarriers
  - Friis equation for calculation of path loss
  - model: Rayleigh channel

Overview of the classes

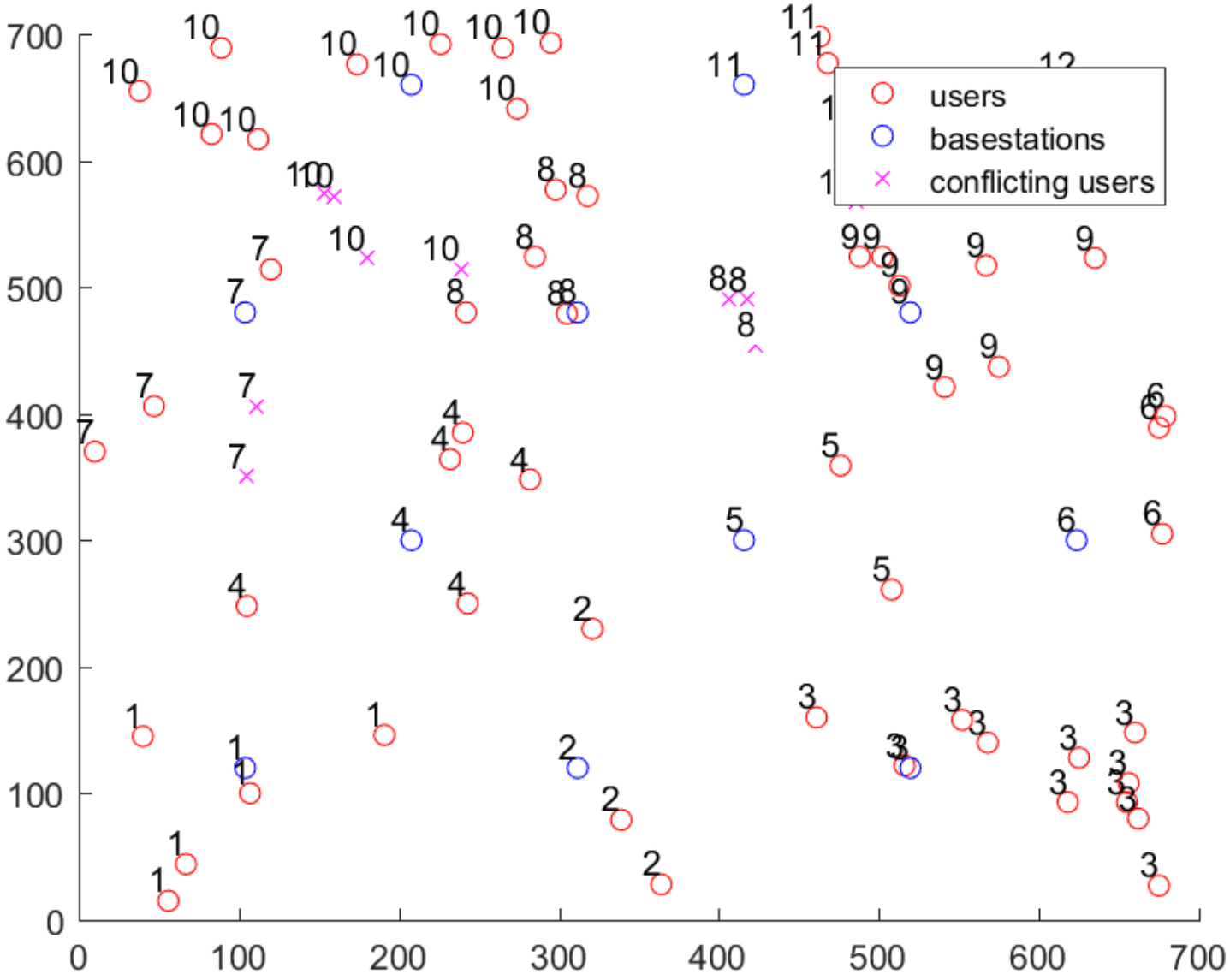


Content

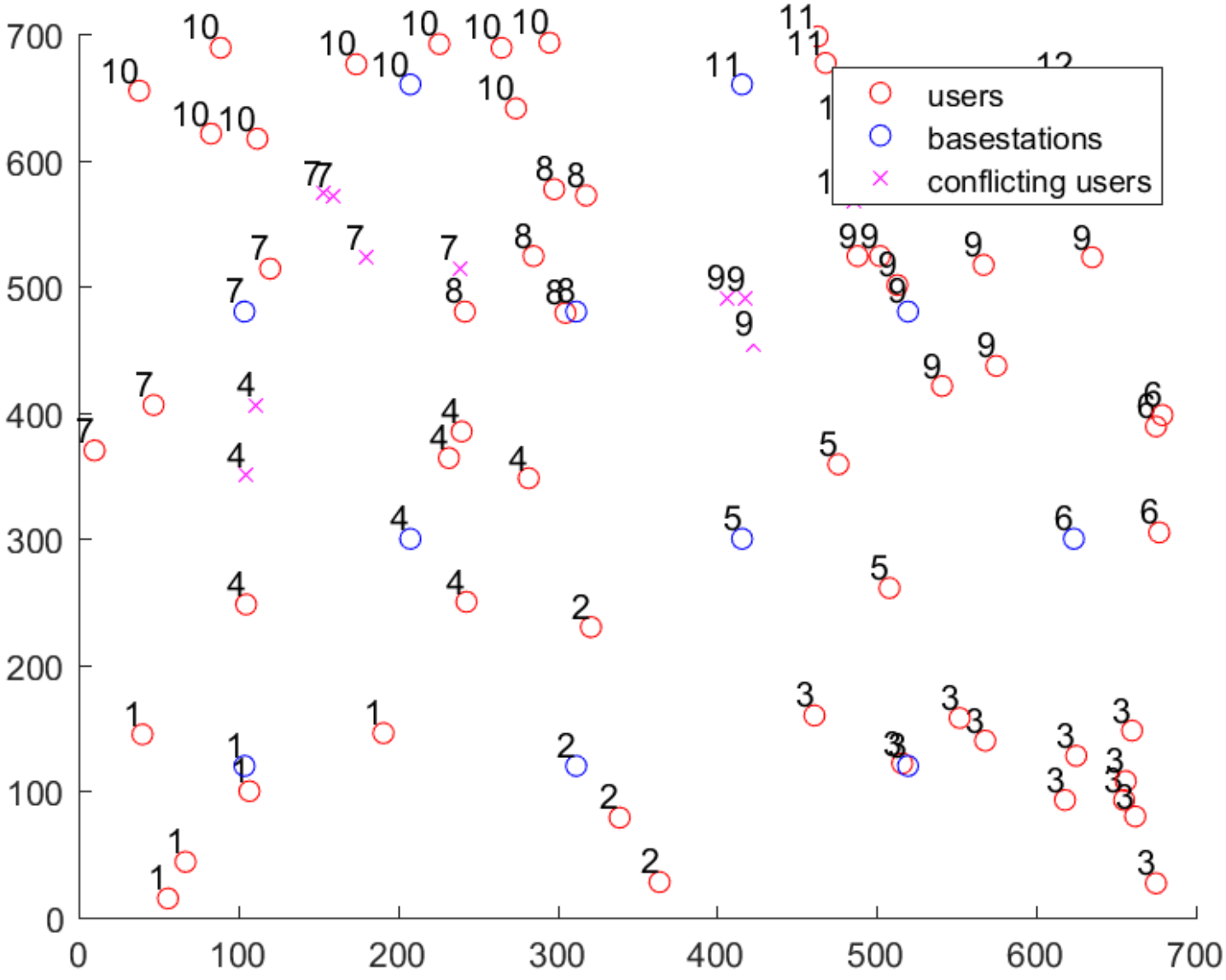
Simulation - main characteristics

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

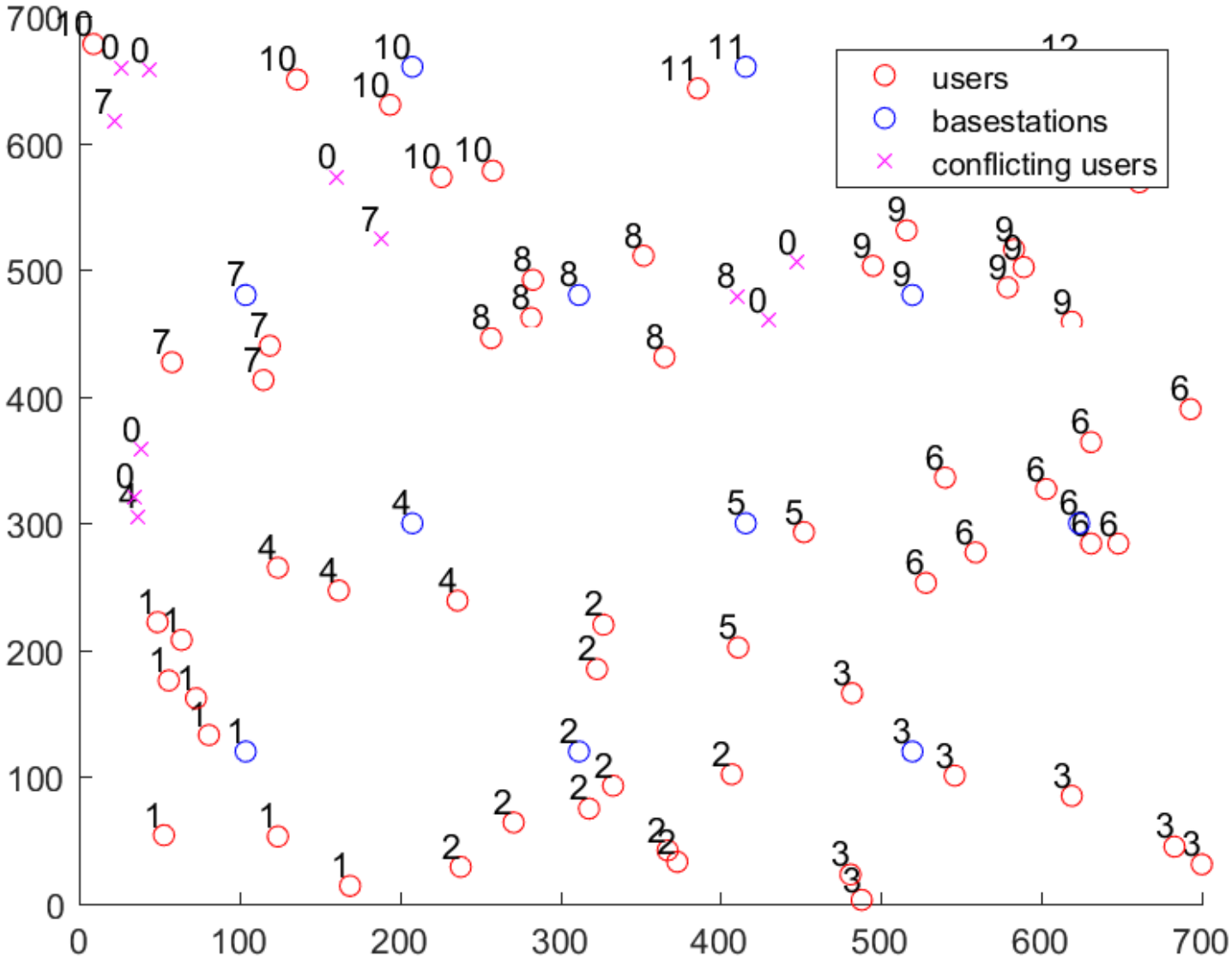
Simulation DPS I



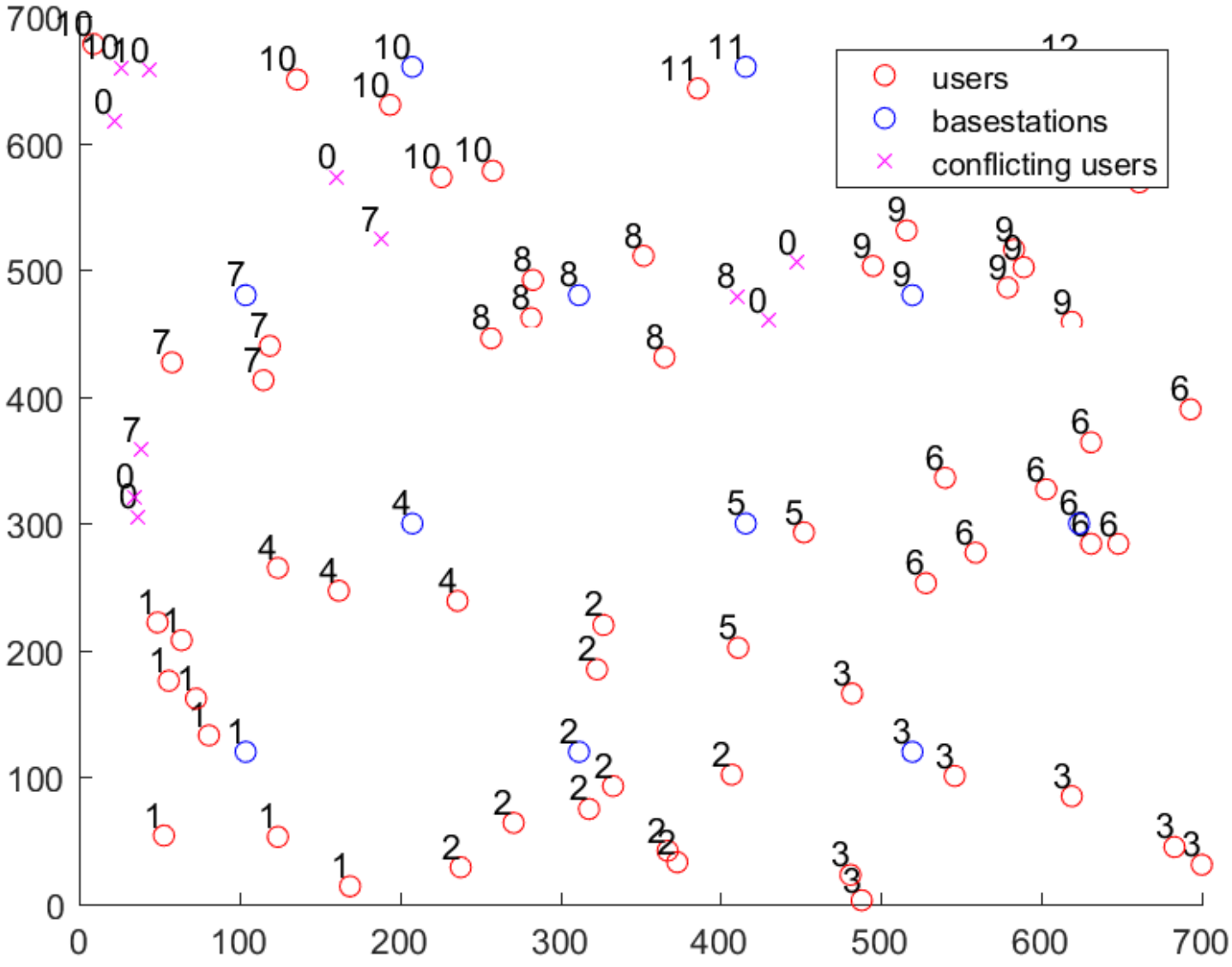
Simulation DPS II



Simulation CS I



Simulation CS II



Content

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

Content

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

Content

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!