4G LTE CoMP, Coordinated Multipoint

4th Semester Institute Project

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Overview

Content

- Motivation
- Background
- System Model
- Simulation
- Evaluation
- Conclusions
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Motivation

- Due to the network densification plans, interference will substantially increase. Interference management will play an important role in future networks
- Mainly cell edge users suffer from interference
- Goal is to improve performance via interference management schemes - such as CoMP
- CoMP is a broad category of cooperation in the network with the aim of enhancing user performance

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Overview on research

- 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

Channel model

- Signal-to-interference-plus-noise ratio -> Description of the channel

$$\frac{P_j * (h_j * w_j)^2}{\sum (h_i * w_i)^2 * P_i + (sigma_N)^2}$$

  - P_j - Power of signal
  - h_j - Channel
  - w - Precoding matrix
  - p_i - Power of interference
  - $sigma_N$ - Noise
- Used to determine signal quality
- Block-fading channel to reduce complexity

User feedback (CSI)

- Channel Quality Indicator
- Determines modulation
  - Transfer block size (TBS)
  - Resource blocks for users
- Depends on SINR
- CSI includes CQI, PMI, RI. CQI depends on SINR, PMI and RI depends on beamforming

Overview

- LTE Advanced: major enhancement of the LTE standard
- CoMP: Coordinate MultiPoint operation
  - Refers to wide range of interference management 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)

Major categories

Joint Processing (JP)

- Joint Transmission (JT)
- Dynamic Point Selection (DPS)
  - With muting
  - Without muting

Coordinated Scheduling (CS) / Coordinated Beamforming (CB)

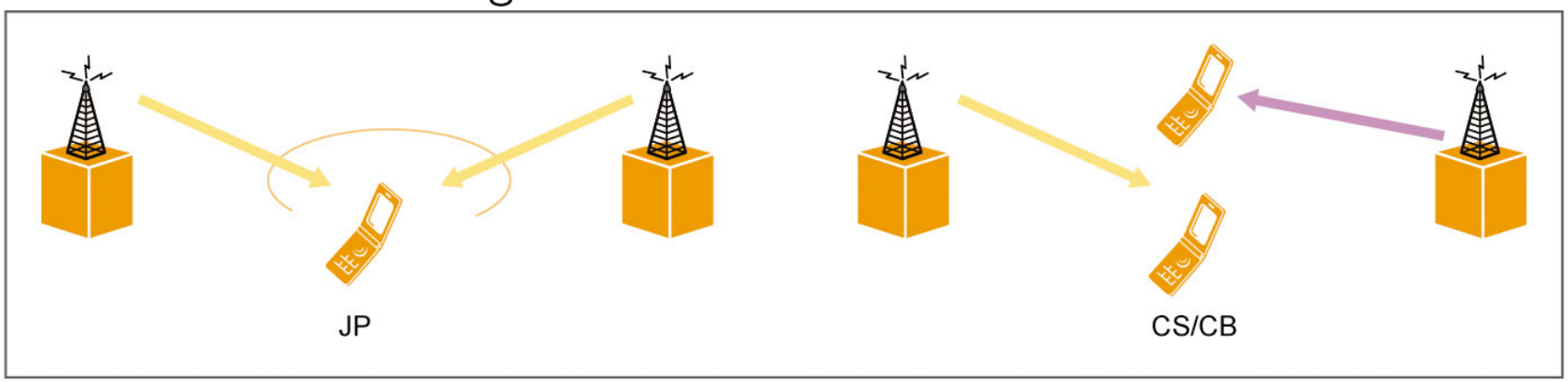
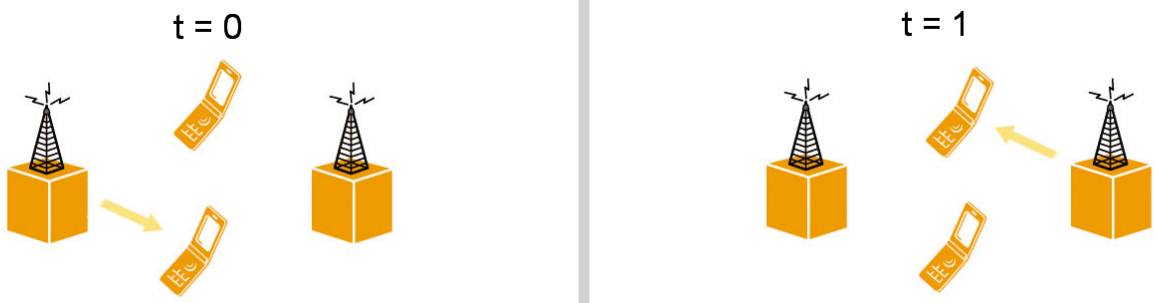


Figure 4. Principle of CoMP.

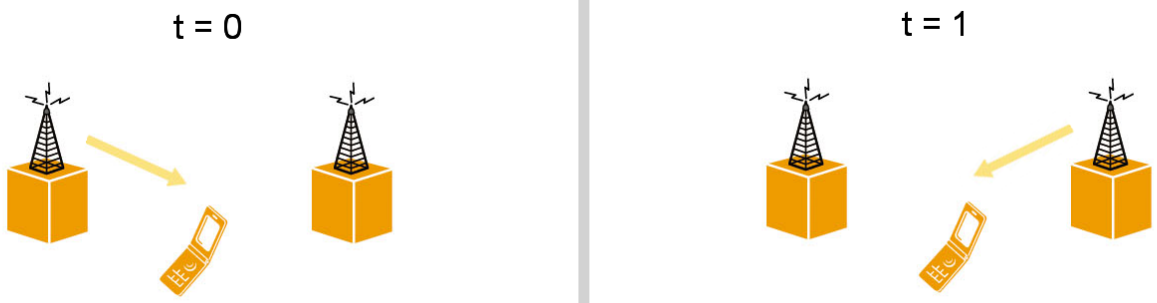
Coordinated Scheduling (CS)

- Data available at one node
- Transfered packets do not overlap in time



Dynamic Point Selection (DPS)

- Data usually available at several nodes
- User decides per packet which base station is best



Content

Assumptions

- Geographical Location of UE is known
- UE does not move so no Doppler effect, studying slow fading
- 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

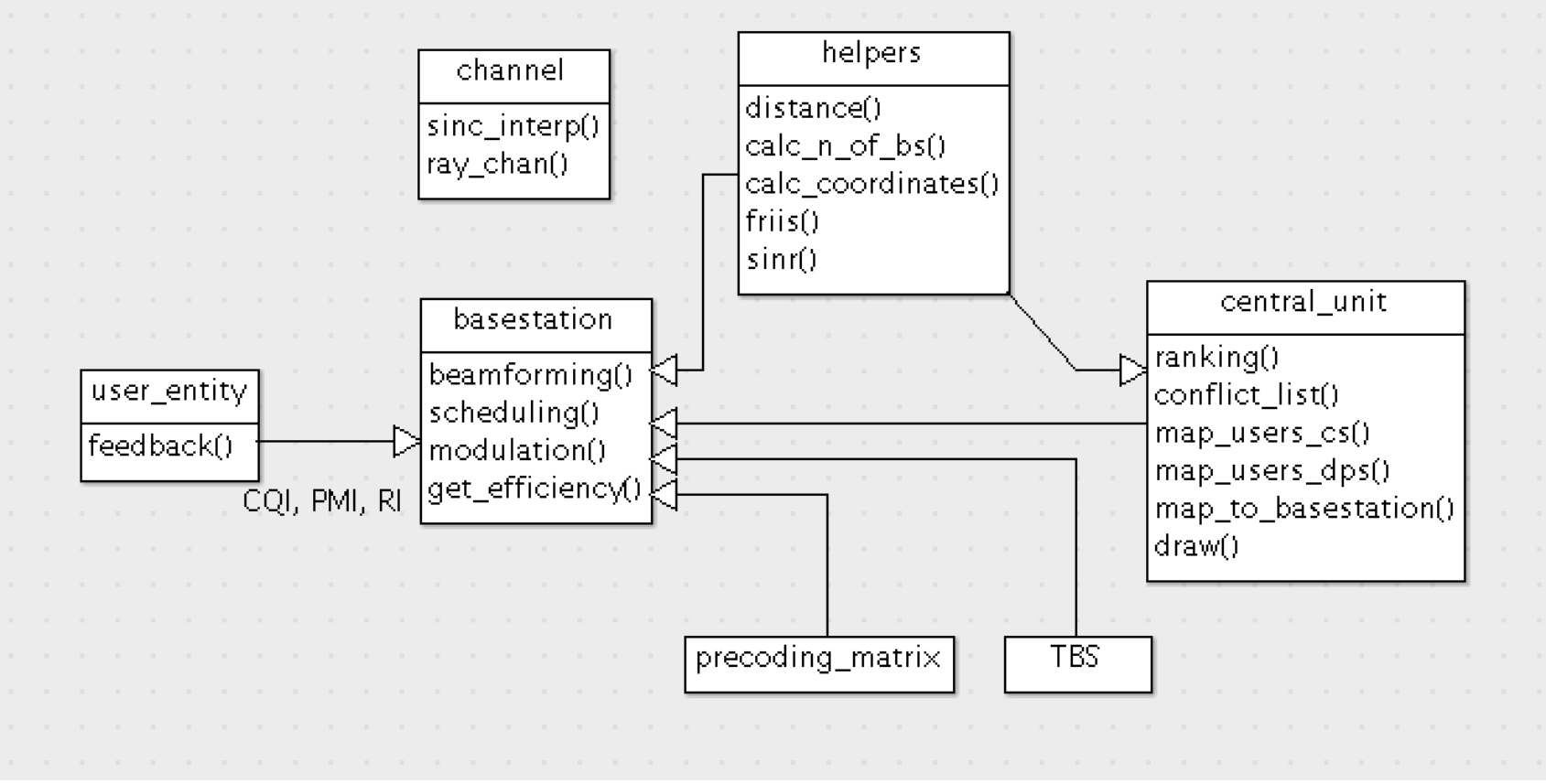
Programming

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

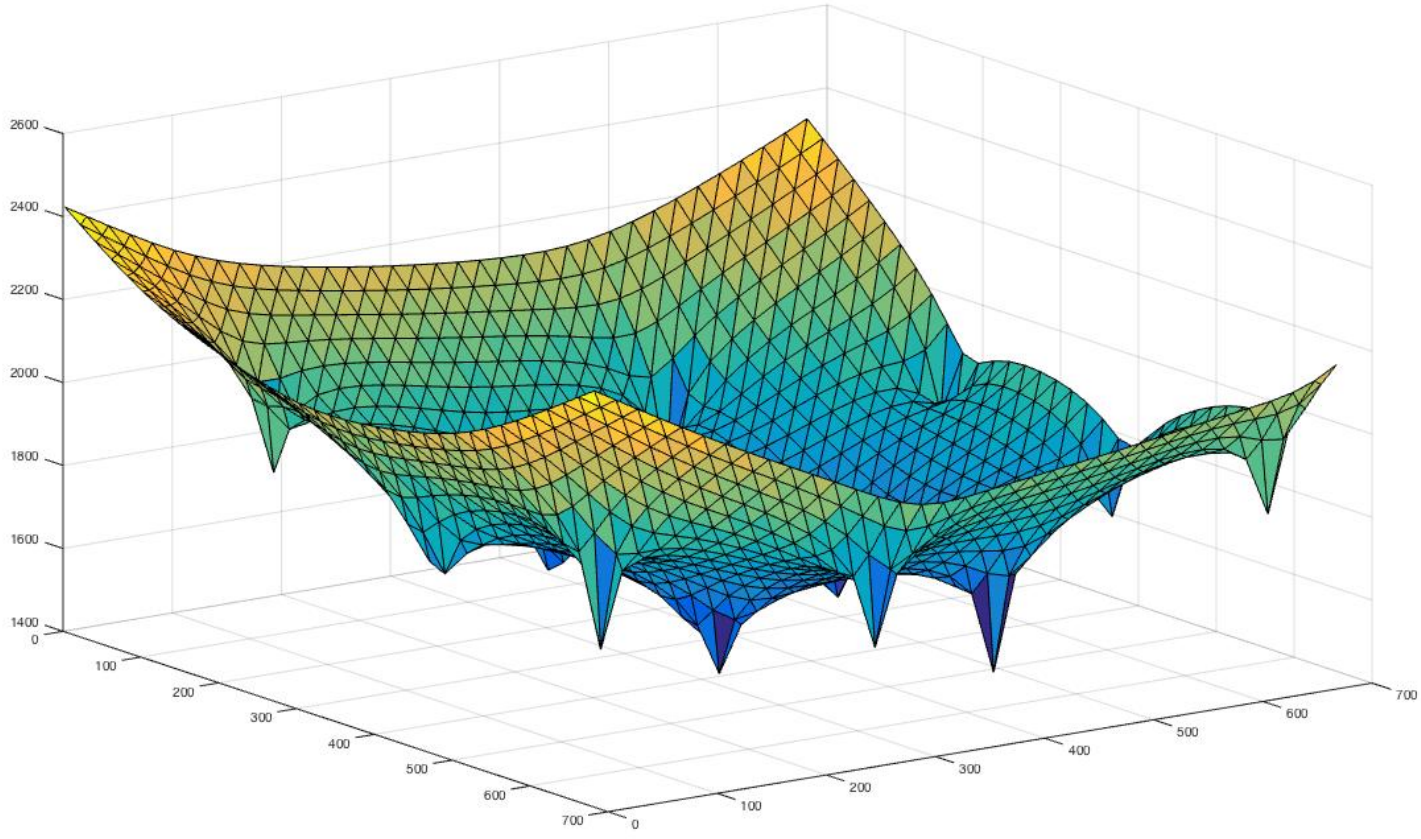
Classes providing main functionality

- 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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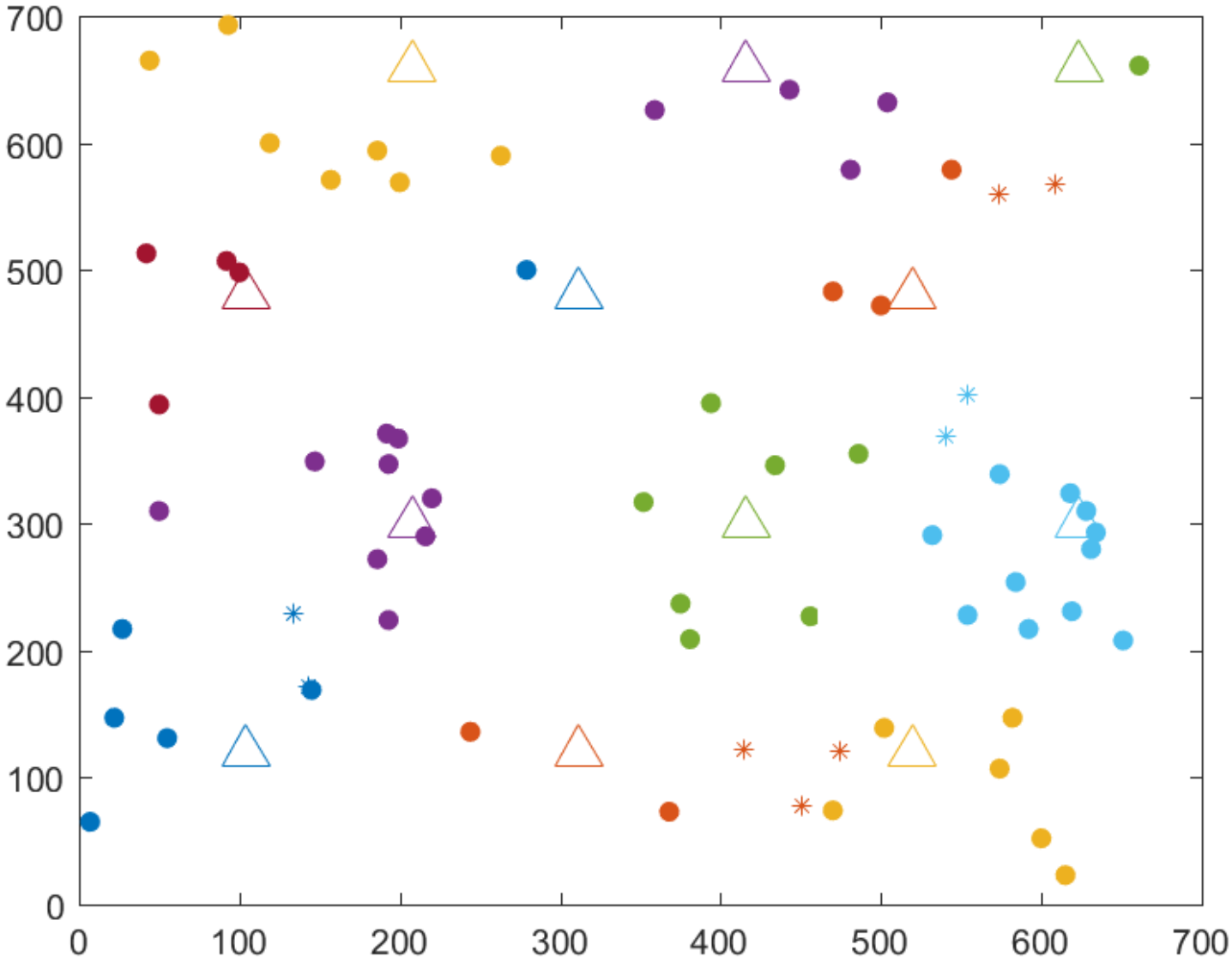
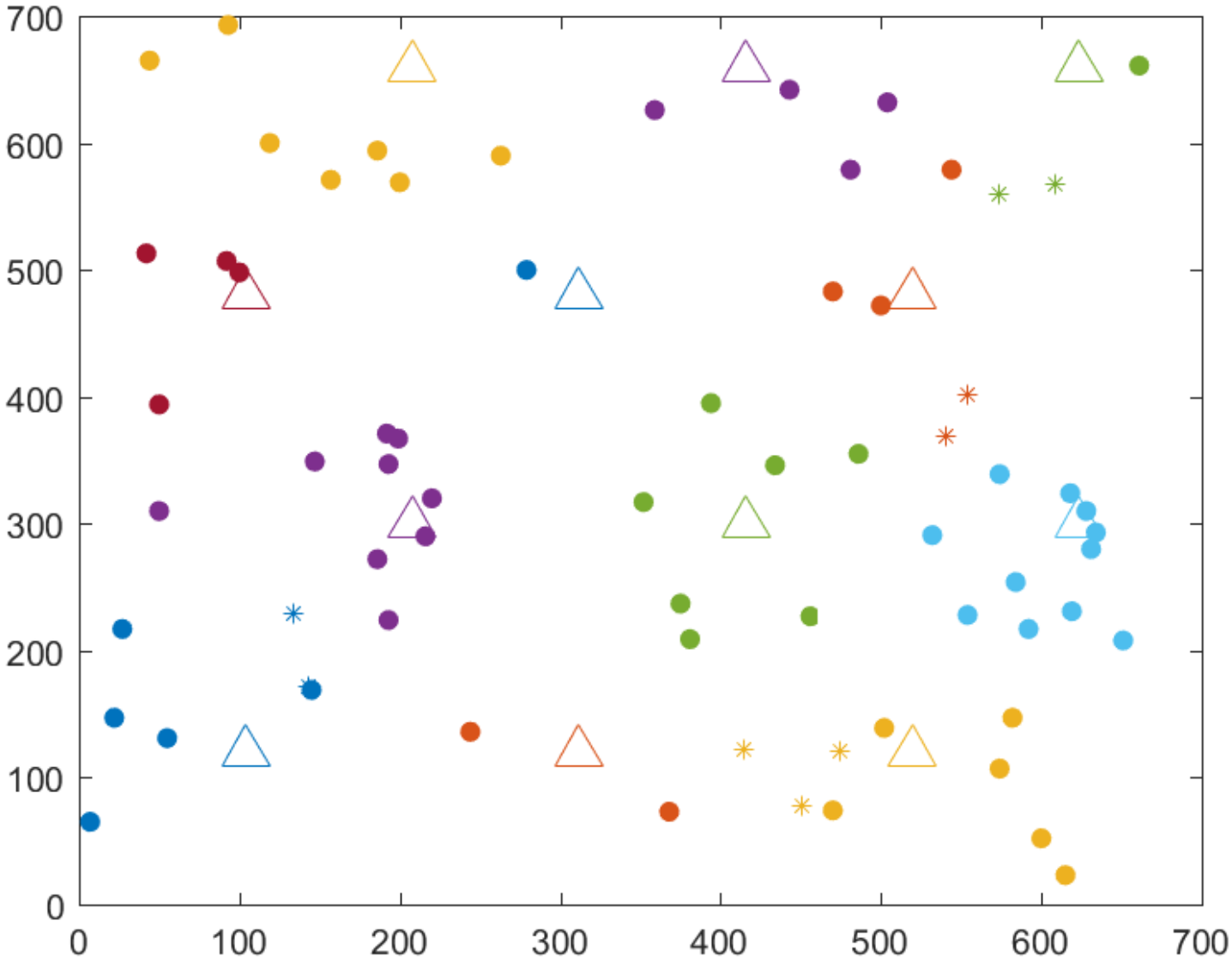
Main characteristics

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

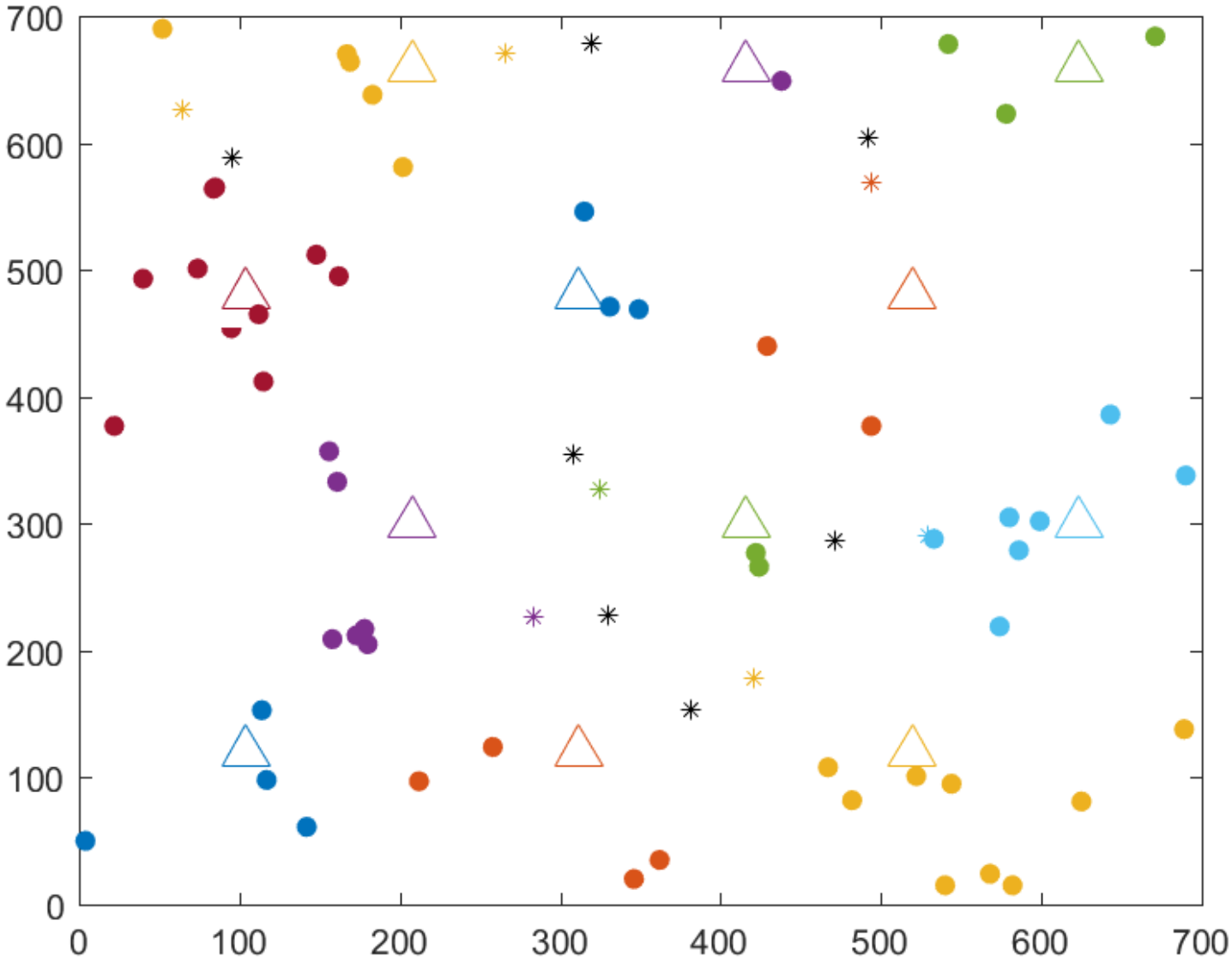
Simulation DPS I



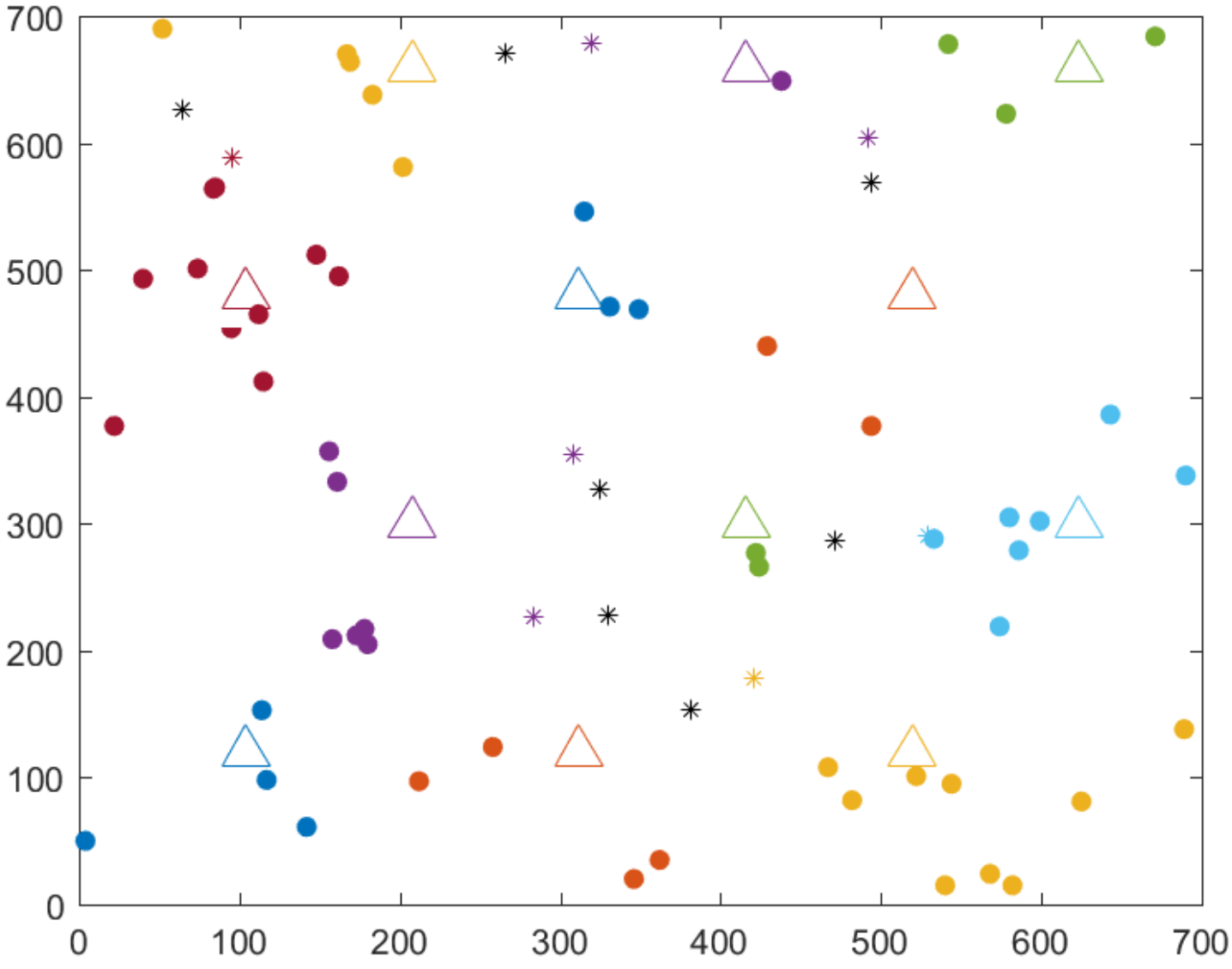
Simulation DPS II



Simulation CS I



Simulation CS II



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Evaluation

- 5000 Simulation Cycles
- 70 User Entities, 12 Basestations

	without CoMp	DPS	CS
users in conflict	19.65%	19.78%	19.67%
unassigned users	0%	0%	10.5%
average backhaul[bit/s]	78081	90791	77317
additional backhaul	+0%	+16.28%	-0.98%

Evaluation

Advantages

- Less interference at cell edges, thus better SINR performance.
- Utilization of different subcarriers inside conflict zones avoids interference

Disadvantages

- Complexity of algorithms
- Infeasibility with restricted backhauls
- Bigger signaling overhead between users and base stations
- More frequent communication with the CU –> bigger backhaul needed

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Summary

- 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

Summary

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

Summary

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
- Making model abstractions while maintaining accuracy

Summary

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

Future work

What comes next?

- Implementation of other CoMP schemes, e.g. coordinated beamforming and joint transmission
- Different channel models (e.g. *fast fading* channels)
- Optimization of CoMP techniques
  - Different allocation of implementation stages between CU and BS
  - Other 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!