

4G LTE CoMP, Coordinated Multipoint

4th Semester Institute Project

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Content

- Introduction
- Background
- System Model
- Simulation
- Evaluations
- Conclusions
- References

Content

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 - ***Motivation***
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- System Model
- Simulation
- Evaluations
- Conclusions
- References

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

- Introduction
- *Background*
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- Simulation
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- References

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

$$\frac{S}{I + N} \quad (1)$$

- 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: maximization 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

Dynamic Point Selection (DPS)

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

Content

- Introduction
- Background
- ***System Model***
- Simulation
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- Conclusions
- References

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

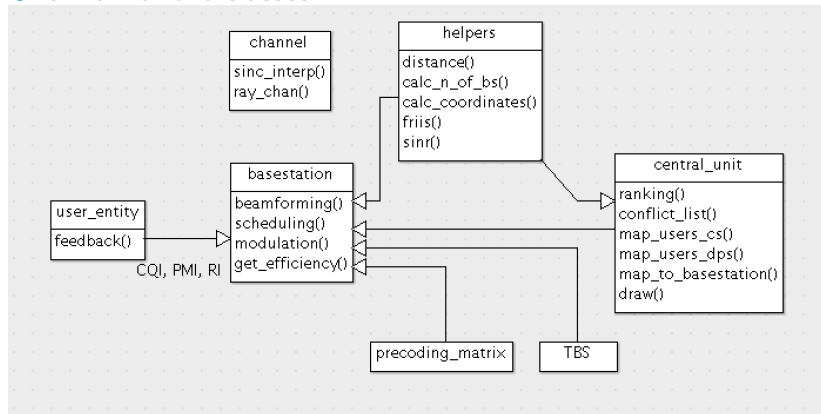
System Model - Programming

- 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



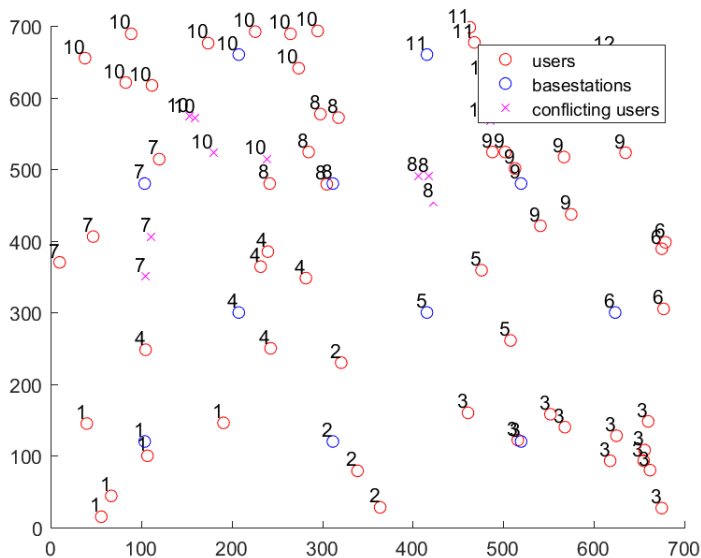
Content

- Introduction
- Background
- System Model
- ***Simulation***
- Evaluations
- Conclusions
- References

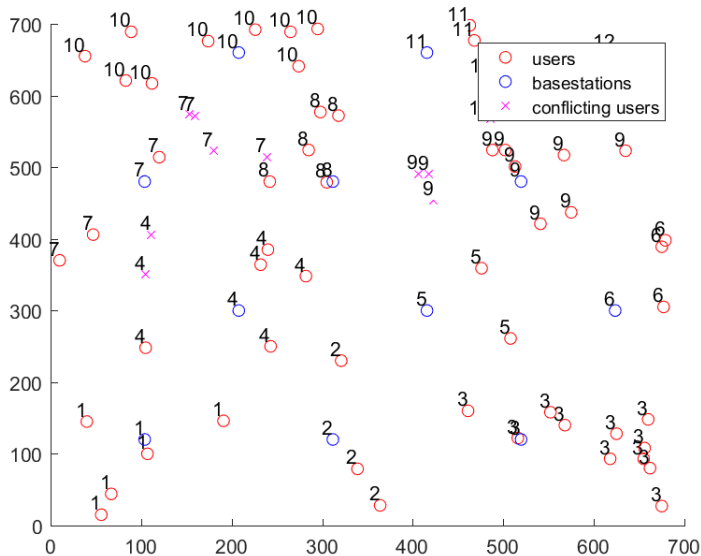
Simulation - main characteristics

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

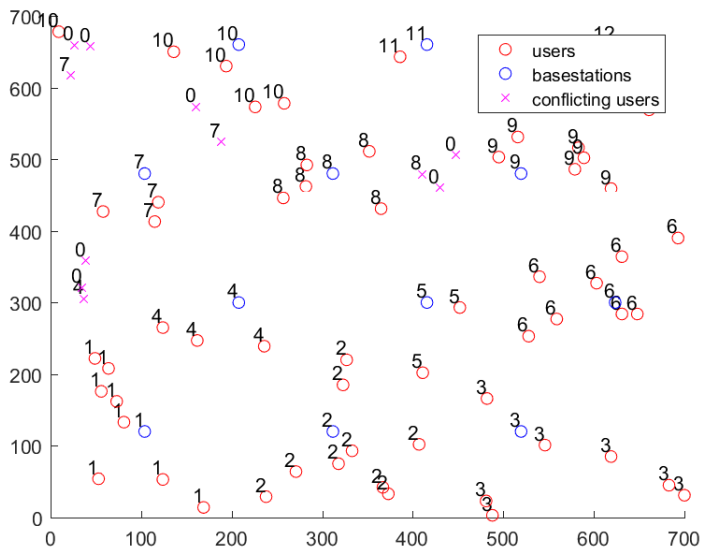
Simulation DPS I



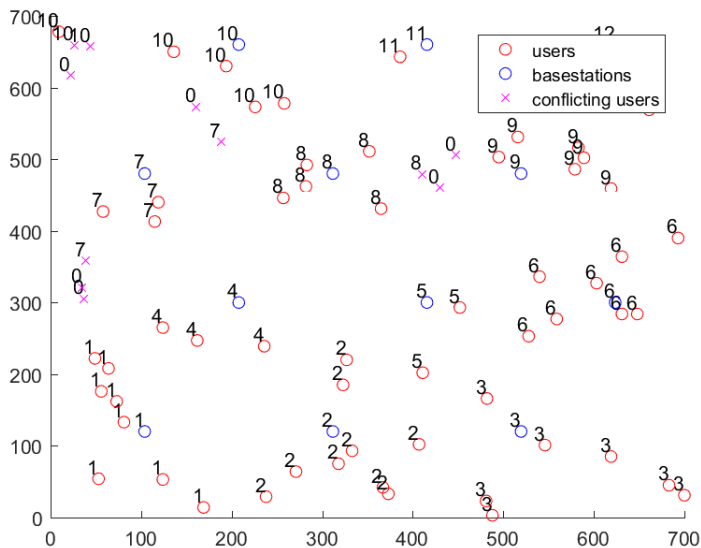
Simulation DPS II



Simulation CS I



Simulation CS II



Content

- Introduction
- Background
- System Model
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- ***Evaluation***
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- References

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

- Introduction
- Background
- System Model
- Simulation
- Evaluations
- ***Conclusions***
- References

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 establishing 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 maintaining 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
- \LaTeX basics 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

- Introduction
- Background
- System Model
- Simulation
- Evaluations
- Conclusions
- *References*

References

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Thank you for your attention!