

4G LTE CoMP, Coordinated Multipoint

4th Semester Institute Project

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

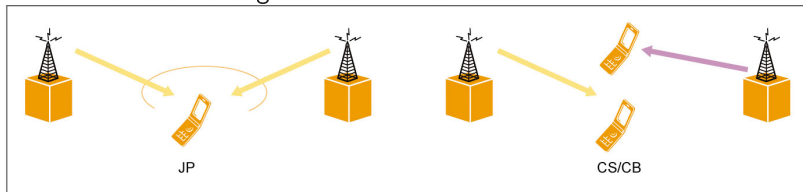


Figure 4. Principle of CoMP.

Coordinated Scheduling (CS)

- Data available at one node
- Transferred 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



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Assumptions

- The geographical location of UE is shown
- UE does not move so no Doppler effect, studying slow fading
- CQI, PMI, RI are randomly generated
- Fixed number of UEs in a simulation
- Multipath channel used from 3GPP Ped/A
- Base stations are always in a hexagonal layout

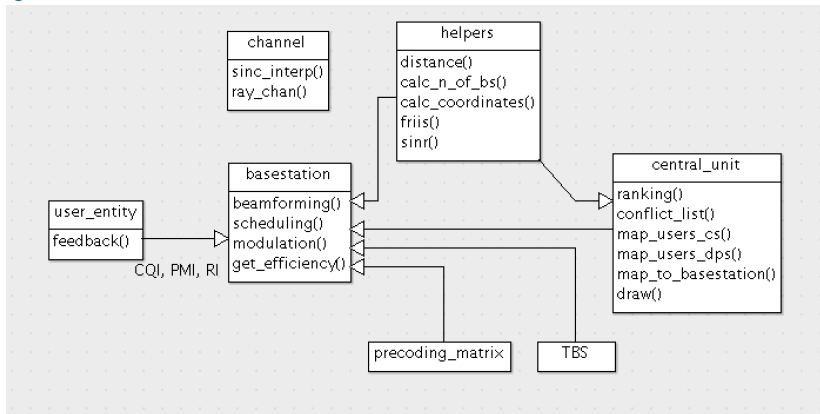
Programming

- 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
 - one CU per simulation
- Base Station: matches subcarriers to connected users, assigns modulation and coding scheme, linked to CU via backhaul links
- User Entity: returns feedback to the base station
- Channel: has a certain frequency and amount of subcarriers
 - Frequency flat channel - using Friis equation for path loss
 - Frequency selective channel - Rayleigh channel

Overview of the classes



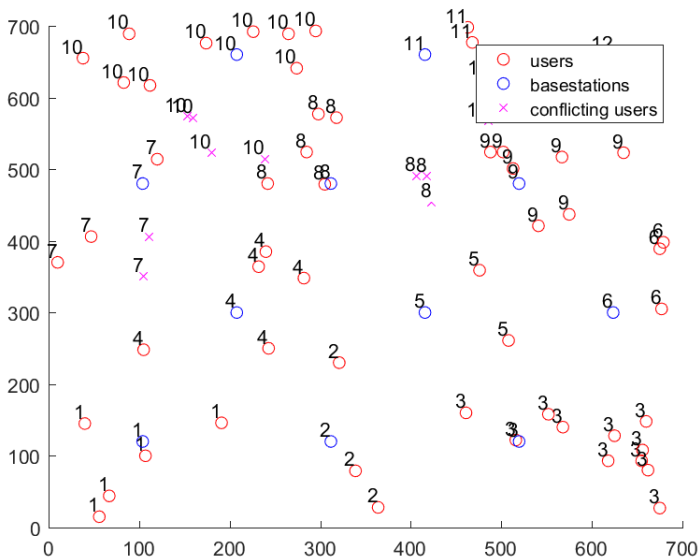
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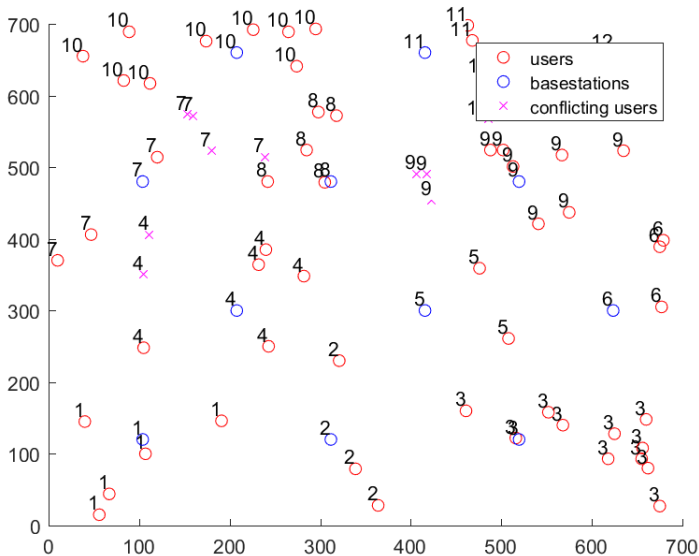
Main characteristics

- Flexibility
- Simulation Process
 - Initialization
 - Simulation Cycle
 - Mapping of users to basestations
 - Assignment of resourceblocks to users
 - Calculation of the best modulation and coding scheme

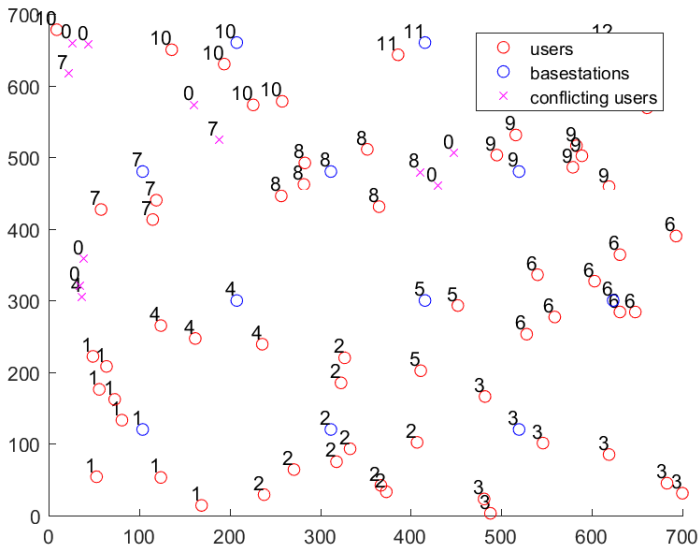
Simulation DPS I



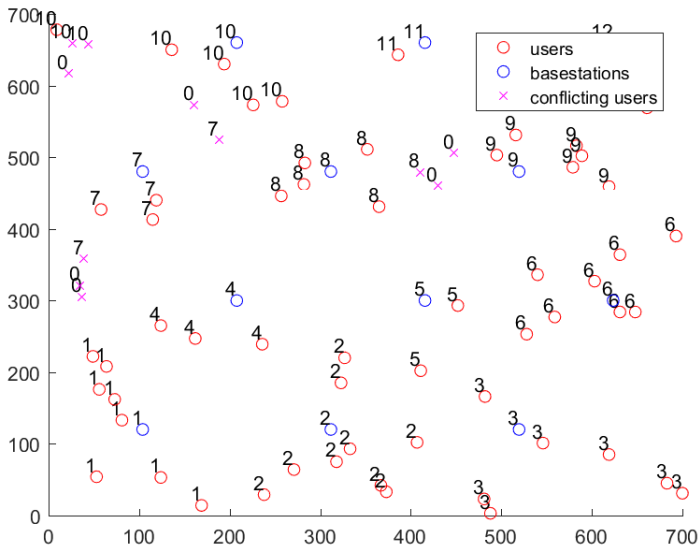
Simulation DPS II



Simulation CS I



Simulation CS II



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

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 backhails
- Bigger signaling overhead between users and base stations
- More frequent communication with the CU → bigger backhaul needed

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- 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
- Making model abstractions while maintaining accuracy

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 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

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- Davydov, A. et al, 2013. Evaluation of Joint Transmission CoMP in C-RAN based LTE-A HetNets with Large Coordination Areas. Globecom 2013 Workshop.
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- Sawahashi, M. et al, 2010. Coordinated Multipoint Transmission/Reception Techniques For LTE-Advanced.

Thank you for your attention!