Combined evaluation of frequency selective scheduling and IfCo

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Outline

Motivation & Background

Methodology

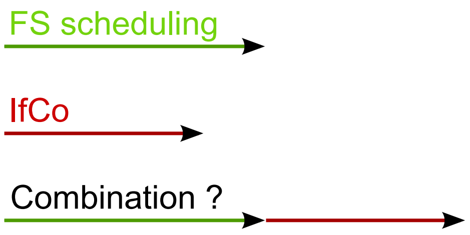
- Optimization
- Fairness

Simulation Results

Motivation

Estimation of the theoretically achievable gain from

- Frequency Selective (FS) Scheduling
- Interference Coordination (IfCo) per Frame
- The combination of both techniques



Boundary conditions

- The scheduling shall provide for fairness, similar to a proportional fair scheduler
- Optimal channel prediction
- Ideal signaling among base stations
- Almost unlimited time for the optimization of the scheduling

WiMAX Background

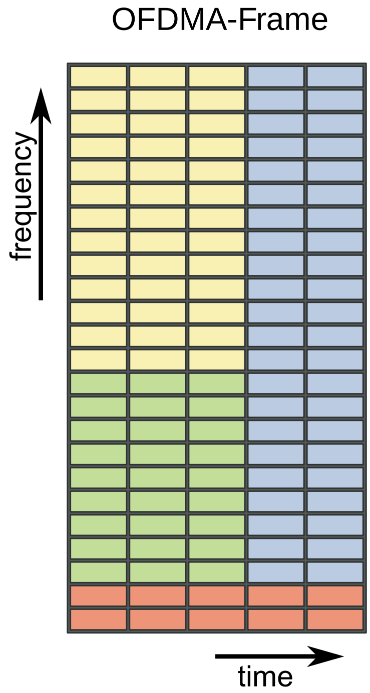
Frame Format & Scheduling

- A WiMAX frame consists of a two-dimensional array of slots
- In downlink, rectangular blocks of logical slots are assigned to the terminals
- These can be mapped to physically adjacent subcarriers for frequency selective scheduling

Interference Coordination

- Beamformers allow to utilize the spatial dimension
- Maximum performance can be achieved with a coordination of the scheduling among base stations for every frame

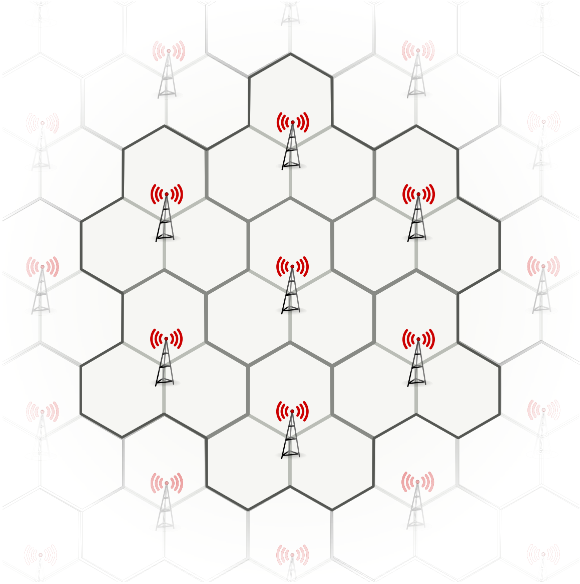
→ IfCo and frequency selective scheduling constrain each other



Scenario

On the basis of WiMAX simulation recommendations

Simulation of a single frame per drop, 80 drops



System model

- 21 sectors, wrap-around, Reuse-1
- 1000m base station distance
- 10MHz, 48 subchannels

User model

- 8 mobile terminals per sector
- Uniformly distributed over sector area
- Traffic: Full buffer

Channel model

- Pathloss according to Hata model, no shadowing
- Frequency-selective fast fading according to ITU-R M.1225 (profile „Pedestrian B")
- Main lobe steering beamformer, 4 antenna elements

Optimization Method: Genetic Algorithm

No exact optimization algorithm feasible

$\rightarrow$ Genetic algorithm (GA) has been used as optimization heuristic

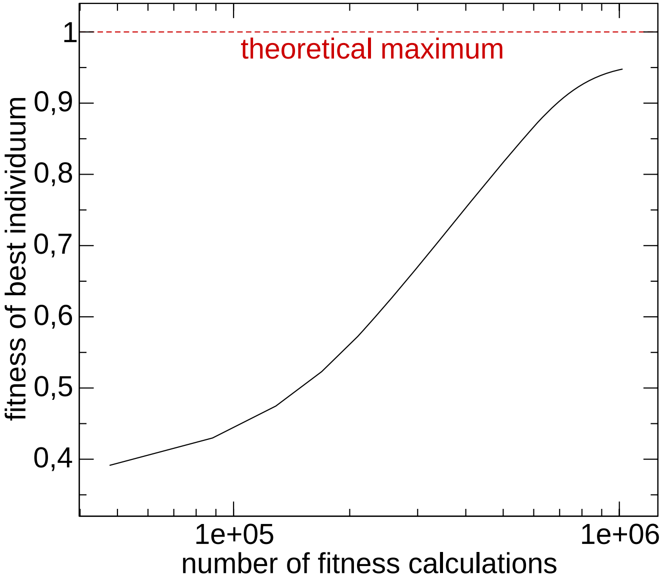
Objective function

- Total system throughput
- Additional weights depending on channel quality to assure fairness

High complexity of the optimization problem

- Need to reduce scheduling granularity
- Need for problem-specific genetic operators

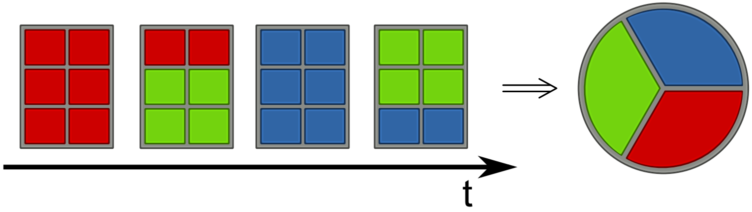
The capability of the optimization algorithm has been verified with test scenarios



Fairness Definition

Usually: Proportional Fair scheduler

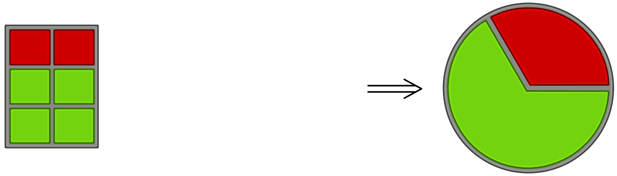
- Fairness over a certain time
- Same amount of resources for all terminals



Here: "Statistical Fairness"

- Assign resources with same probability
- Probability must not depend on channel quality

→ Fair, although only single frame



Results: Fairness

Reference

Round robin scheduler without channel knowledge

Max. C/I GA

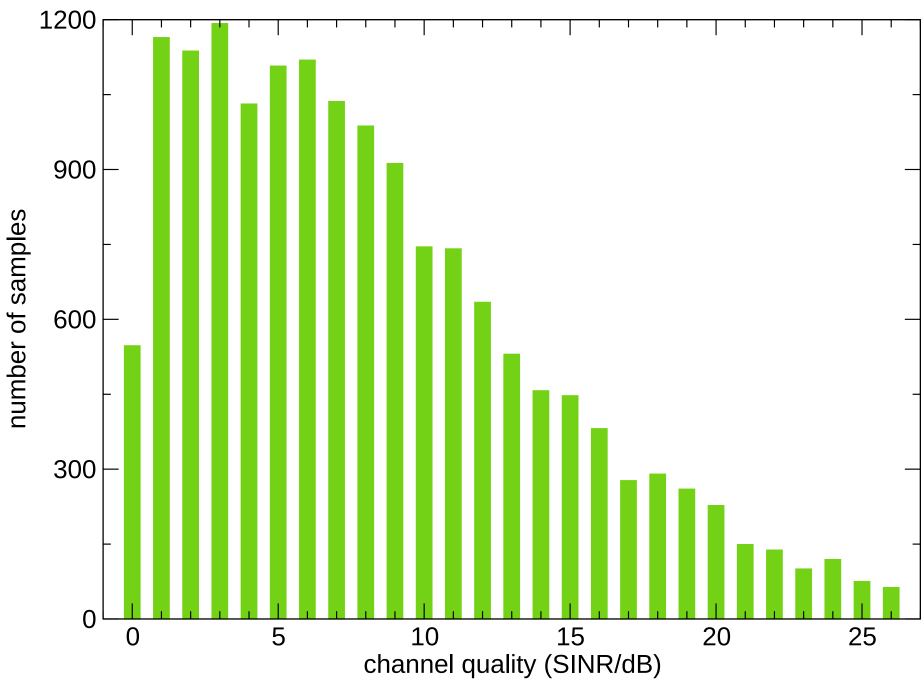
Without weights, GA optimizes for throughput

→ Unfair scheduling

Fair GA

"Statistical Fairness" by higher weights for mobiles with bad channel conditions

→ Fair scheduling



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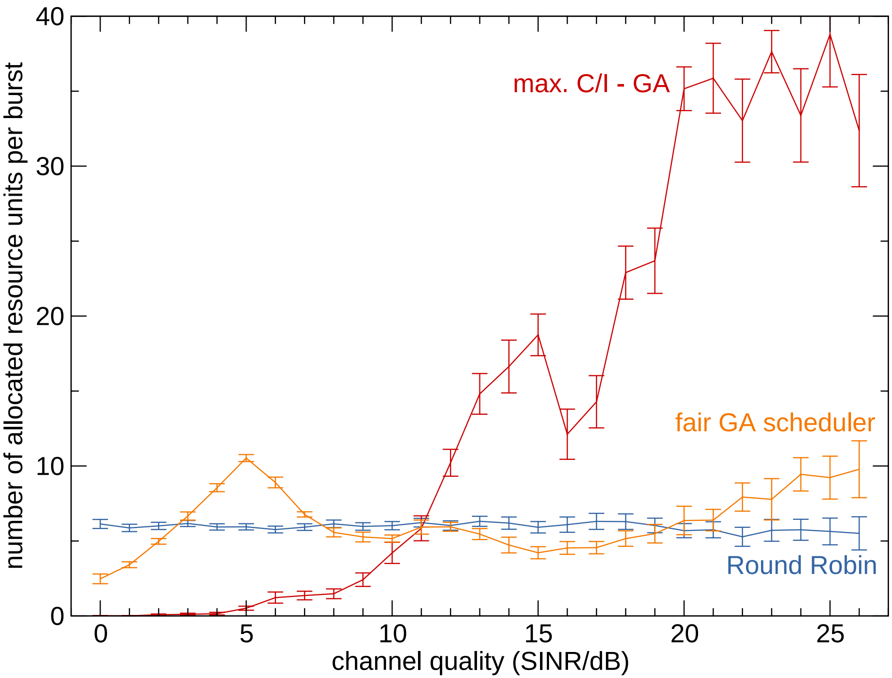


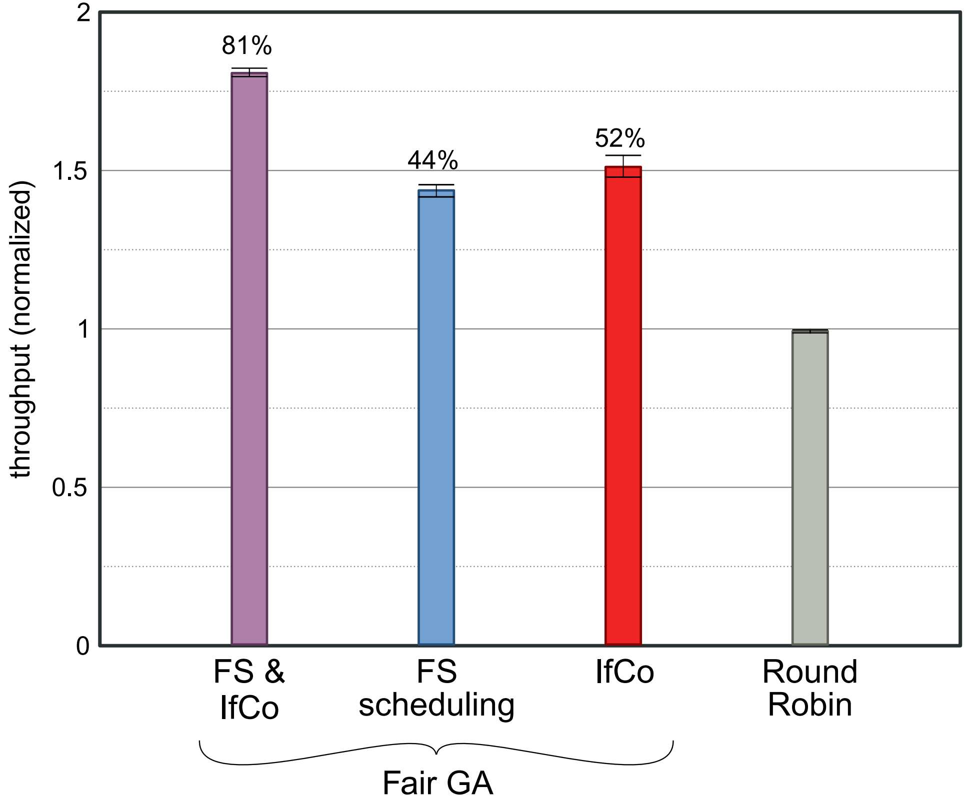
Results: Throughput

Superposition of multiple effects

- Scheduling gain
- Influence of fairness
- More efficient link adaptation when interference known

Interpretation

- Gains not independent
- Combination reasonable
- About 20% by combination of both techniques



Summary and Outlook

Summary

- Objective: Compare theoretically achievable performance gain of
  - Frequency selective scheduling
  - Interference coordination
  - Combination of both techniques
- Optimization based on genetic algorithms
- Fairness constraints
- Results: Combination reasonable, although gains not achievable independently
- Restrictions in real world implementations
  - Channel knowledge
  - Traffic variations
  - Communication between base stations
  - Time constraints

Outlook

Comparison to other algorithms under more realistic conditions