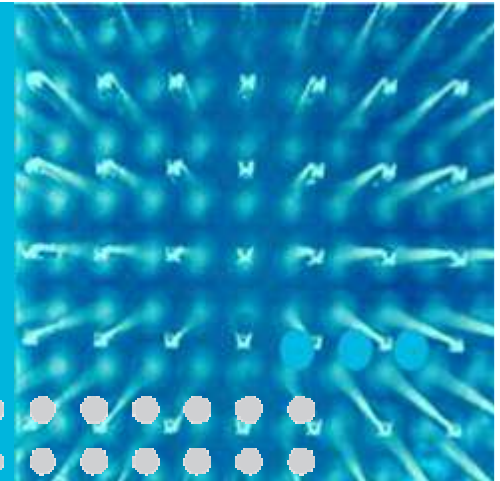


SON in 4G Mobile Networks

Self-Optimization Techniques for Intelligent Base Stations



Bell Labs Stuttgart

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9. Fachtagung des ITG-FA 5.2, Oktober 2010

Self-organizing Radio Access Networks

Motivation

Current situation for radio access network management

- Deployment and maintenance become more and more complex and cost extensive
 - Trend to smaller cells, multi-band operation, heterogeneous mobile networks
 - High manual intervention for configuration, capacity upgrade or in failure cases required
- High effort required for optimisation of system performance
 - Deep system expertise required
 - High effort necessary for measurement campaigns (drive tests)
- Different tools for planning, configuration, measurement/KPI acquisition and optimisation involved

increasing effort for network management and optimisation



→ new concepts for simplified network operation required

Self-organizing Radio Access Networks Requirements

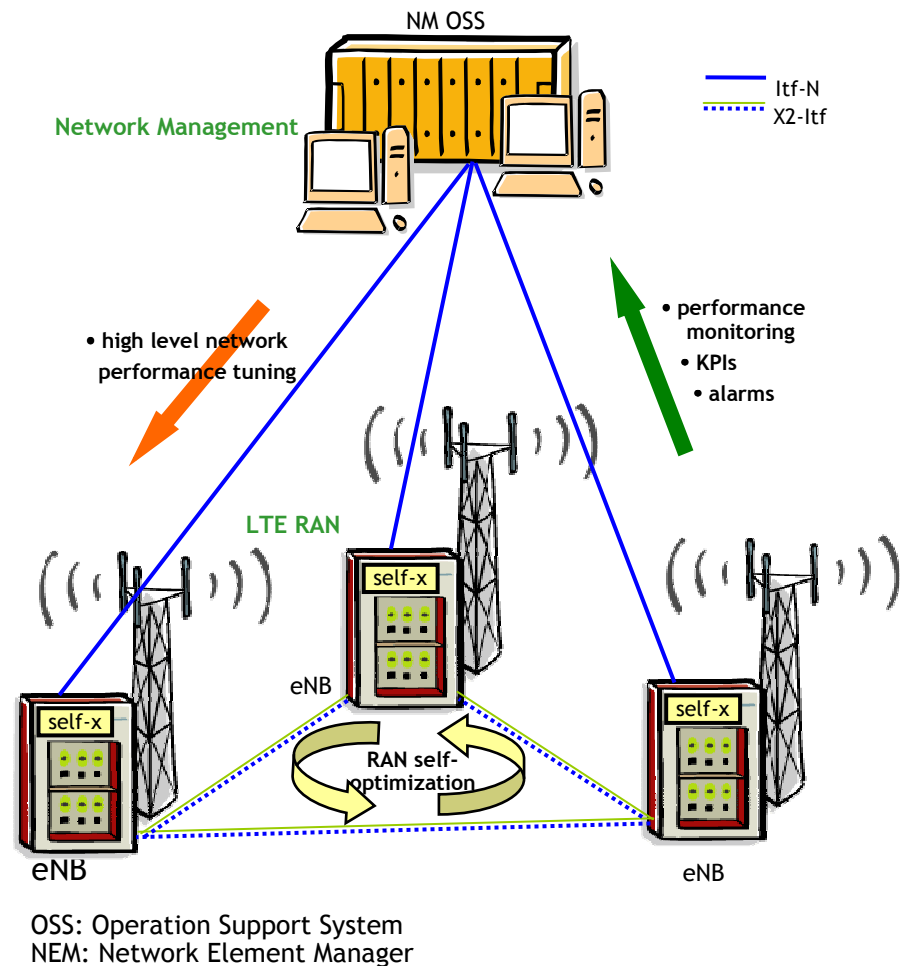
Management of radio access networks has to be self-organized in future

- Automated configuration, optimization and fault management:
 - towards real plug-and-play self-configuration
 - continuous up to autonomous self-optimization
 - fast self-healing mechanisms
- Paradigm change:
 - to put network optimization know how into intelligent self-x algorithms
 - to focus network management on high level monitoring and performance tuning
- High performance self-x algorithms required:
 - fast convergence
 - stable operation
 - tuneable according to operator requirements
 - managing mutual dependencies between self-x use cases

Self-X Architecture

Vision of fully distributed self-management

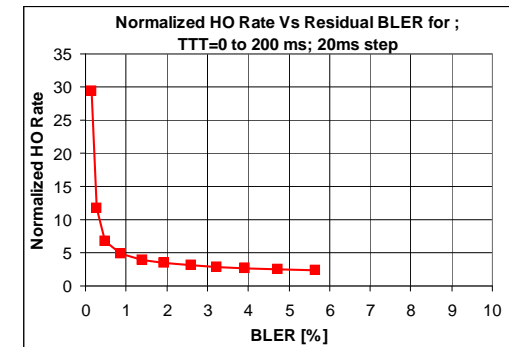
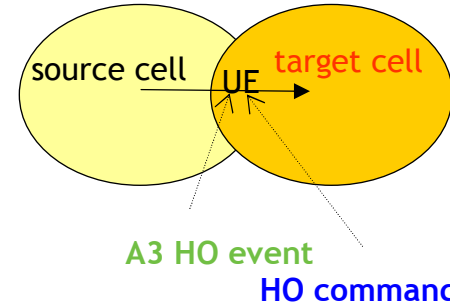
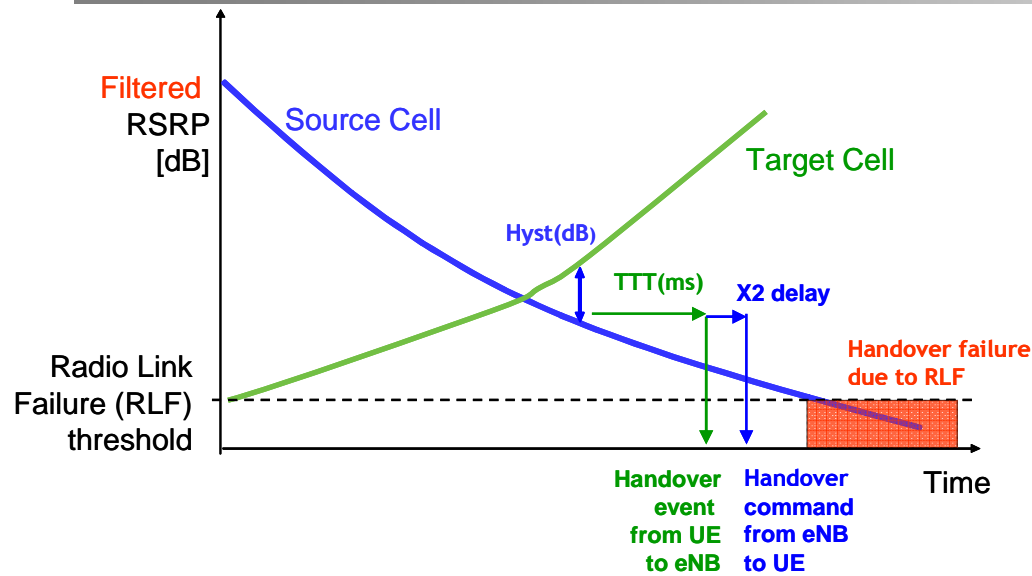
- “NEM less” network management
- Fully autonomous, distributed RAN optimisation
- Self-x functions in UE and eNB
 - measurements, UE location info
 - alarms, status reports, KPIs
 - distributed self-x algorithms
- Network management in NM OSS focussed on
 - network planning
 - alarm and performance monitoring
 - high level performance tuning





Mobility Robustness (Handover Optimization)

Configuration Parameters for Handover in LTE



BLER: block error rate of HO command → RLF

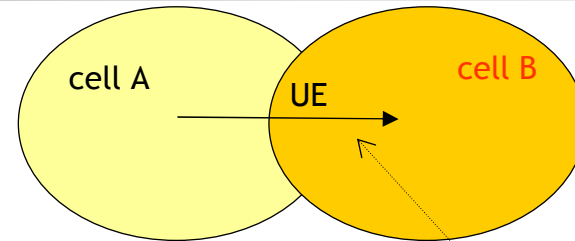
Normalized HO rate: without slow/fast fading

LTE handover performance has large impact on system performance

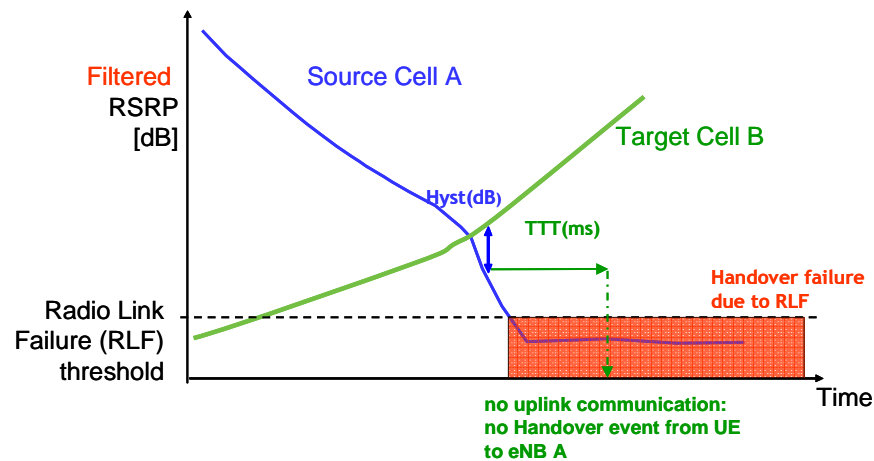
- Configuration parameters
 - Filtered RSRP values
 - Handover Margin, i.e. hysteresis between source and target
 - Time to trigger (TTT)
 - Cell Individual Offset (CIO), add on handover margin
- Target
 - High handover success rate

SON algo:
find best trade-off between minimum BLER and minimum HO rate (ping pong)

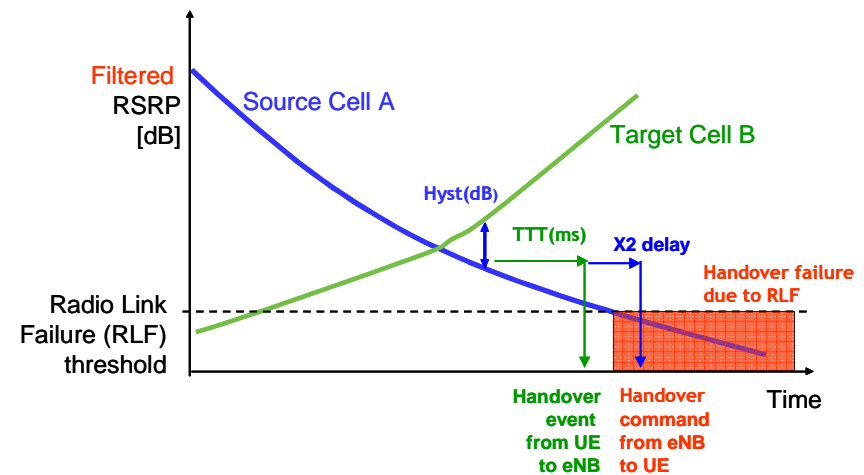
SON definition: too late Handover



RLF, as UE still associated to cell A

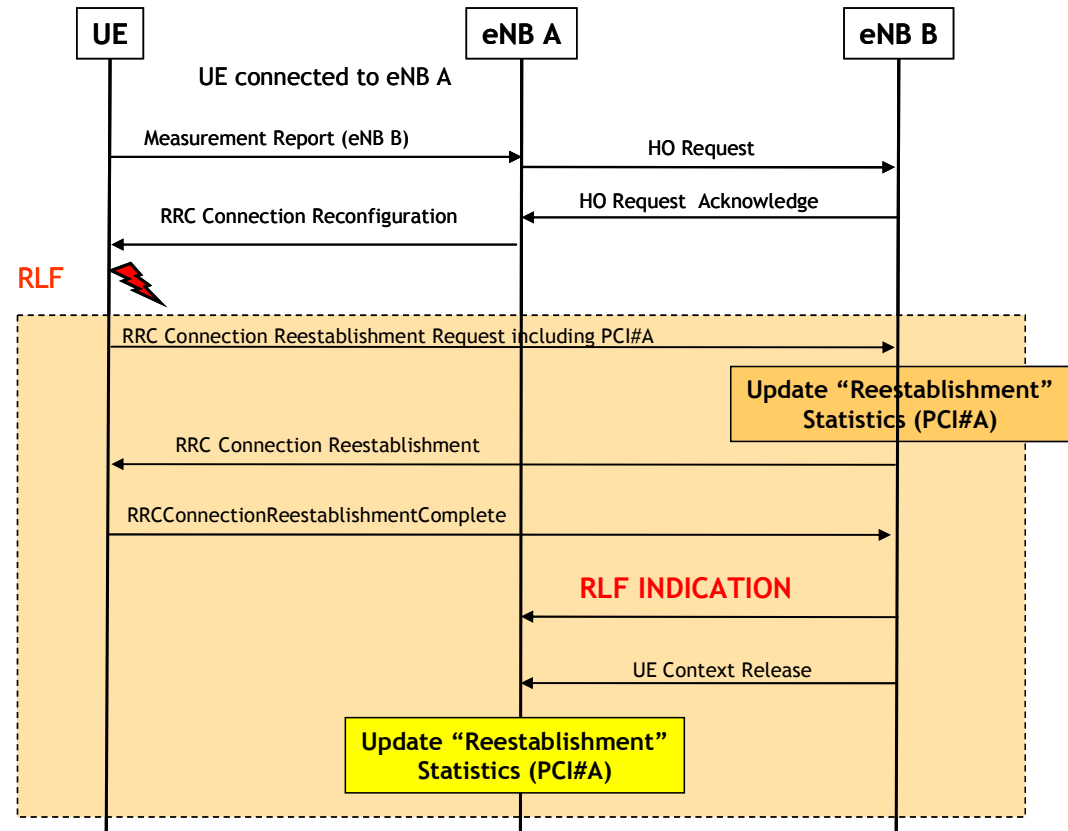


Alternative 1: a failure occurs in the source cell before the HO was initiated



Alternative 2: a failure occurs in the source cell during the HO procedure

Messages and algorithm for “too late” handover



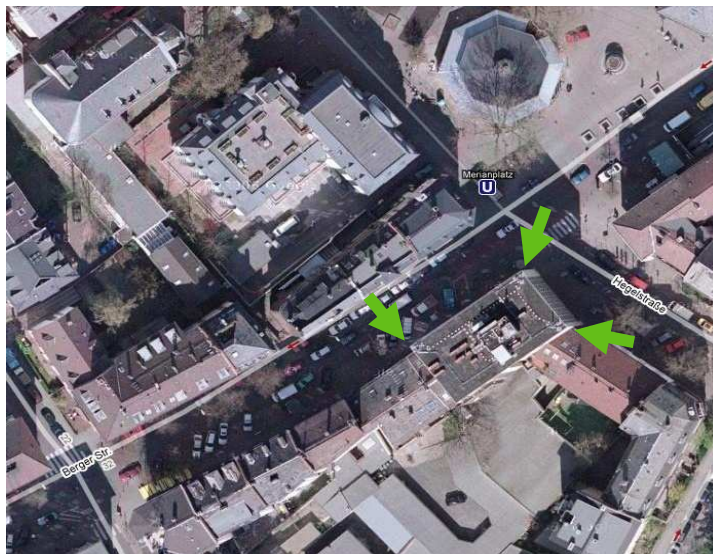
- SON Algorithm**
- sufficient measurements for decision of HO problem ?
 - analysis of measurements and other data (own eNB and other eNB)
 - modify HO parameters
 - for all UE speed classes
 - mobility state dependent
 - start new measurement cycle

SON based HO optimization

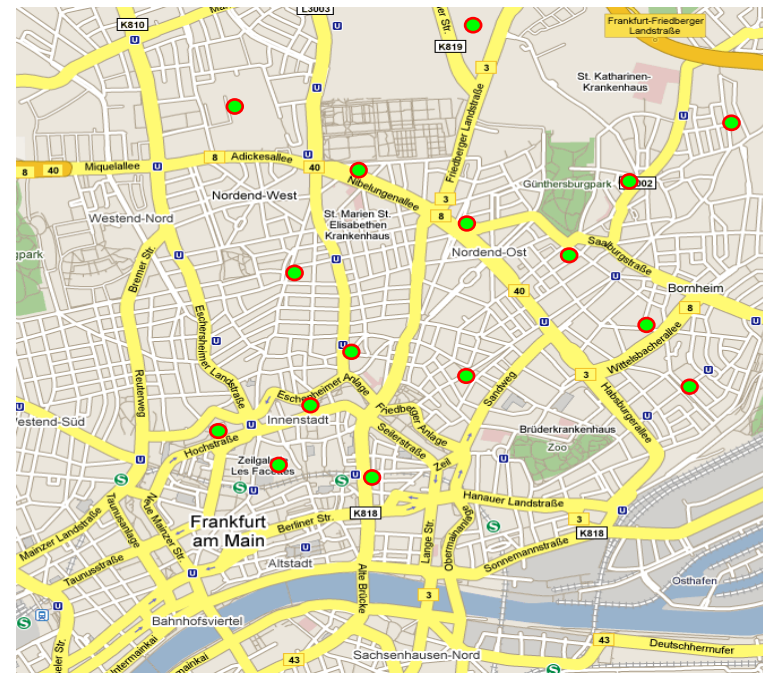
Characteristics of simulation scenario “Frankfurt”

Available ray-tracing data

- Input data characteristics:
 - 16 real world antenna locations in the city of Frankfurt
 - Tri-sectorized configuration (i.e. 48 cells)
 - individual antenna type information, heights and beam directions
 - topographic map of region (4000m × 4000m)

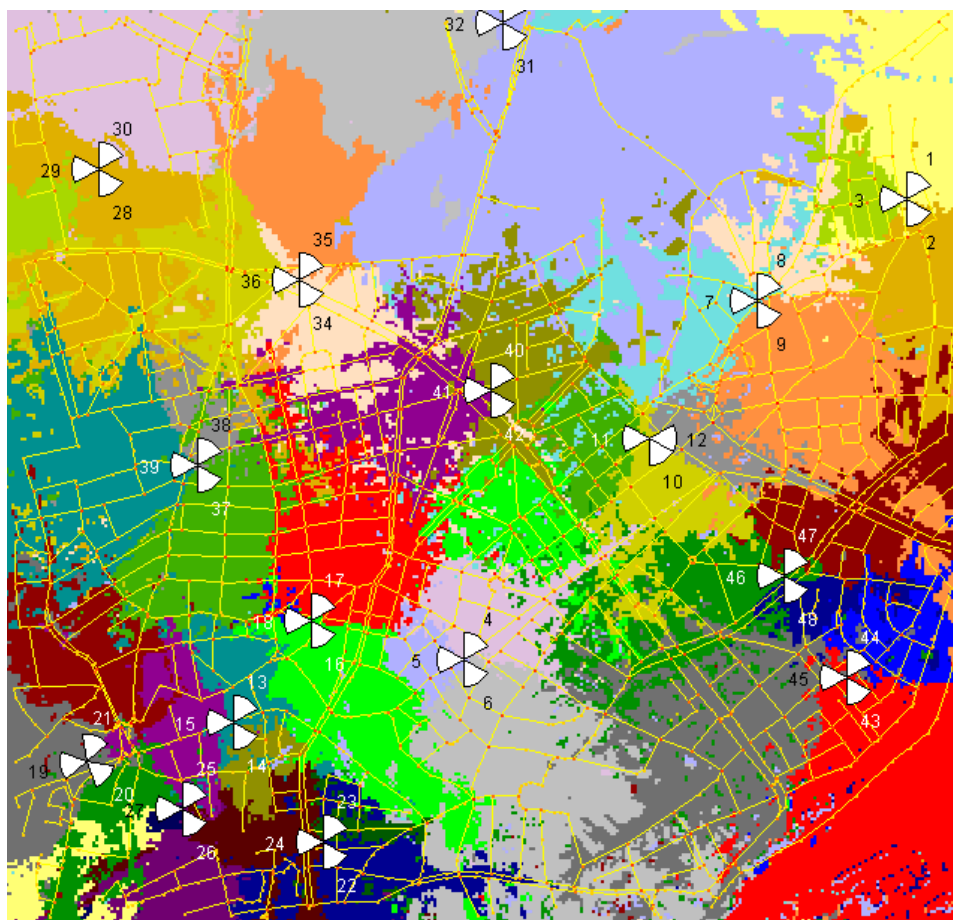


- Output data characteristics:
 - Integer type pathloss data per 10m × 10m grid point per antenna
 - Range: -88dB to -214dB



SON based HO optimization

Algorithm test in simulation



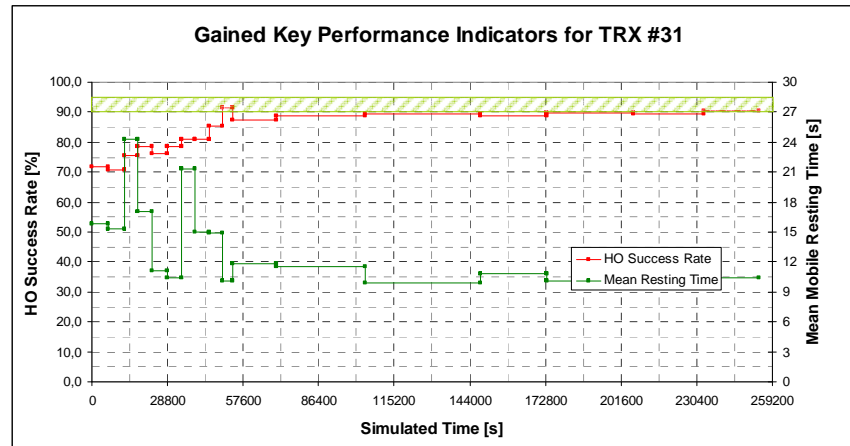
- Event based simulation of HO events, one algorithm instance per simulated cell
- Interference level: 50% load
- mobile speed: 3, 30, 120 km/h
 - 16 mobiles active per speed
 - moving along given roads
 - at crossroads, mobiles choose randomly next road
- same initial mobility parameters at simulation start

SON based HO optimization

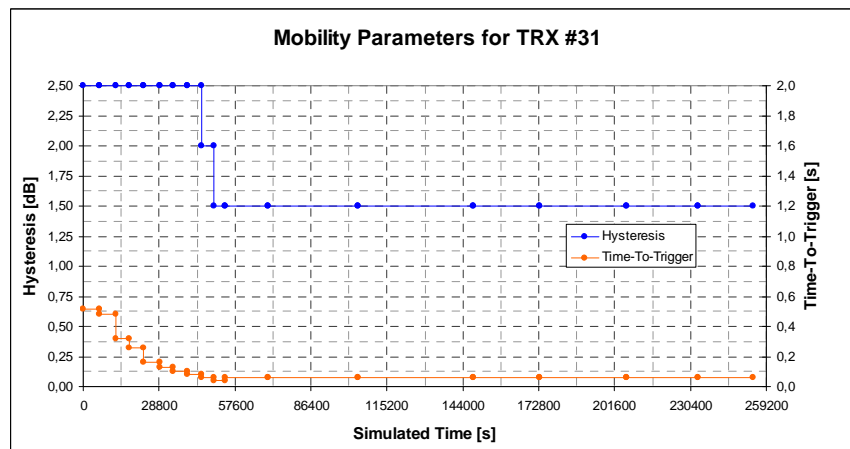
HO success rate window controller

Simulation results

(Simulated network operation: 3 days = 259200 s)



- A quick convergence of the cell global parameters can be observed for frequently visited cells (i.e. on many HO events)
- Choosing initial HO parameters above optimal settings causes a HO success rate below given limit
- The algorithm instance tunes the parameters towards earlier decision for HO, achieving an improvement of the cell total HO success rate





Coverage and Capacity Optimisation

Antenna Tilt Optimization

Optimization goals:

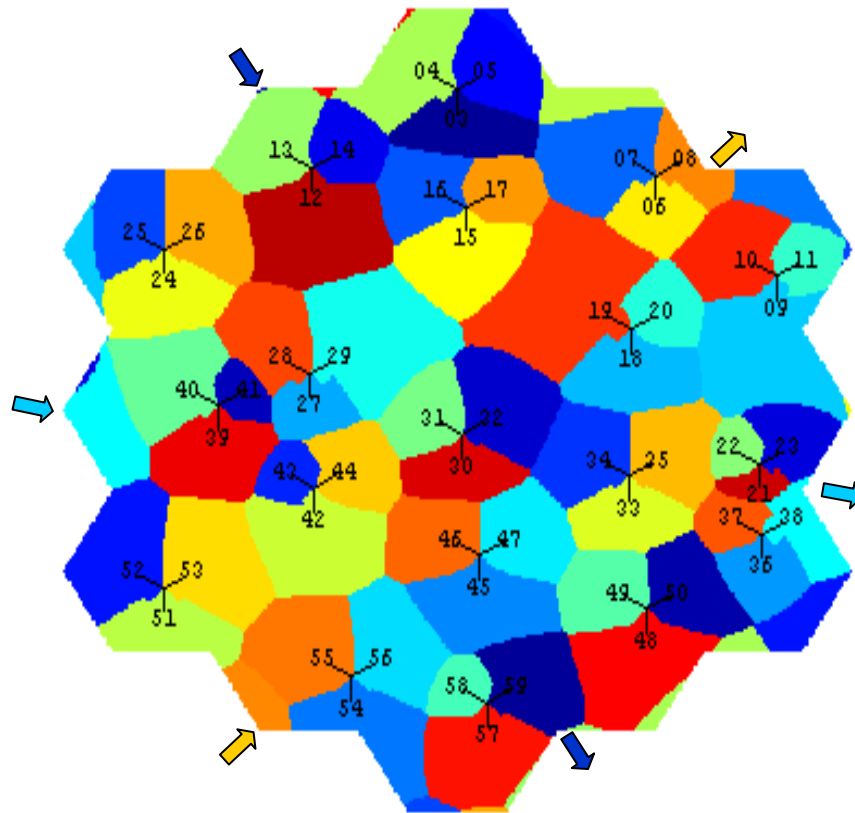
- sector coverage
- sector capacity
- based on downlink performance metric bits/sec/Hz

Approach:

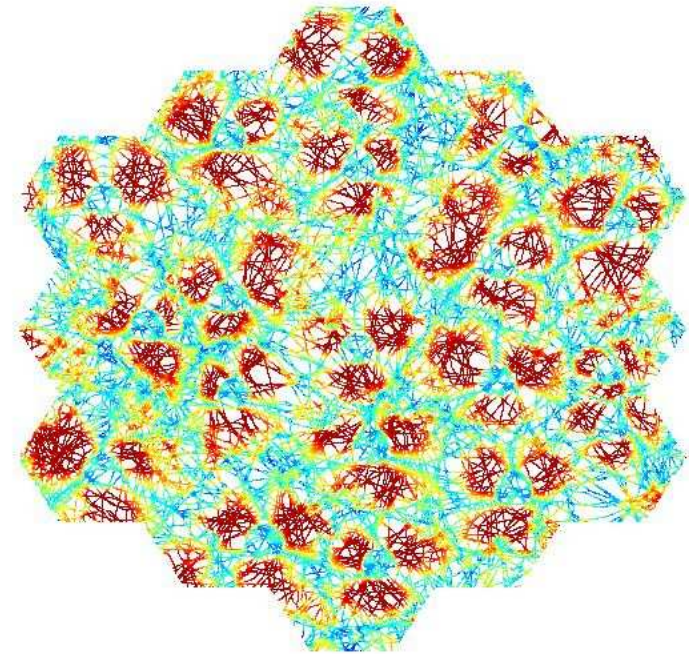
- Distributed optimization:
 - optimization of single cells together with closest neighbors
→ targeting global optimum
 - by adjusting the antenna tilt for each sector individually
 - distributed approach, co-operating eNB and neighbours

Antenna Tilt Optimization

Best Serving Sectors, Displaced Site Locations



after optimization

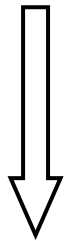
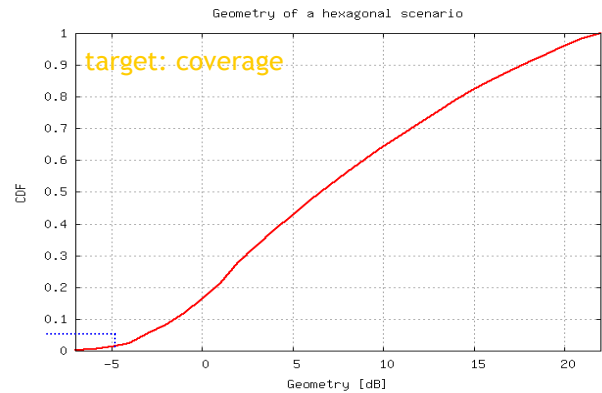


- sites are displaced but playground borders are kept fixed, with wrap around →→
- slow fading with area correlated shadowing is invisible in best server plots due to the equal attenuation of all sectors at a certain point, independent of the direction of the signal

Antenna Tilt Optimization

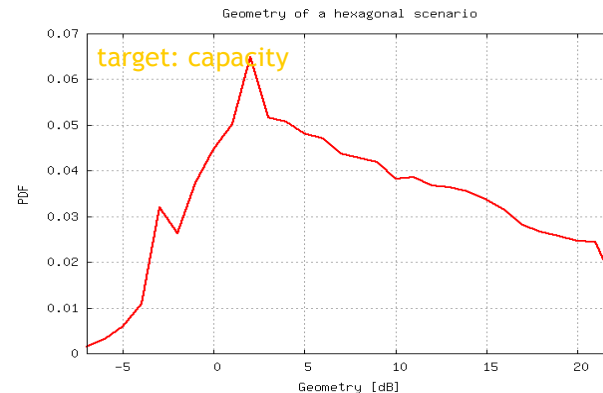
Metrics

Cell wide optimization approach



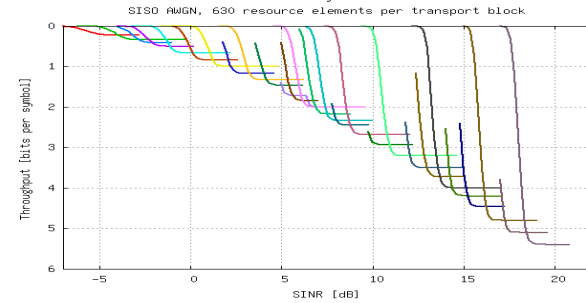
coverage metric:

$$M_1 = B \cdot T_{tf}(G_{5\text{-percentile}})$$

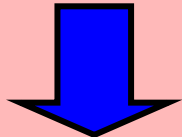



capacity metric:

$$M_2 = B \int_{G_{\min}}^{G_{\max}} p(G) \cdot T_{tf}(G) dG$$



- M: performance metric
- G: Geometry
- B: bandwidth
- p(G): probability
- T_{tf}: throughput per MCS
- W: weighting factor

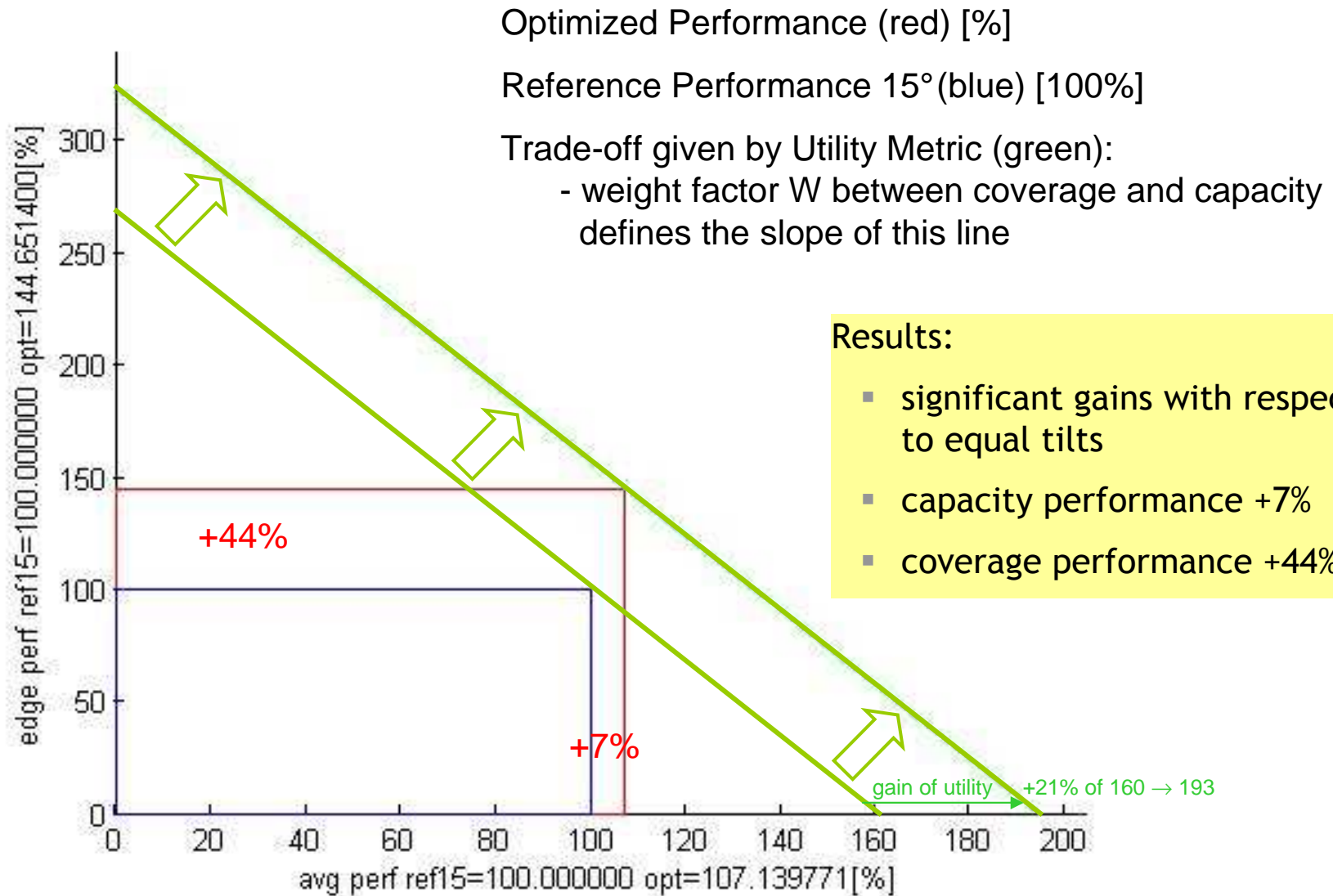

next charts:
 concrete simulation studies:
 operator tunable weighting
 parameter W = 0.91


→ weighted coverage/capacity metric:

$$M = W \cdot B \cdot T_{tf}(G_{5\text{-percentile}}) + (1-W) \cdot B \int_{G_{\min}}^{G_{\max}} p(G) \cdot T_{tf}(G) dG \quad (1)$$

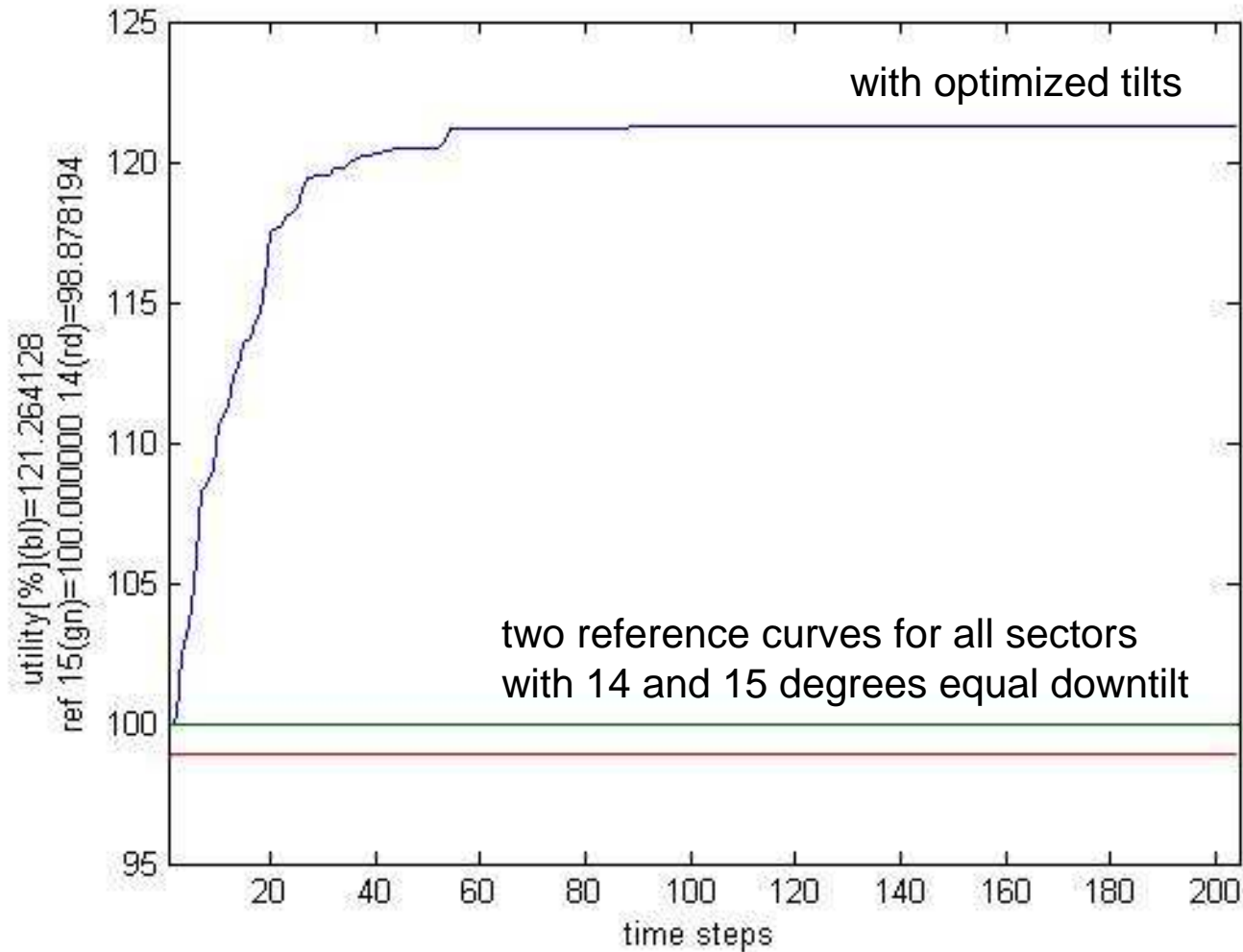
Antenna Tilt Optimization

Performance Gains of Sector Average Performance and Sector Edge Perf.



Antenna Tilt Optimization

Convergence Speed and Gains of Performance Metric



one cycle through all sectors equals 57 steps

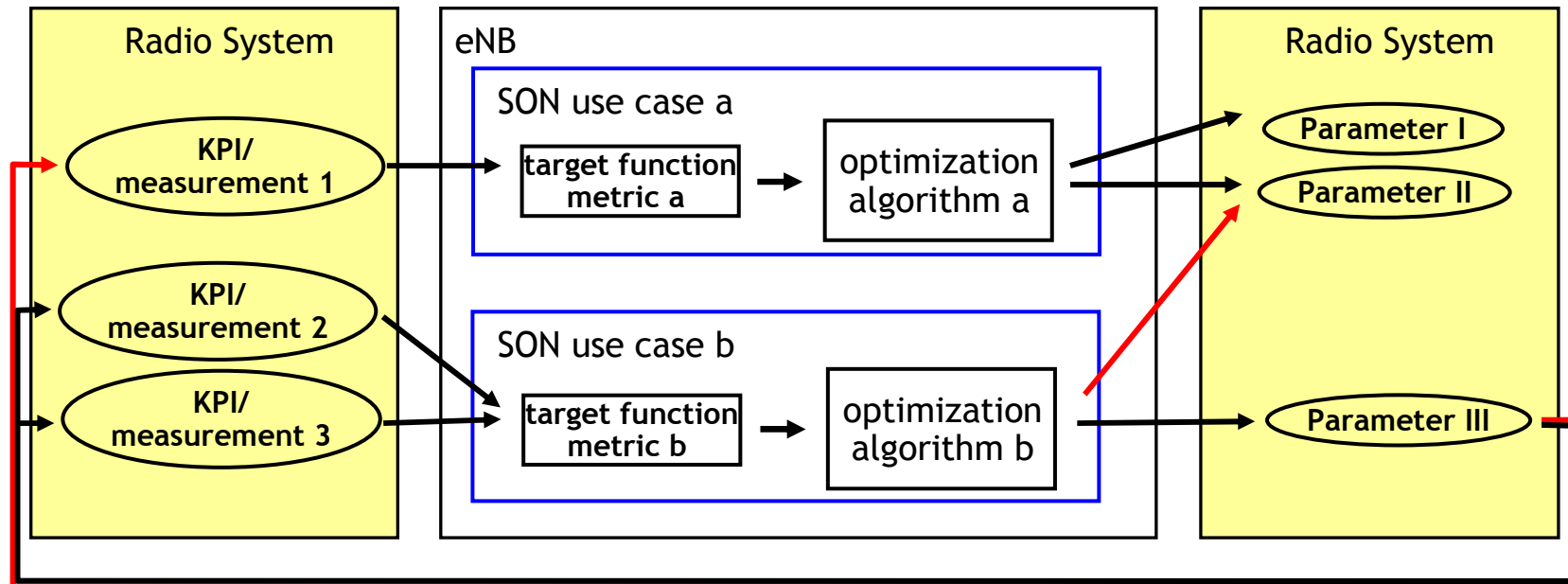
Results:

- promising, playground wide improvement
- non-oscillating
- fast convergence



SON challenges

Mutual interactions of SON optimization algorithms



Mutual impact on optimization target:

One metric is influenced by parameters of different SON algorithms

Coupling by same control parameter:

One parameter is modified by different SON algorithms

Interference Coordination <-> Load balancing

Handover <-> Load balancing

- different coupling mechanisms, different coupling strength !
- ⇒ solution required to manage SON use case interworking

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