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SON Interactions

Where are we and where do we need to go?

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Self-organization in 4G Radio Access Networks

Management of radio access networks has to be self-organized in the 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 SON algorithms
  - to focus network management on high level monitoring and performance tuning

- Challenges:
  - strong requirements on SON algorithms:
    - fast convergence: cope with scarce and noisy measurements
    - well performing also for complex solution spaces: overcome local minima
    - tuneable according to operator requirements: managing target trade-off
    - stable operation
  - mutual dependencies between SON use cases

→ SON use case interactions

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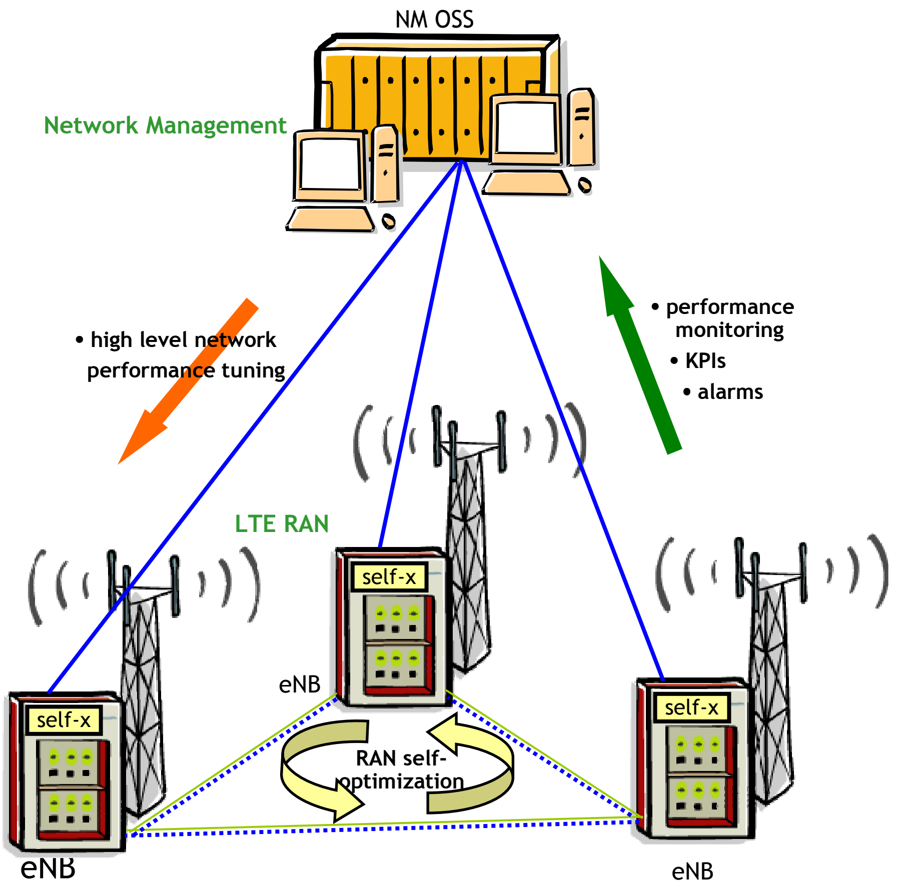
Self-X Architecture

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



OSS: Operation Support System
NEM: Network Element Manager

Use case types

- single objective use case
  e.g. Physical Cell ID (PCI) self-configuration
- multiple objective use case
  e.g. tilt optimization:
  impact on coverage and capacity
- multiple use cases impact one objective
  e.g. Handover (HO) parameter optimization and Load Balancing (LB):
  both have impact on HO performance

Interworking of optimization mechanisms:

- multiple optimization mechanisms → same objective
  e.g. HO parameter adaptation for load balancing
  and semi-static Interference coordination (ICIC) for load balancing
- counteracting effect of optimization mechanisms
  e.g. HO parameter adaptation for load balancing affects handover performance
- conditional dependency
  e.g. cell switching off (energy saving) requires tilt optimization (coverage and capacity)

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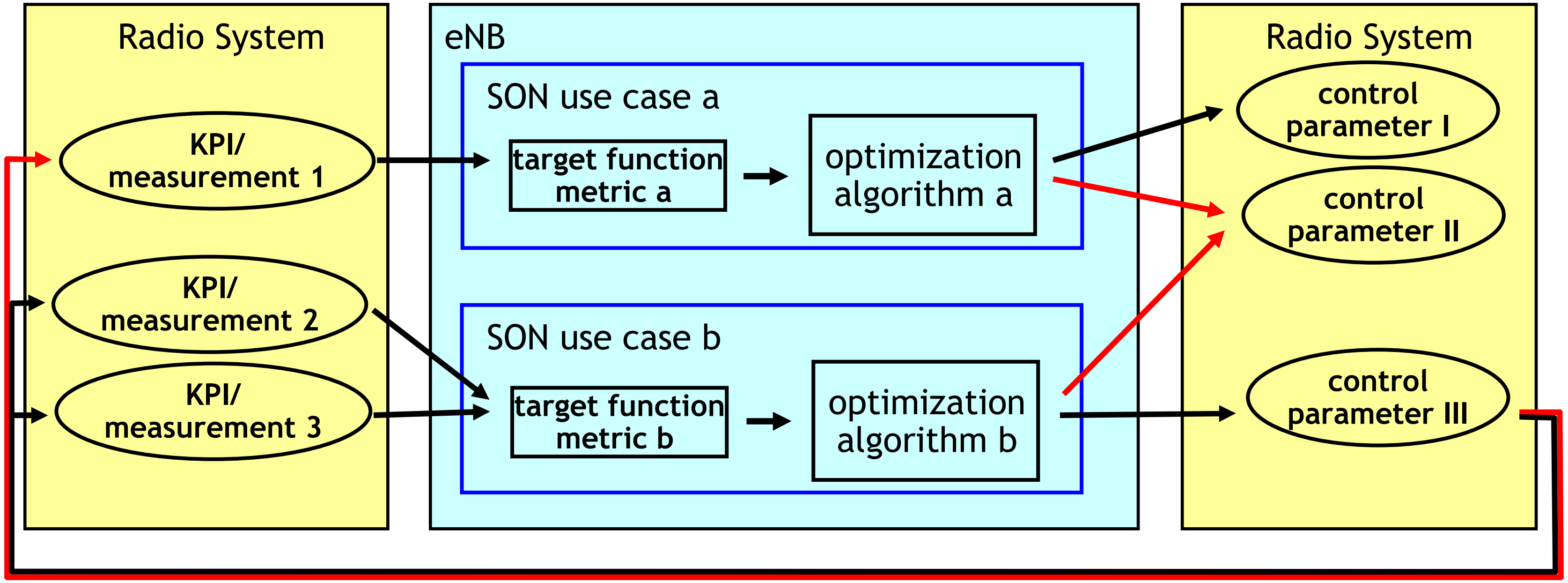
Interworking of SON use cases
Mutual dependencies



Mutual impact on optimization target:
One metric is influenced by control parameters of different SON algorithms:

ICIC and load balancing (metric: load)

Coupling by same control parameter:
One control parameter is modified by different SON algorithms

handover optimization and load balancing (control parameter Cell Individual Offset CIO)
coverage and capacity (antenna tilt angle)

Solution required to manage SON interworking:

⇨ different coupling mechanisms, different coupling strength

⇨ different coupling schemes

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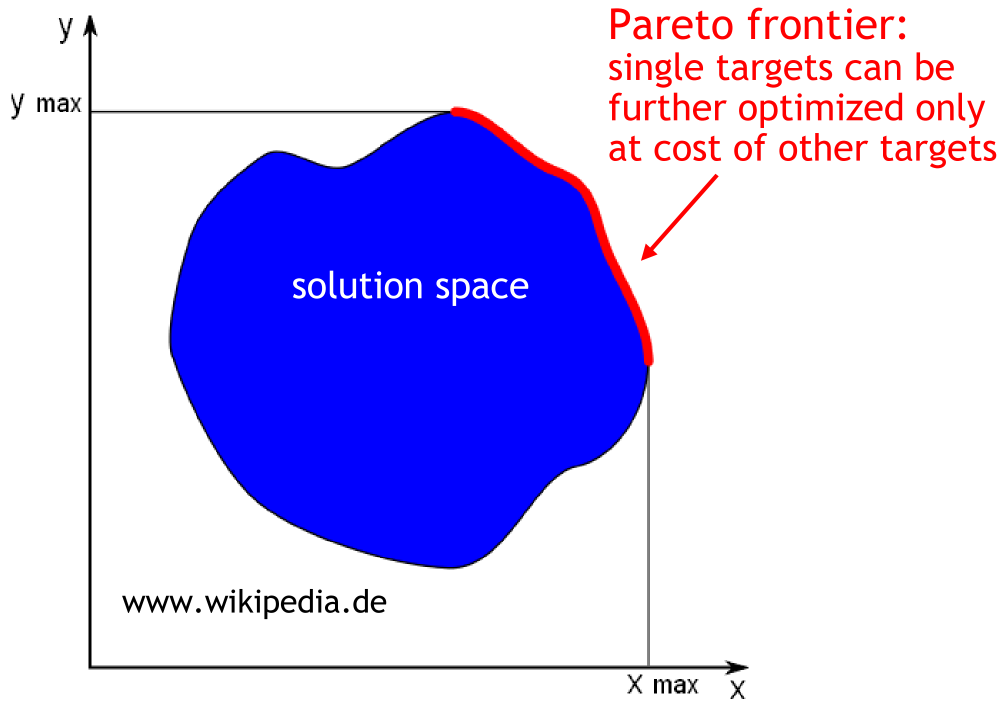
Interworking schemes
Case 1) Tightly interwoven optimization targets:

Separate target optimization not possible

⇨ Multi-target optimization

Pareto optimum



- mutual dependent optimization targets
  - Pareto optimum
  - requires parameter to define the system operation point
    ➔ operator tunable weighting factor
  - example:
    automatic antenna tilting
    ⇓
    coverage and capacity optimization

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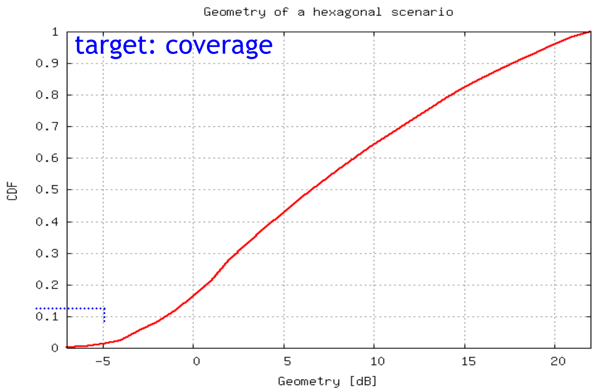
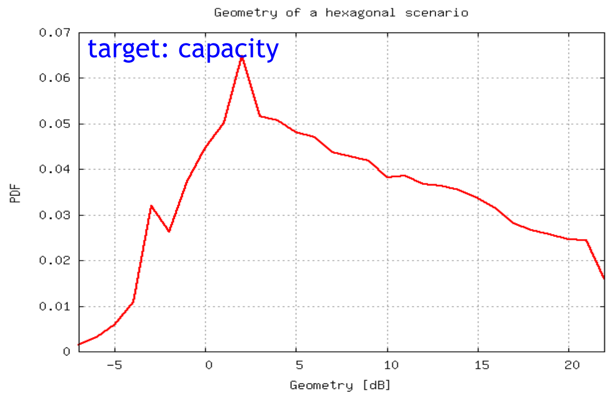
Example for tightly interwoven optimization targets
Antenna Tilt Optimization

Metrics and optimization trade-off





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

coverage metric:

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

capacity metric:

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

next chart:

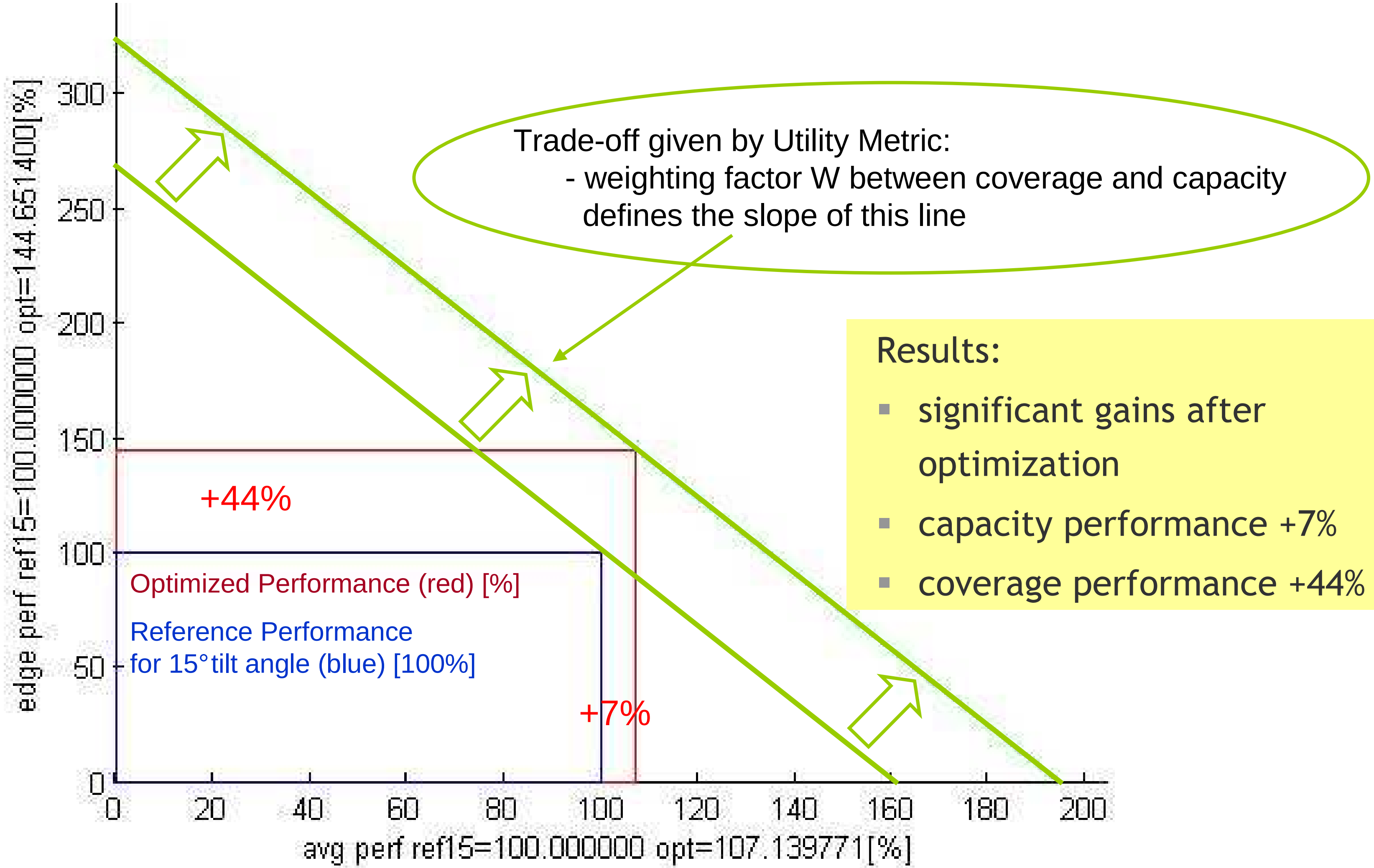
simulation study with operator tunable weighting factor W = 0.91

→ weighted coverage/capacity metric:

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

Example for tightly interwoven optimization targets: Antenna Tilt Optimization

Optimization Gains of Sector Throughput and Sector Edge Performance



Results:

- significant gains after optimization
- capacity performance +7%
- coverage performance +44%

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Case 2) Weakly interwoven or conditionally depending optimization targets:

Self-managed SON use case interaction

Interaction by information

Algorithm A → Algorithm B

Modified parameters / performance / expected impact

Cell operational status (on/off) → *ICIC FFR coloring scheme*

Interaction by control

Algorithm A → Algorithm B

Trigger

Energy efficiency cell switching → *Tilt optimization*

Algorithm A → Algorithm B

Handover optimization → *Load balancing*

Policies, e.g.:

- Permitted parameter range
- Overruling of parameters

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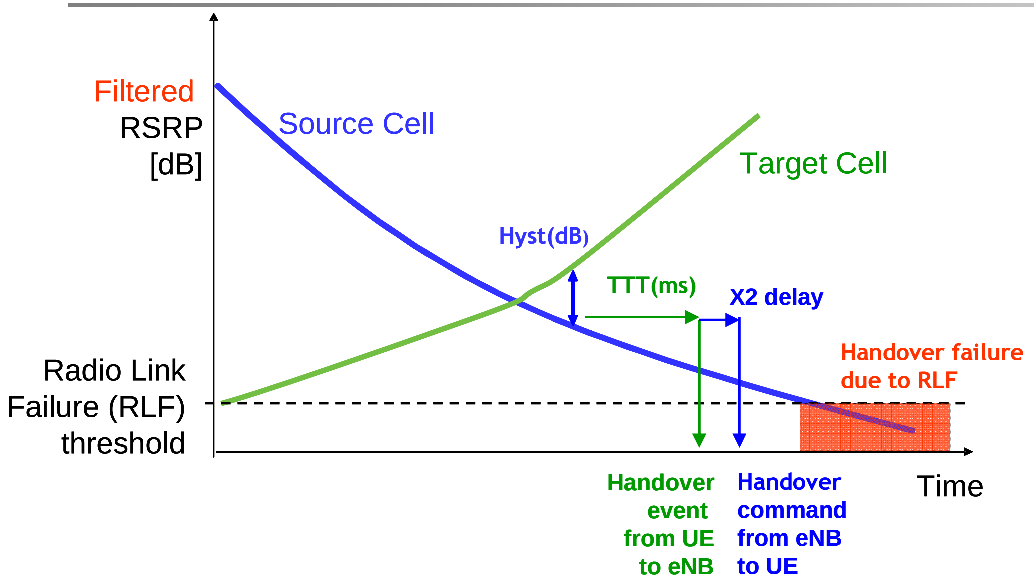
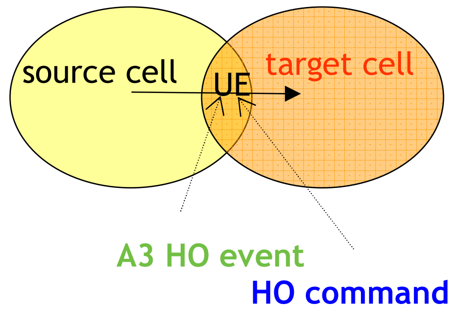
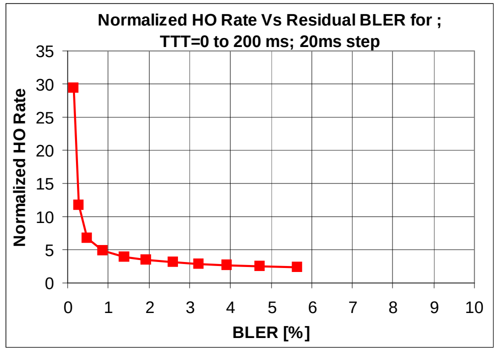
Example for Weakly interwoven or conditionally depending optimization targets: Handover Optimization and Load Balancing







BLER: block error rate of HO command → RLF

Normalized HO rate: without slow/fast fading

- Configuration parameters
  - cell global:
    - Filter Coefficient, Handover Margin (hysteresis between source and target) and Time to trigger (TTT)
  - neighbor relation specific:
    - Cell Individual Offset (CIO, add on handover margin)
- Coupling
  - via Cell Individual Offset → neighbour specific HO performance adaptation; → load balancing
- Optimization restrictions
  - due to different scope of parameters

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

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Example for Weakly interwoven or conditionally depending optimization targets: Handover Optimization and Load Balancing

Interworking approaches:

- by “self-managed” interworking:
  - no load balancing:
    - HO parameter optimization operates in normal mode
  - load balancing active:
    - HO parameter optimization algorithms control LB algorithm for best operating point
- improved solution:
    - Bell Labs is currently working on a combined algorithm combining handover parameter optimization and load balancing

Conclusions

- SON interworking solutions are required
  - as enabler for a broad introduction of SON functionality
  - to achieve “real” self-organizing SON functionality
    - especially for distributed SON architectures
  - to manage convergence and stability challenges

- Different coupling of SON use cases:
  - two coupling schemes must be covered:
    - Tightly interwoven optimization targets
      ➔ Multi-target optimization
    - Weakly interwoven or conditionally depending optimization targets
      ➔ Self-managed SON use case interaction

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