Self-configuration and Self-optimization of 4G Radio Access Networks

E. Kuehn, A. Ambrosy, D. Hofmann, C. Gerlach, M. Litzenburger
Alcatel-Lucent R&I
Stuttgart, Germany
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Motivation

Current situation for radio network configuration and optimization: deployment, maintenance, and optimization of radio networks become more and more complex and cost extensive. High manual intervention and high expertise required. Several different tools for network planning and optimization involved:

today:

<table>
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<tr>
<th>Task</th>
<th>Tool</th>
<th>Processing type</th>
</tr>
</thead>
<tbody>
<tr>
<td>planning, configuration, optimization and error handling</td>
<td>manually operated network management tools</td>
<td>conventional (re-)configuration</td>
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**Main Targets:** CAPEX and OPEX reduction
Solution Approach

Solution: introduction of self-x mechanisms

Task
- planning, configuration, error handling and optimization

Tool
- manually operated network management tools

Processing type
- conventional (re-)configuration

self-configuration and self-optimization

future
- add new site/cell, capacity upgrade
- failure cases
- performance optimization

self-x

Automated supervised or autonomous network management tools

significantly increased automation
simplified deployment procedures
faster recognition and reaction on fault situations
automatic and continuous radio access network optimization
adaptation to dynamic system behavior
Solution Approach: Self-Configuration and Self-Optimization

- Deployment
  - Set of optimized radio parameters
- Self-optimisation function
  - System model + optimization algorithms
  - Model adaptation
  - Analysis system performance
- Operational mode
- Self-configuration of radio and RRM parameters (pre-operational mode)
- Deployment of new cells & nodes
- Performance monitoring, measurements
- Topological info (e.g. morphology data, eNodeB and UE based measurements with location info)

Algorithmic description of system behavior
Architecture and Standardization Aspects

Relevant self-x scenarios:
Public Access, Office and Home

Self-x Architecture
- self-x function required in OMC (network element manager) and base stations
- self-x support by MS (measurements and preferably MS location info) and by base stations (measurements, Key Performance Indicators (KPIs), alarms and status reports)
- self-x control and supervision via OMC
to be adapted to scenario specific RAN architecture
centralized vs. distributed self-x functional architecture is ffs.

Required interfaces:
- interface between base station and OMC: tailored to specific network node implementation: to achieve maximum optimization efficiency
- multi vendor support vs. OMC northbound interfaces

Standardization relevance:
- configuration and reporting of MS based measurements and (if available) location info
- multi vendor support
Self-Configuration Targets

Overall Targets:
- real plug and play for installation of new nodes and cells
- guaranteeing acceptable QoS when switching to operational mode
- fast re-configuration in failure cases

Configuration functions:
- set-up of neighborhood relations (cell, base station)
- initial resource allocation to cell and base station
- set-up of (initial) base station radio and RRM parameter configuration
- neighbor re-configuration

network planning, network live cycle campaign, new QoS
Self-configuration Use Cases and Tasks

Self-configuration Use Cases:
- Add cell / add site scenarios, removal of cells / sites
- capacity upgrade
- failure cases (cell/node)

Self-configuration tasks:
- automated initial configuration of cells and network nodes before entering operational mode (real plug & play) including reconfiguration of neighborhood nodes and cells:
  - assignment of radio resources (frequency bands, interference coordination, physical channel parameters)
  - assignment of required identifiers (e.g. cell ID)
  - adaptation of predefined radio configuration parameter sets to actual location and environment, e.g.
    - radio parameters (e.g. power settings)
    - RRM parameters (e.g. handover parameters like thresholds, timers, hysteresis, ...)
  - reconfiguration of mutually depending parameters of neighbor nodes
- set-up of neighborhood relations
  - key function for RRM and self-x use cases (required e.g. for set-up of handover relations between cells, coverage optimization, interference coordination)
  - neighborhood information required in base stations and OMC databases
Self-Optimization Targets

Overall Targets:
- continuous improvement of service availability, QoS and network efficiency
- optimization of radio and Radio Resource Management parameters and of neighborhood relation list
- fast reconfiguration/compensation in failure cases
- adaptation to short and long term dynamic system behavior

Optimization process:
- control of optimization process
  - interactive, supervised, up to autonomous monitoring of optimization process
- optimization functions based on system performance analysis and modeling of system behavior
- topological info (e.g. morphology data, MS and base station based measurements)
- application of an optimization strategy
- optimization targets configurable application of predefined parameter constraints
- maintain stable system operation

network planning, network live cycle campaign, new QoS

self-optimization

starting point for self-x

optimization algorithms

synchronized deployment and activation of optimized radio parameters

performance measurements

update neighborhood relations

download presets

self-configuration

start-up configuration of new cell / new site and neighbor nodes

addition / removal / failure of cells and sites
Self-optimization Use Cases and Tasks

Optimization tasks (examples)

Coverage optimization

detection of areas with insufficient coverage by analysis of measurements and Key Performance Indicators (e.g. received power and call drop rates)
corrective actions:
  - adaptation of transmit power settings
  - adaptation of antenna direction and tilt (if available by remote control)
constraints given by the maximum tolerable interference to neighbor cells

Interference coordination and optimization

detection of cases with non acceptable high inter-cell interference and support of static and dynamic interference coordination schemes by analysis of measurements, Key Performance Indicators (e.g. interference level and call drop rates)
corrective actions:
  - resource reassignment for interference coordination schemes
  - automatic assignment of re-use factors > 1
  - power setting modification
  - antenna tilt and direction modification (if available by remote control)
constraints are to keep coverage in overlap areas of neighbor cells
Self-optimization Use Cases and Tasks

**Handover optimization**
minimizing handover failure rates and avoidance of so-called ping pong handovers. Problem
detection by analysis of Key Performance Indicators (handover failure rates, number of discarded
PDUs and received signal level during handover, visit time distribution of target cells, ...)
corrective actions:
  - adaptation of handover thresholds, hysteresis and timers
includes intra and also inter technology handover

**Load balancing**
increasing the overall throughput by avoiding overload situations with increased blocking rates
and insufficient provisioning of ongoing services w.r.t. QoS. Detection of unbalanced load
situations by measuring usage of radio resources (e.g. total transmit power, interference,
throughput) and computational power of the base stations
corrective actions:
  - modification of handover parameters to force handover to neighbor cells
  - redistribution of radio resources

**Updating neighborhood relations**
correction of neighbor relations according to real environment (key function for self-x and RRM)
Conclusions

- Self-x reduces OPEX and CAPEX -- simplified processes for deployment, maintenance, and optimization
- Enabling real plug & play for new network nodes and cells
- Continuous optimization of network performance adaptation to short and long term dynamic system behavior
- Standardization required for self-x