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Self-organisation in Wireless Networks – Use Cases and their Interrelation

Dr. Werner Mohr
Nokia Siemens Networks
werner.mohr@nsn.com

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WWRF 22 Meeting

Outline

- Introduction – Drivers for self-organisation
- The SOCRATES project
- Self-organisation use case examples
- Interrelation of use cases
- Conclusions

Drivers for Self-organisation

Technical:

- Increasing complexity and size of mobile networks
- Operation of several network generations in parallel
- Paradigm shift from telco specific towards IT networking technologies

Market:

- Increasing diversity and complexity of offered services
- Reduced time-to-market and lifetime of services
- Enhanced requirements on service quality

High efforts for radio Network planning and optimisation

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The SOCRATES Project

Self-Optimisation and self-ConfiguRATion in wirelESs networks

- STREP project within the EU FP #7
- Duration Jan. 2008 – Dec. 2010

Goals:

- Development, Evaluation and Demonstration of methods and algorithms for self-configuration, self-optimisation and self-healing
- Improve network coverage, resource utilisation and service quality
- With a focus on 3GPP E-UTRAN, investigation of impact on standardisation, network operations and service provisioning

SOCRATES Approach

Measurements: continuous activity, collection of information from various sources (NE, UE, OAM)

Parameter settings: newly calculated / updated parameters are deployed to network elements

Self-optimisation: algorithms to intelligently process measurements and update configuration parameters

Self-healing: automated fault management to resolve incidental radio and networking errors

Self-configuration: for incidental events, e.g., deployment of new NEs or services

SOCRATES Phases

Requirements phase:

- Identification of use cases and requirements for self-organisation
- Definition of a self-organisation framework (architecture, assessment criteria for algorithm development, scenarios, operator policies etc.)

Development phase:

- Detailed solutions (methods and algorithms) for selected self-organisation use cases
- Validation of solutions

Here we are

Integration phase:

- Integration of solutions with framework
- Demonstration of benefits and implications of solutions
- Dissemination of solutions (standard contrib., workshops)

SOCRATES Selected Use Cases

Use Case Title	Self-organisation Area
Self-optimisation of Home eNodeB	Self-optimisation
Load Balancing	Self-optimisation
Interference Coordination	Self-optimisation
Packet Scheduling	Self-optimisation
Handover optimisation	Self-optimisation
Admission & Congestion Control	Self-optimisation
Coverage Hole Detection & Compensation	Self-optimisation
Cell Outage Management	Self-healing
Management of Relays & Repeaters	Self-config./Self-opt.
Automatic Generation of Default Parameters	Self-configuration

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Home eNodeB - Overview

- Home base stations are expected to be extensively used in 3G LTE
- Coverage / capacity extension in limited areas (office / in-house)
- Installed by end user and physically inaccessible for operator
- Characteristics:
  - Small coverage areas, probably few users per cell
  - May be turned on and off frequently, may be switched off and moved
  - Closed or open access
  - May operate on a separate frequency band as the macro eNodeBs (segregated spectrum) or in the same band (shared spectrum)

Several self-organisation use cases apply for Home eNodeB, with different conditions than for macro network

Home eNodeB – Sub Use Cases

- Home eNodeB neighbour relations (including other HeNB and macro)
  - Detect neighbouring eNodeBs
  - Maintain and optimise neighbour cell list
- Home eNodeB handover optimisation (HeNB – macro, HeNB – HeNB)
  - Automatically decide if handover should take place
  - Optimise handover parameters to ensure seamless mobility
- Home eNodeB interference and coverage optimisation
  - Consider the compensation of coverage holes
  - Consider influence on macro network in case the same band is used
  - Consider tradeoff between interference and coverage
- Home eNodeB initialisation and configuration
  - Connection to operator network
  - Define appropriate settings for integration into running network

Selected

Selected

Home eNodeB - Approach

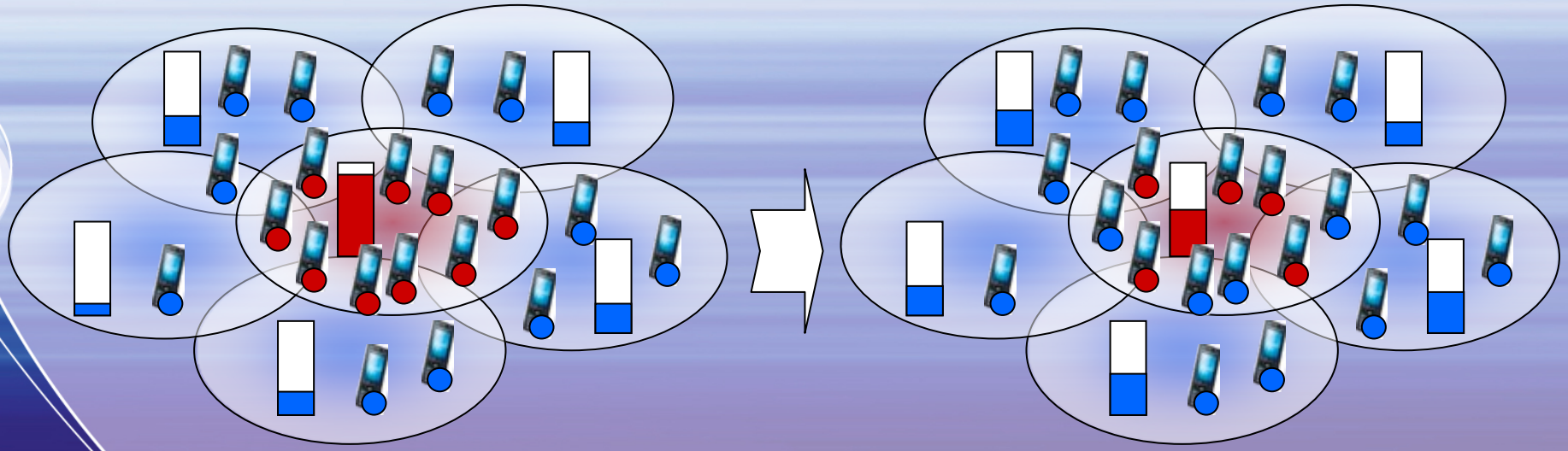
Measurements, e.g.
UE Reference Signal Received Power / Quality
UE last visited cells (UE history), UE Packet loss / delay
eNodeB Downlink Reference Signal Transmit Power, call drop ratio

Operator Policies, e.g.
Provide coverage, provide a guaranteed service
Relieve load from macro cells, with keeping impact on macro network performance low (e.g. handover ping-pong effects, interference)
Commercial / marketing

Configuration Parameters, e.g.
Uplink / downlink power settings
Handover offsets, favouring / discriminating particular cells

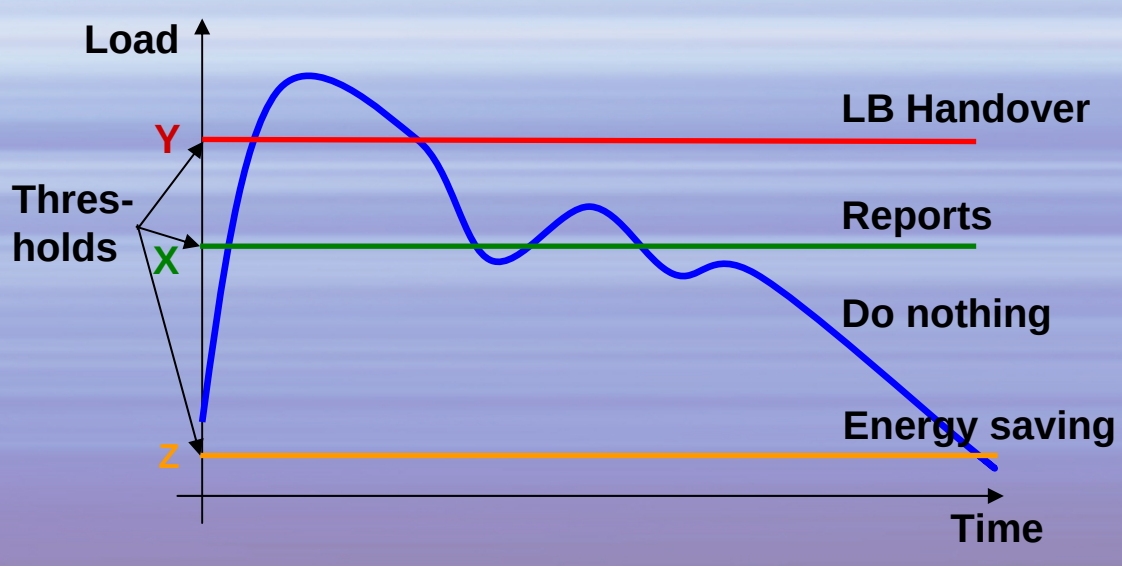
Load Balancing - Overview

- Problem: unequal user distribution, with heavily loaded cells in vicinity of lightly loaded cells
- Goal: detect and compensate load imbalance between cells to
  - Improve resource utilisation
  - Improve Quality / Grade of Service for end users



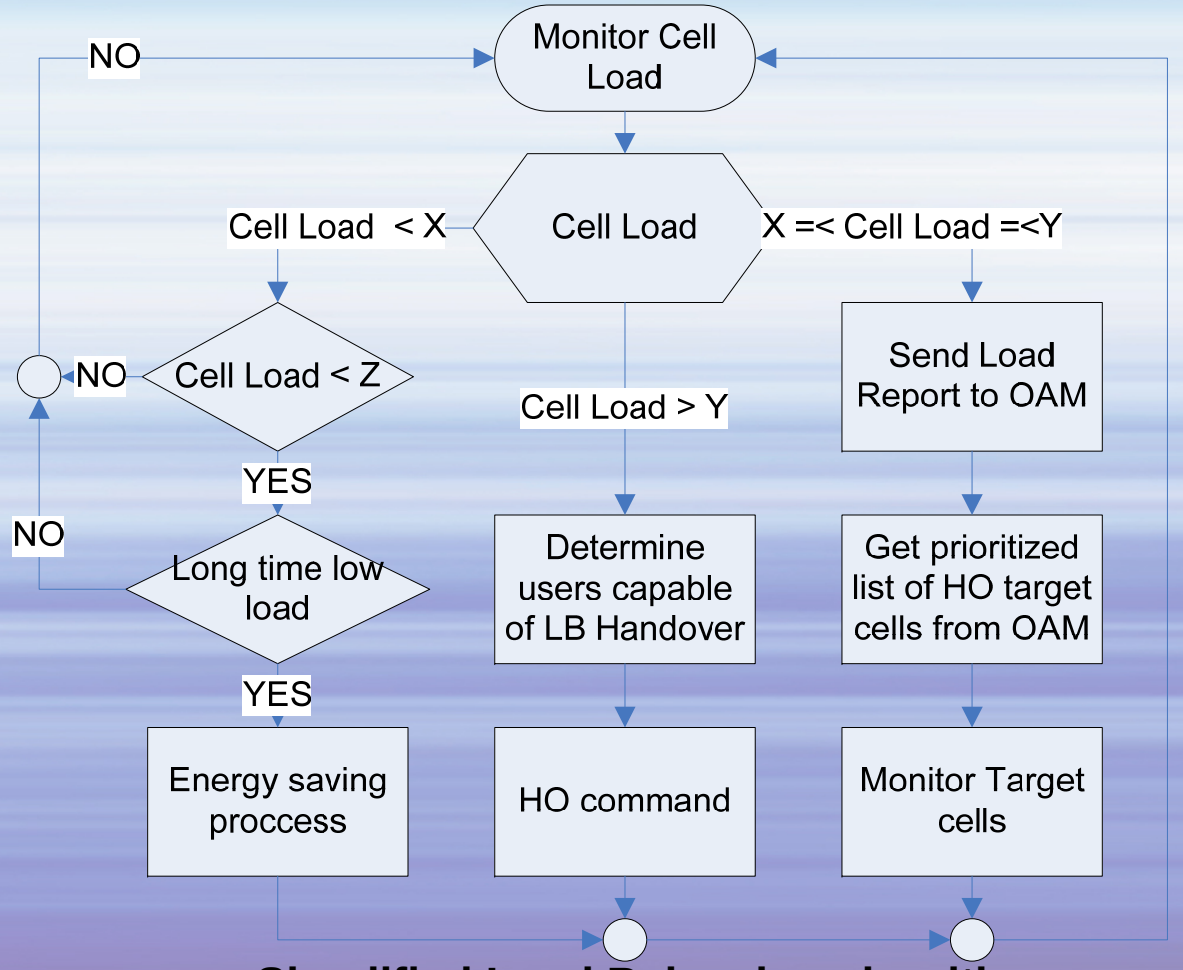
Load Balancing - Status

- Only load balancing within LTE system is regarded
- Triggers:
  - Overloaded cell — Load > Y (close to 100%)
  - QoS improvement — Load < Y but higher than in neighbour cells
  - Energy saving — Load << 1 (very low load)
- Thresholds:
  - Keep LB message size and frequency low
  - Set load thresholds to trigger LB functionalities



Load Balancing – Solution Approach

- Load balancing only works for capacity driven networks with sufficient cell overlaying
- Besides HO of UEs to neighbouring cells, adjustment of cell size & coverage (transmitter power or antenna params.) are possible solutions



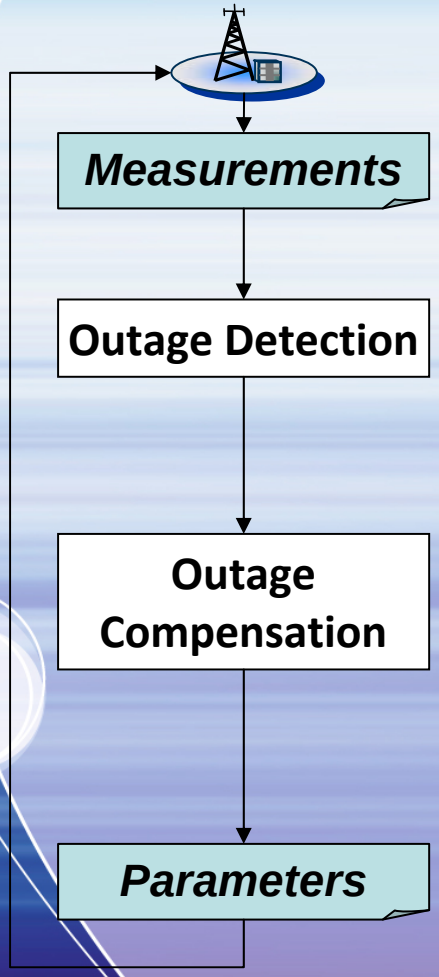
Simplified Load Balancing algorithm

Cell Outage Management – Overview

- Goal: minimise network performance degradation in case of outage
- Reasons for cell outage:
  - Hardware / software failures (e.g., radio board failure, channel processing implementation error, etc.)
  - External failures (e.g., power supply or network connectivity failures)
  - Erroneous Configuration
- Operator optimisation goals for outage compensation:
  - Achieve the best coverage possible
  - Provide the highest accessibility
  - Deliver the best possible quality in the outage area and surrounding cells

Not all goals can be reached at the same time, they need to be weighted according to quality, coverage, or capacity policies

Cell Outage Management – Solution Approach



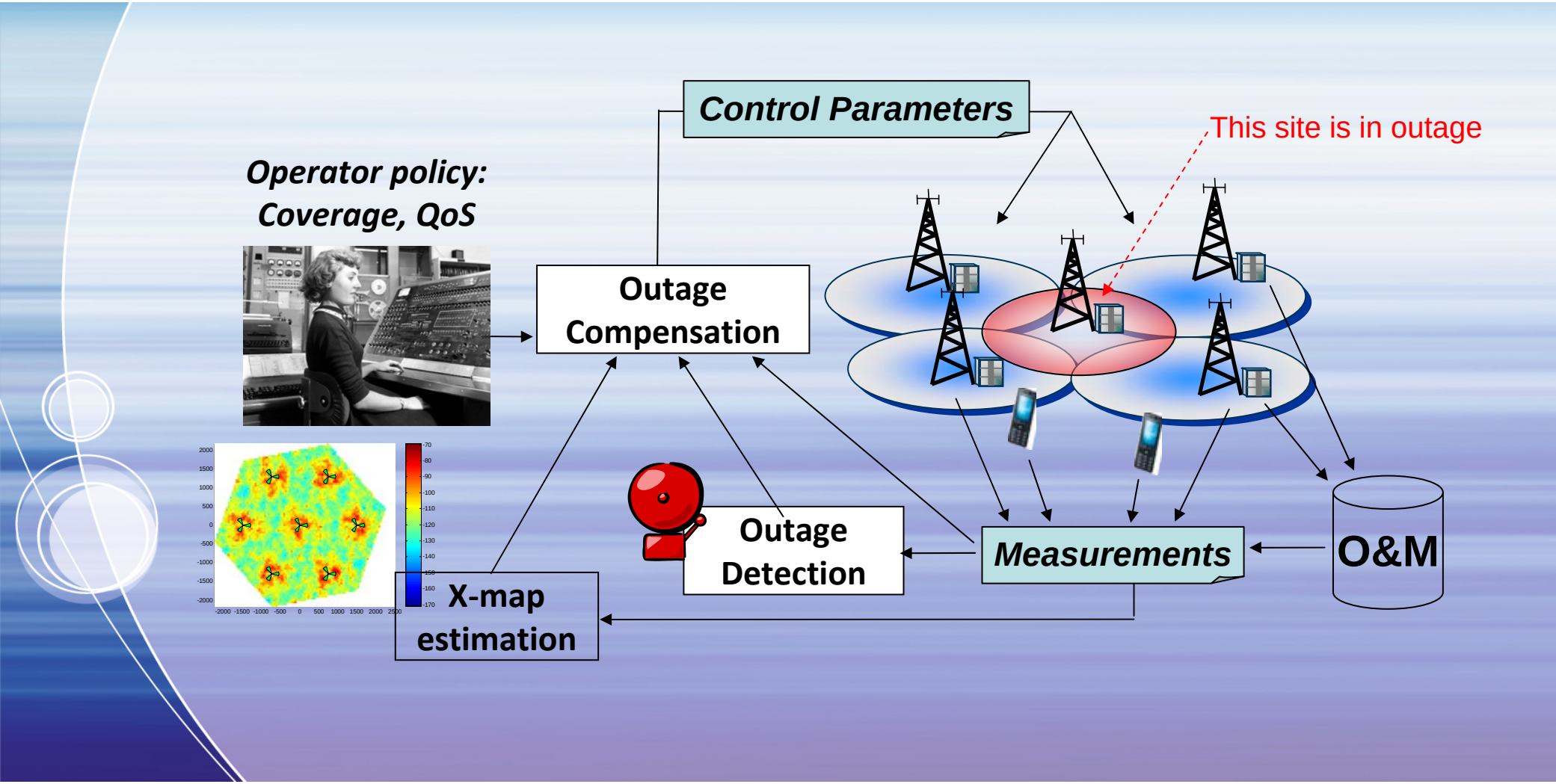
Continuous and event-triggered measurements (counters, timers, alarms, KPIs, radio measurements) from various sources (OAM, eNodeBs, UEs)

Outage scenarios: sleeping site / sector, site / sector failure, transport link failure

Which surrounding cells are to be taken into account
Compensation scenarios: large cells → coverage, high-capacity cells → accessibility, service quality
Estimation of compensation results using “X-map”, “X” = coverage, accessibility, packet loss, throughput etc.

Physical channel settings (e.g. power settings)
Antenna parameters (tilt, azimuth, multi-ant. techniques)
Home eNodeB for compensation or to reduce interference

Cell Outage Management – Solution Approach



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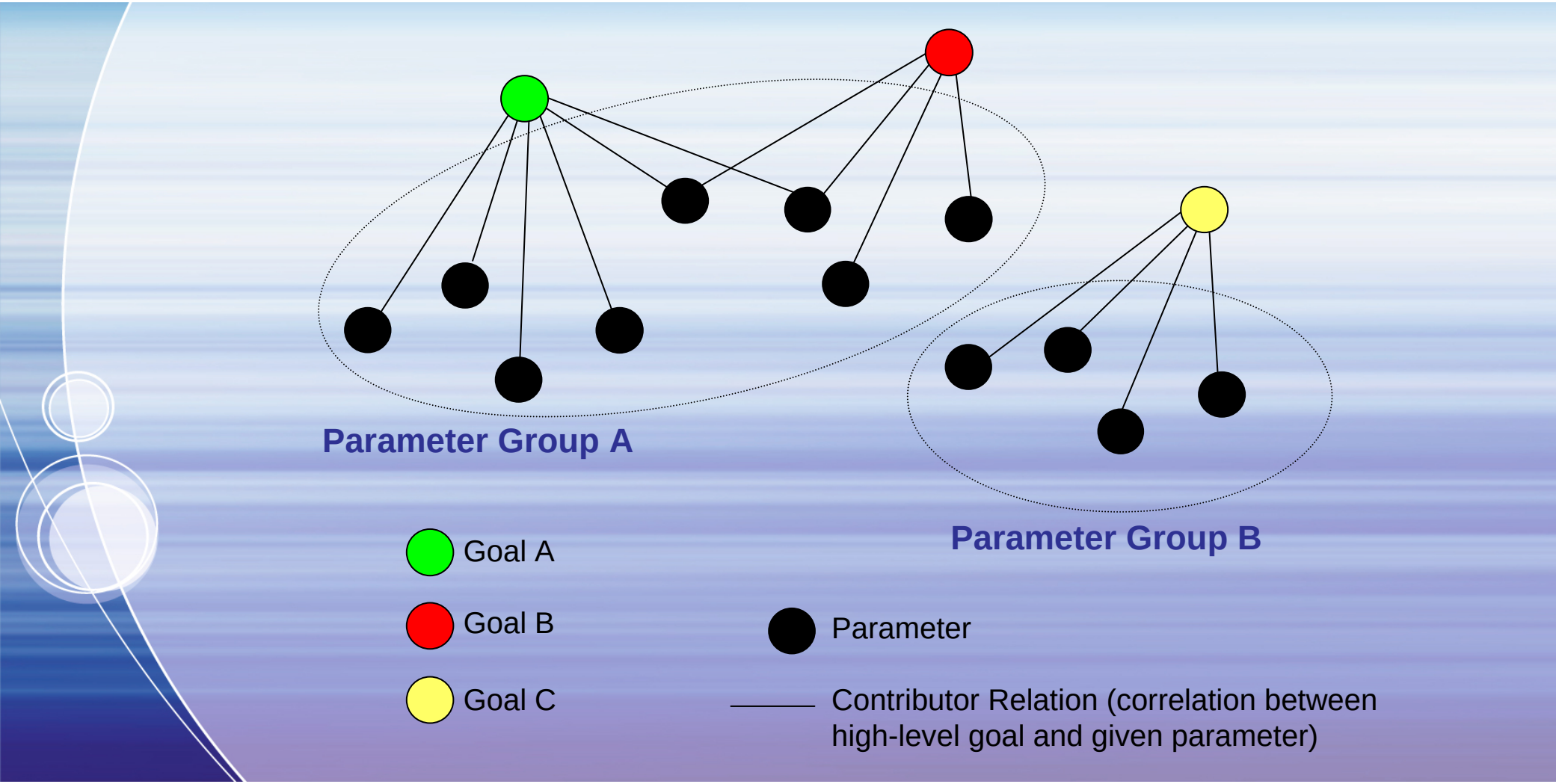
Interrelation of Use Cases

- Each self-organsiation use case modifies a set of configuration *Parameters* (dedicated configuration setting) in the corresponding network elements to achieve the intended self-configuration, self-optimisation or self-healing *Goals* (high-level target of self-organisation)
- Several use cases are running in parallel, and therefore several self-optimisation functionalities may alter the same configuration parameters

Allover system performance may depend on conflictive parameter adjustments

Interaction of self-organisation functionalities needs to be analysed, to identify functionalities that need to be coordinated

Configuration Parameter Grouping - Example



Goals and Parameters - Examples

Goal	Parameters
Minimise interference	• Radio bearer transmit power • Radio bearer assignment • Antenna parameters • Channel quality indicator thresholds for schemes switching
Balance load	• Radio bearer transmit power • Antenna parameters • Handover parameters • Cell re-selection parameters
Maximise / Optimise coverage	• Radio bearer transmit power • Antenna parameters

Conclusions

- Each single use case requires considerable effort regarding
  - Analysis of input data, measurements, and configuration parameters
  - Development of solution algorithms and deployment scenarios
  - Evaluation of impact to OAM and RAN architecture
- Self-organisation is to be regarded as a whole
  - Use cases are not independent of each other regarding their influence on the system configuration and parameters
  - Self-organisation goals have to be defined as system goals, and these system goals have to be broken down to the single use case goals
  - For the development of self-organisation solutions, the solutions of single use-cases have to be coordinated and integrated

Contact

SOCRATES Project Website: www.fp7-socrates.org

Authors of WWRF 22 contribution:

L.C. SCHMELZ (Nokia Siemens Networks, Munich, Germany)
J.L. VAN DEN BERG, R. LITJENS (TNO ICT, Delft, The Netherlands)
M. AMIRIJOO, K. ZETTERBERG (Ericsson, Linköping, Sweden)
K. SPAEY, I. BALAN (IBBT, Gent-Ledeberg, Belgium)
N. SCULLY (Vodafone, Newbury, United Kingdom)
S. STEFANSKI (Nokia Siemens Networks, Wroclaw, Poland)

Contact:

Dr. Werner Mohr
Nokia Siemens Networks GmbH & Co. KG
80240 München Germany
werner.mohr@nsn.com

Lars Christoph Schmelz
Nokia Siemens Networks GmbH & Co. KG
80240 München Germany
lars.schmelz@nsn.com