Realistic Scenarios for System-Level Simulations of LTE Networks with SON Features

7th COST 2100 Committee Meeting
February 16th - 18th 2009
Braunschweig, Germany

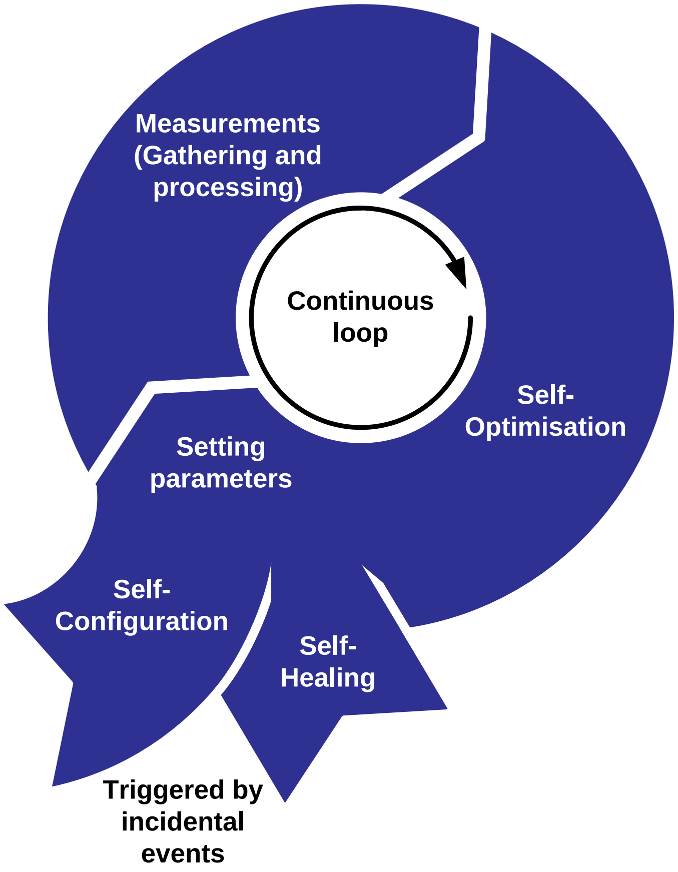
Authors: Andreas Eisenblätter, atesio, Berlin
Thomas Jansen, TU Braunschweig, Braunschweig
Thomas Kürner, TU Braunschweig, Braunschweig
Ulrich Türke, atesio, Berlin
John Turk, Vodafone, Newbury

Outline

1. The SOCRATES Project
2. Self-Organising Networks (SON)
3. Self-Organisation in the interference coordination use case (ICO)
4. Simulation requirements of the SOCRATES use cases
5. Impact on simulation scenarios and data format
6. SOCRATES simulation scenarios
7. Conclusions

Objectives of the SOCRATES-Project

- Increase the network performance
  - quality of service, system capacity, throughput, …
- Reduce the effort of human intervention
  - automate optimisation processes
  - fast adaptation to network conditions
- Reduce operating costs
  - energy consumption
  - operational expenditure (OPEX)
- Continuously collecting measurements
  - UE measurements
  - Cell measurements
  - Information exchange between eNodeBs



SON features considered for LTE

- SOCRATES investigated 24 use cases
  - Use cases address situations where self-organisation may be of benefit
  - Divided into 3 categories [1]

- Self-Optimisation
  - Interference coordination
  - Handover optimisation
- Self-Configuration
  - Automatic generation of default parameters
  - Intelligently selecting site locations
- Self-Healing
  - Cell outage management
  - Coverage hole management

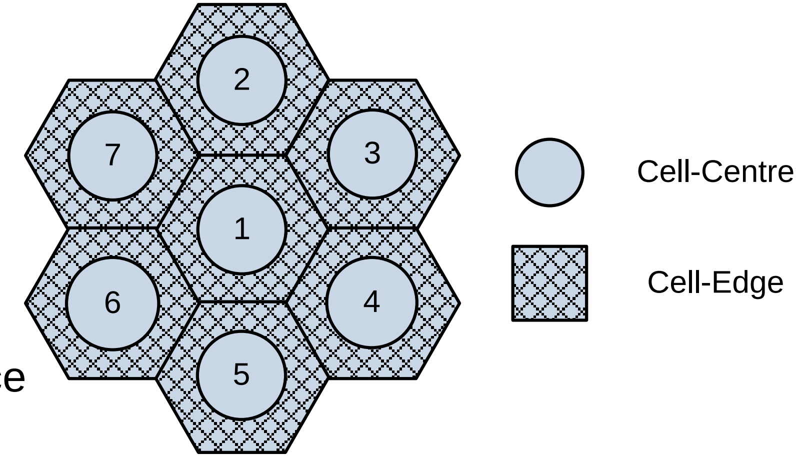
- No generally accepted definition of what is considered to be SON

- From 3GPP TS 32.500-800
  - Self-Organising Networks (SON) are introduced to reduce the operating expenditure (OPEX) associated with the management of a large number of nodes from more than one vendor
  - SON functions can help to automate network planning, configuration and optimisation processes

[1] Reference: TD (08)616, "**Use Cases, Requirements and Assessment Criteria for Future Self-Organising Radio Access Networks**", COST2100, Lille, France, October 2008

Interference coordination as SON use case

- Triggers
  - Low quality of service (QoS)
  - High ratio of blocked and dropped calls

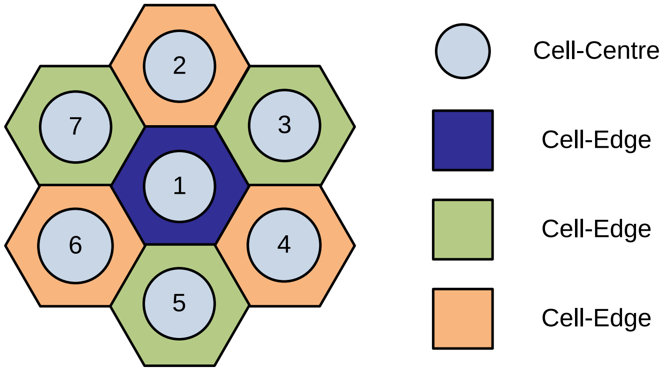


- Goal
  - Ensure good cell edge performance
  - Minimise the impact of inter-cell interference
  - Maintain a fair balance between cell-edge users performance and performance of the users closer to the cell-centre
  - Consider QoS requirements regarding demanded type of service

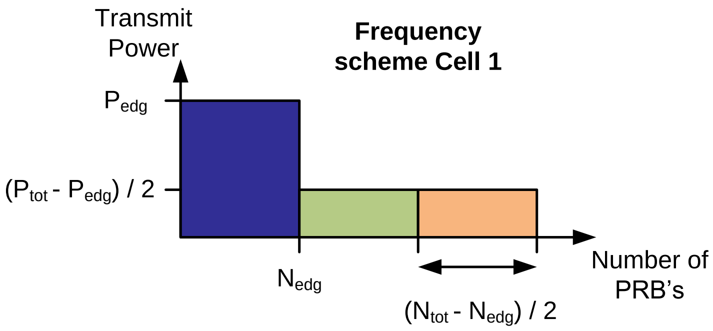
- Important network conditions
  - User's location (cell-edge, cell-centre)
  - User mobility
  - Type of service
  - …

Interference coordination as SON use case

- We follow two different approaches to develop SON algorithms
  - SON algorithm on top of soft frequency reuse scheme (Figure below)
  - Individual assignment of physical resource blocks to the users depending on the actual interference situation



- Main control parameters
  - Physical resource block (PRB) allocated per UE (DL & UL)
  - PRB tx power per UE (DL & UL)
  - Reference symbol power
  - Antenna tilt
  - Beamforming



Radio Network Simulations

- Analytic evaluation
  - Analyse performance of the algorithms analytically
- Monte-Carlo Simulations
  - Variation of network condition snapshots (not over time)
  - Reach statistical relevance
- Short-term Dynamic Simulations
  - Small short-term variations in the network condition
  - Analyse the algorithm performance to short-term changes
- Dynamic Simulations
  - Analyse the adaptability of the algorithms to realistic network condition fluctuations over time

Interference coordination: Simulations requirements

Simulation requirement	Value
Algorithm location	Centralised or Distributed
Number of considered cells	2 – 10
BTS Types	Macro, Micro, Femto
Level of simulation	System-Level (Static and Dynamic)
Information exchange	Between neighbouring cells and SON functions (Handover optimisation, …)
Time resolution	ms
Mobility	Simple models
Traffic	Realistic models
Network topologies	Hexagonal and Realistic
Exceptional events	User concentration, High speed users, …

- For the algorithm assessment a list of assessment criteria is defined [2]

[2] Reference: SOCRATES Deliverable D2.3: "**Assessment Criteria for Self-Organising Networks**", EU STREP SOCRATES (INFSO-ICT-216284), Version 1.0, July 2008

Simulations requirements across all use cases

Simulation requirement	Range	Example use case (high requirement)
Algorithm location	Centralised, Distributed and/or Local	
Number of considered cells	1 – **N * 100 cells**	Cell outage compensation
BTS Types	**Macro, Micro**, Femto	SO of home eNodeB
Level of simulation	Static - Dynamic	Load balancing
Time resolution	h - min - ms	Admission control
Mobility	None - Full mobility	Congestion control
Traffic	Simple - **Realistic models**	Handover optimisation
Network topologies	Hexagonal / **Realistic**	Interference coordination

→ MORANS data format meets several requirements

SOCRATES Simulations requirements

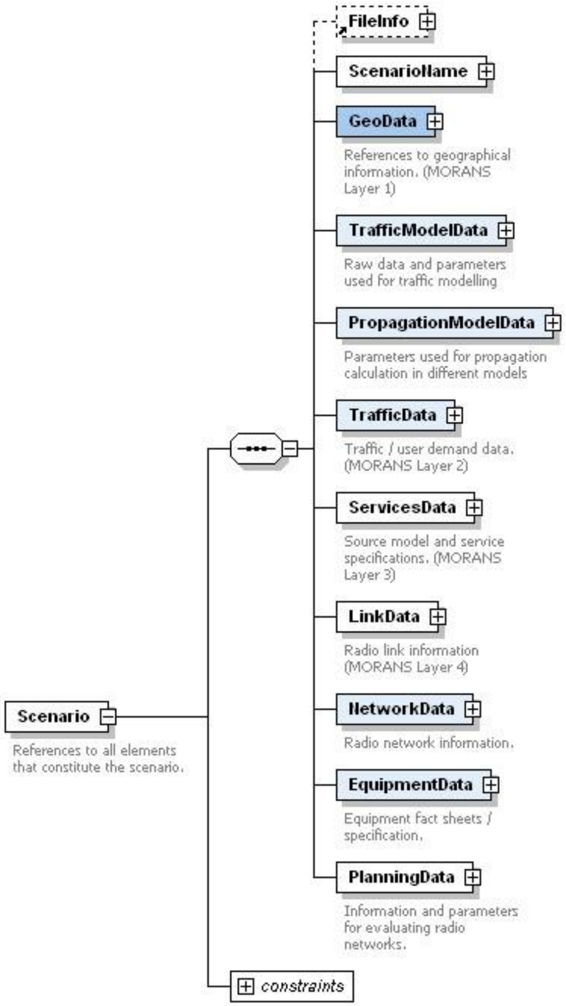
- Control parameter changes during the simulations with high impact on network condition
  - Antenna tilts
  - Tx powers
  - Handover parameters

- Drastic network condition changes by exceptional events
  - System outage
  - High speed users (Train)
  - Traffic concentration (Football match, Exhibition, ...)
  - Home eNodeB may be switched off

- Simulation scenarios and corresponding data formats need to cope with these simulations requirements

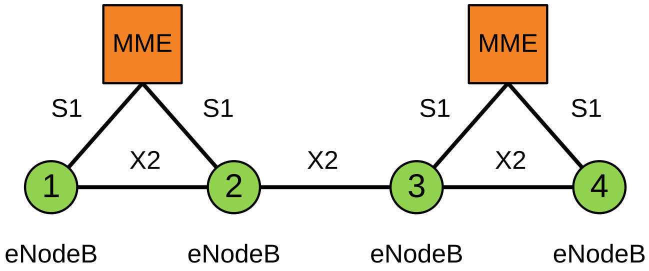
MORANS Data format

- Developed in the MOMENTUM project
- COST further developed MORANS
- MORANS is a UMTS specific data format
- The format is generic and XML-based
- Adjustments to LTE specifics and SOCRATES simulations requirements mainly in highlighted areas



Extensions to the MORANS data format

- Extended hardware requirements
  - Home eNodeB
  - Relays / Repeater
  - Multi antenna arrays (MIMO, Beamforming)
  - Antennas from different network generations mounted on one panel

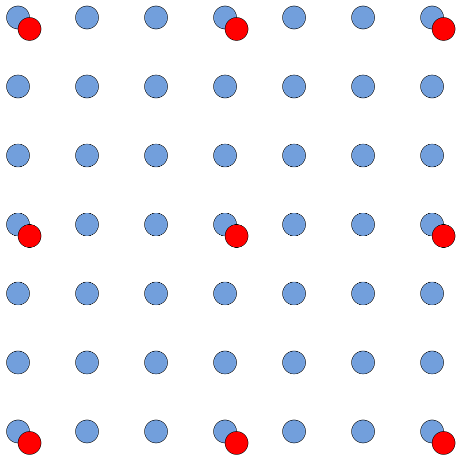


Source: Google Earth 5.0

- Multi-Layer data
  - Needed for indoor scenarios / outdoor-to-indoor / indoor-to-outdoor
  - Separate propagation files for different building levels
  - Example use cases: Optimisation of home eNodeB's

Extensions to the MORANS data format

- Multi-Resolution data
  - Desired to allow for different simulation accuracies
  - Example: Land-use class pixel-maps in different resolutions



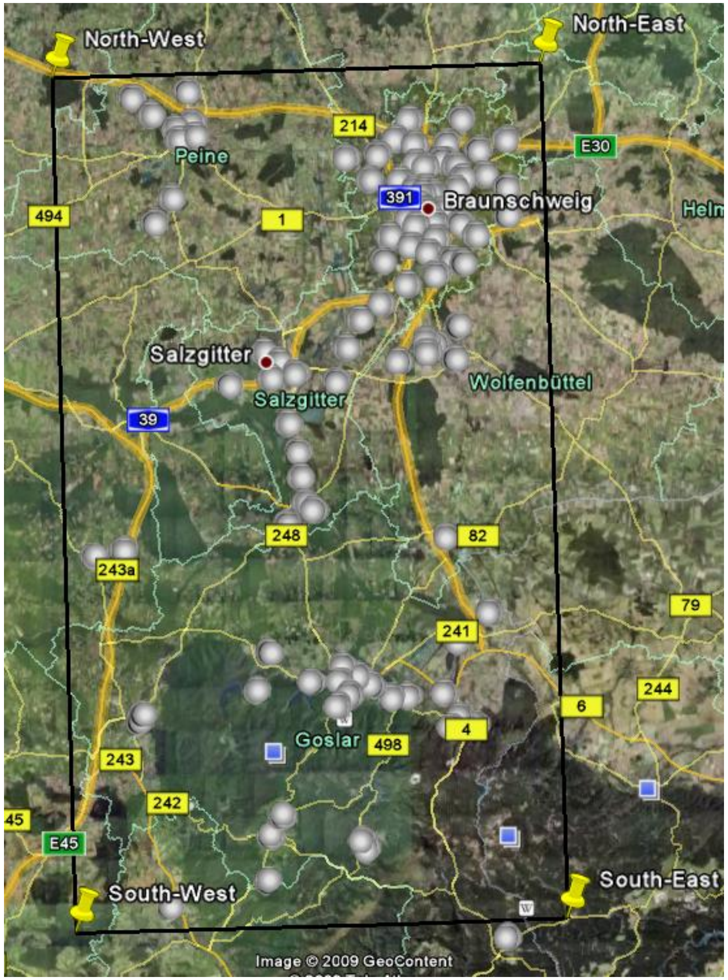
- Network condition changes
  - Scenario data is needed for the following cases
    - Cell outage
    - Coverage hole
    - Traffic concentration
    - High speed users
    - Switching home eNodeB on and off
  - Transform the network
    - Algorithms change network configuration (extended data needed)
    - Antenna configuration impacts signal propagation

SOCRATES simulation scenarios

- Two settings defined for the project

1. Berlin Area
   - Size: 13 km * 13 km
   - Urban, Dense-Urban, Hot-Spot
   - Terrain height variation: ~ 20 m
   - Hundreds of cells

2. Braunschweig Area
   - Size: 40 km * 70 km
   - Dense-Urban, Urban, Sub-Urban
   - Terrain height variation: ~ 700 m (Mountain Hartz)
   - Hundreds of cells



Source: Google Earth 5.0

Conclusions

- The development of SON features entails various simulation requirements
- Simulation scenarios need to provide
  - Scenario data for changes over time
    - Network configuration
    - Network failure and repair
    - Demand patterns
  - Multi-Layer data
  - Multi-Resolution data
- MORANS data format is an excellent starting point
  - Adapt to LTE
  - Extended hardware requirements: MIMO, Beamforming, Home eNodeB
  - Higher network entities and interfaces: MME, S1 and X2

Thank you very much for your attention