

Algorithms for Self-configuration and Self-healing

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Lars Christoph Schmelz
Nokia Siemens Networks



- Drivers for Self-configuration and Self-healing
- Self-configuration in SOCRATES
- Self-healing in SOCRATES
- Selected use cases
 - Automated Generation of Initial Default Parameters
 - Cell Outage Management
- Summary / Conclusion



Self-configuration

- Rollout for new network elements / networks causes considerable cost (e.g. for new LTE networks) for on-site installation and commissioning
- First concepts and solutions to automate initial NE configuration procedure (IP settings, software, security, configuration data) have already been published in the research community or are part of the standardisation process

Self-configuration solutions are required that support self-optimisation and self-healing

Self-healing

- Service degradation or service outage cause considerable cost for the operator due to lost revenues and reduced customer satisfaction
- Failure analysis and (temporary) elimination or compensation require high manual effort and are rather time consuming, thereby cutting off fast recovery of the service

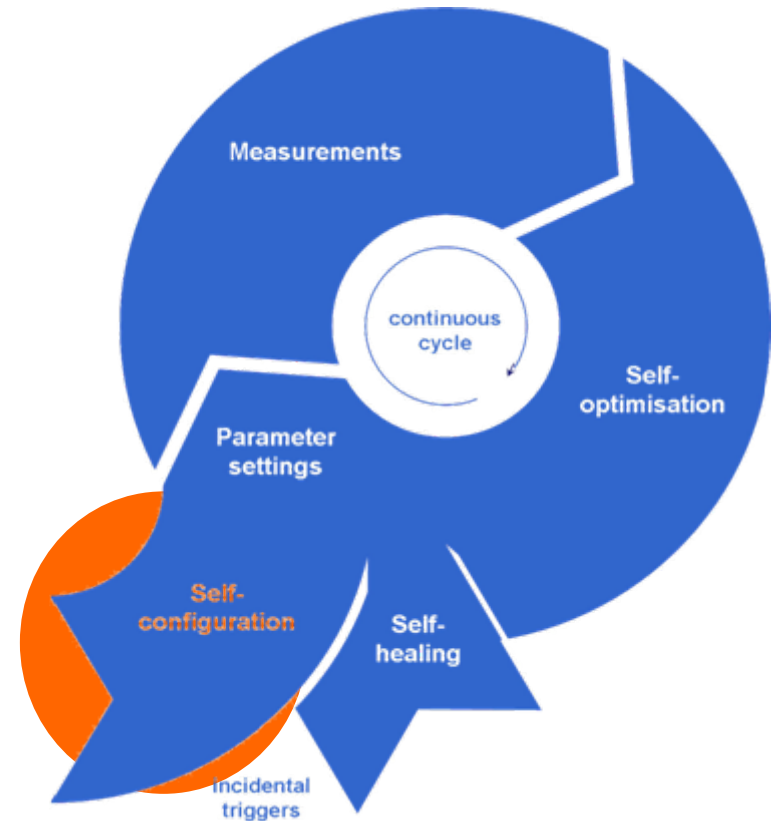
Self-healing solutions are required that considerably reduce manual efforts for service recovery

Definition

- *Self-configuration is about automatically deriving a sensible initial configuration for a piece of equipment as part of its installation process or as a consequence of the installation of adjacent network nodes*

SOCRATES Approach

- *Evaluate concepts, develop and validate models and methods for advanced self-configuration of radio parameters*
 - *With focus on LTE*
 - *Incidental trigger e.g. through NE insertion*
 - *Interconnection with self-optimisation process*
 - *Derive impact on OAM architecture and NE and UE functionality*

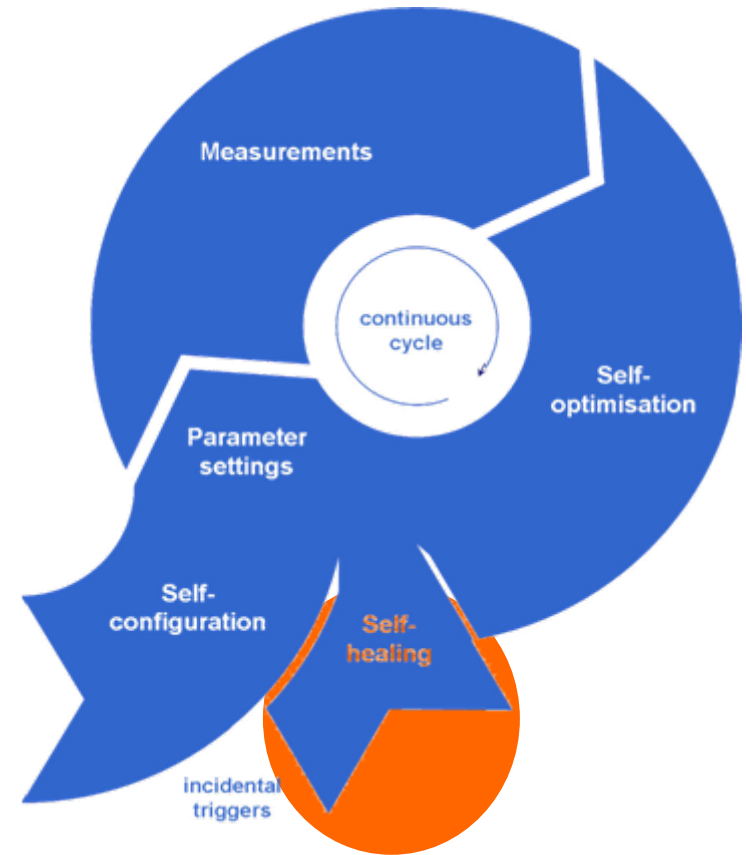


Definition

- *Minimising the impact on network performance caused by HW and SW failures in the radio nodes, by near-real-time detection of faults and provisioning of alternative and temporary ways to serve the users in the affected area*

SOCRATES Approach

- *Develop and validate mechanisms to avoid unplanned manual maintenance activities*
 - *Focus on LTE*
 - *Timely detection of failures using (where applicable) available mechanisms and measurements from OAM, network, and user equipment*
 - *Repair of failures or, if impossible, compensation of failures by re-configuration of the network*



Self-configuration and Self-healing use cases (WP4)

- Automated generation of initial default parameters (Self-configuration)
 - Define an operator- and site-specific set of radio parameters for new network elements to simplify and accelerate the rollout and insertion in the operational network
- Management of relays and repeaters (Self-optimisation and Self-configuration)
 - Address the specific requirements for LTE relays and repeaters during NE insertion and operation, with selected sub-use-cases mainly on self-optimisation topics
- Cell Outage Management (Self-healing)
 - Detection and timely compensation of incidental cell or NE outages to prevent from long-term service degradation in affected areas
- Coverage Hole Management (Self-optimisation; detection part closely related to COM)
 - Detection of areas with no or insufficient service coverage
 - Compensation through self-optimisation mechanisms or as input to network planning

- Drivers for Self-configuration and Self-healing
- Self-configuration in SOCRATES
- Self-healing in SOCRATES
- **Selected use cases**
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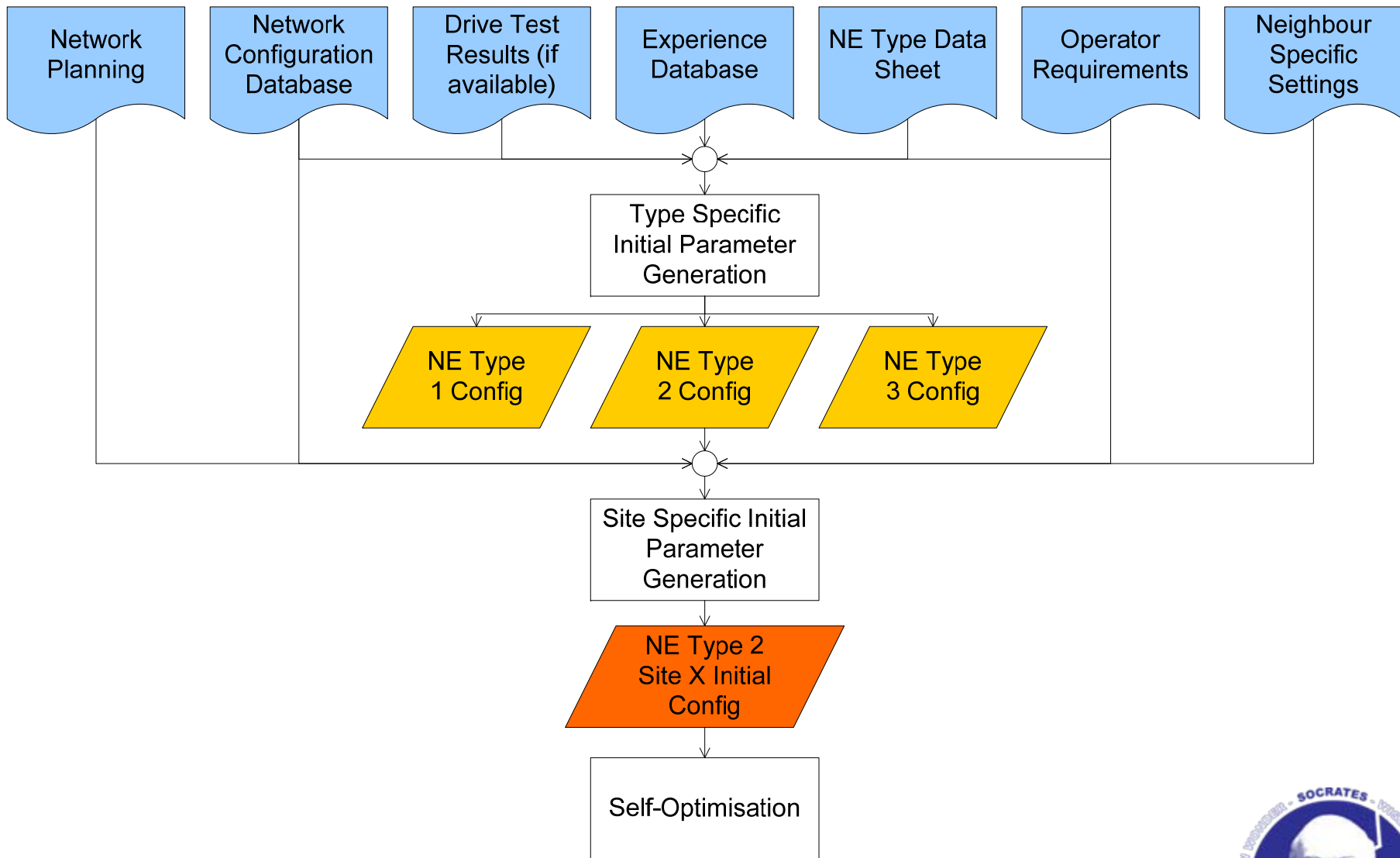


Automatic Generation of Initial Default Parameters - Overview

- Motivation:
 - When introducing new network elements today the complete radio configuration has to be planned in advance and corresponding radio and network parameters have to be calculated and set manually, which is time-consuming and expensive
- Objectives:
 - Simplify and accelerate deployment of new NEs
 - Enable automated adjustment and self-optimisation of radio network parameters before new NE becomes operational
- Means:
 - Create a NE-type (e.g. Macro, Micro) and operator-specific default configuration for dedicated radio parameter settings that is deployed to the new NE during initial configuration
 - Adjust this default configuration with site specific settings
 - From these settings the new NE can start self-optimisation



Automatic Generation of Initial Default Parameters - Workflow

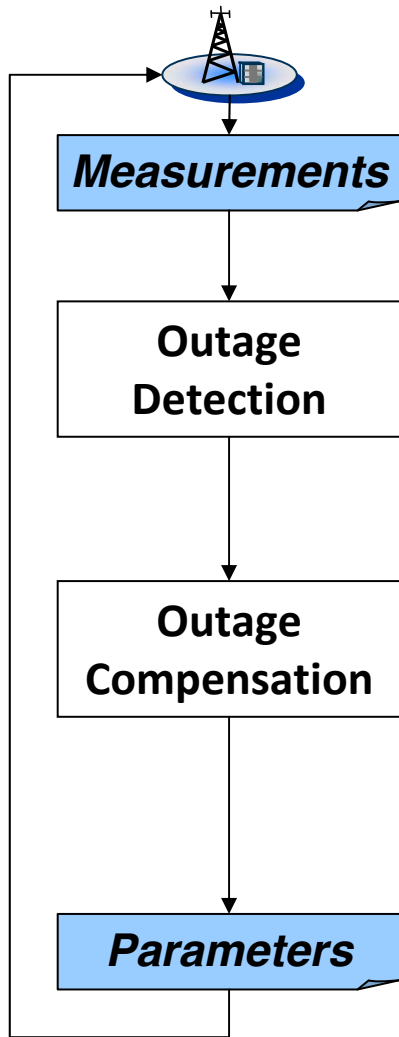


- Primary parameters (general parameters from
 - Electrical antenna down-tilt
 - Transmission power settings
 - Handover parameters (general parameters)
 - Physical cell ID
- Secondary parameters (site specific):
 - Packet scheduling parameters
 - Handover parameters (site-specific)
 - Load balancing parameters
- Secondary parameters may be set based on current parameter settings in surrounding of new site (e.g. by “averaging” values)

Cell Outage Management - Overview

- Motivation
 - Service outages in the network are partially difficult to detect (e.g. sleeping cell) and require considerable manual effort for compensation
 - Temporary outages can today not be compensated within a short timeframe, causing the affected area to be out of service / coverage
- Cell Outage Management is an umbrella use case, including:
 - Cell outage prediction: early warning of a (potential) cell outage, to reduce detection and compensation time
 - Cell outage detection: detection of a cell outage using information from various sources (eNodeB internal / external, OAM, user equipment, aGW), including measurements, alarms, counters, timers, statistics, KPIs etc.; analysis of information for root cause analysis
 - Cell outage compensation: modification of eNodeB / neighbouring nodes / network parameters to repair or compensate the cell outage within a short timeframe
- SOCRATES COM concentrates on Cell Outage Compensation

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

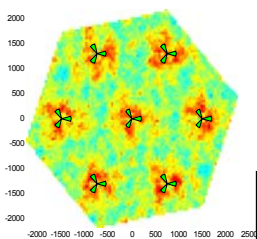
Which surrounding cells are to be taken into account?

Compensation scenarios:

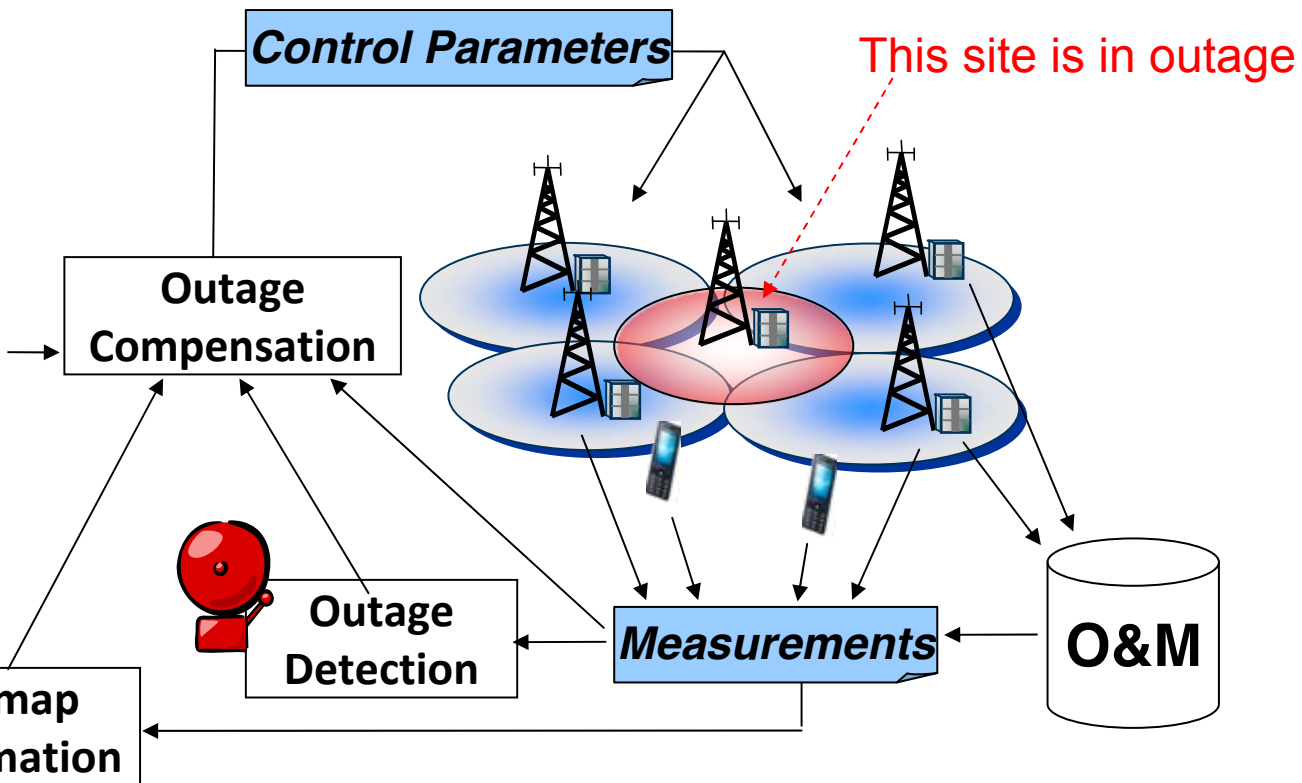
- large cells → coverage
- high-capacity cells → accessibility, service quality
- Estimation of compensation results using “X-map”, “X” = coverage, accessibility, packet loss, throughput etc.
- Physical channel settings (e.g. power settings)
- Antenna parameters (tilt, azimuth, multi-ant. techniques)
- Home eNodeB for compensation or to reduce interference

Cell Outage Management – Solution Approach

**Operator policy:
Coverage, QoS**

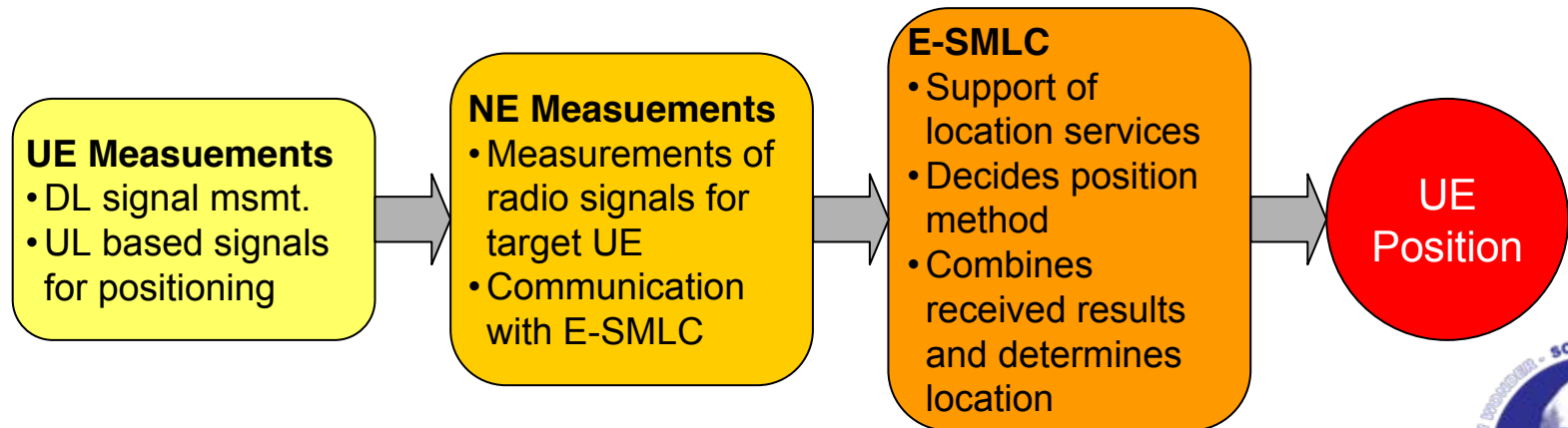


**X-map
estimation**



Cell Outage Compensation – X-Map Estimation

- Reasons for X-Map estimation:
 - To estimate cell outage compensation success related to coverage
 - X-Map estimation shall circumvent drive tests as these are costly, time-consuming (and therefore not appropriate for self-x) and can only cover parts of the networks
- Main principle:
 - Connect UE events and measurements with estimated position
 - Use UE reports to build map relating geo reference and metric of interest
- UE Positioning:



- A-GNSS / A-GPS
 - primary location technology for location based services
 - best accuracy (meets US FCC requirements)
 - use of different GNSS separately or in combination
- OTDOA (Observed Time Difference of Arrival)
 - utilises differences of time measurements for position calculation
 - complements the A-GNSS / A-GPS technologies when the hearability of GNSS / GPS satellites are limited in certain environments
- enhanced cell ID positioning methods
 - information about serving eNB and cell is used for position calculation
 - additional radio resource measurements to improve location estimate
 - E-UTRAN carrier RSSI
 - Reference Signal Received Power (RSRP)
 - Reference Signal Received Quality (RSRQ)

- **Coverage:** percentage of the area (surface area) of the failed cell that is covered by other cells after compensation; furthermore the changes in the coverage of surrounding cells after compensation

$$Coverage_{A_{Comp}} [\%] = \frac{\sum_{k=1}^{N_A} \rho_k - \sum_{l=1}^{N_{A_outage}} \rho_l}{\sum_{k=1}^{N_A} \rho_k} \times 100$$

- **Accessibility:** probability that the user gets the desired service i.e. the session set-up success rate (only for Guaranteed Bit Rate services, e.g. speech, VoIP)

$$Session\ set\ up\ success\ rate = (1 - Session\ blocking\ ratio) = 1 - \frac{N_{blocked}}{N_{blocked} + N_{accepted}}$$

- **Quality:** probability that the user gets the desired QoS, measured with IP throughput (only for non-GBR services such as http, ftp)

$$IP_Throughput = \frac{\sum_{Samples} V_{tp_DL}}{\sum_{Samples} T_{tp_DL}}$$

Cell Outage Compensation – Available Measurements

Measurements	Description	Type
eNodeB Measurements		
Cell capacity	Related to the actual or average load of a cell	Statistic
Radio Link Failure statistics	RLF statistics are maintained by each eNodeB,	Counter
Internal handover failure rate	Counts the number of failed eNodeB-internal handovers	Counter
Incoming / Outgoing handover failure rate	Counts the number of failed inter-eNodeB handover preparations via the X2 interface	Counter
Resource Status Reporting	Resource Status messages are envisaged to be exchanged between eNodeBs over the X2 interface	Statistic
Downlink interference	The downlink interference describes signal power measurements based on reports from the UE	Measurement
Uplink received interference power	Uplink received interference power measurement	Measurement
Calls blocked	Statistics of blocked calls	Counter
Calls dropped	Statistics of dropped calls	Counter
UE Measurements		
Reference Signal Received Power (RSRP)	The RSRP measurements are taken by the UE of the serving and surrounding	Measurement
Channel Quality Indicator (CQI)	The CQI measurements are taken by the UE of the serving cell and indicate signal quality	Measurement
UE history information	Last visited cell list	Information

Cell Outage Compensation – Next Steps

- Observability study:
 - Mapping between desired KPIs and available measurements to determine measurable KPIs
 - Requirements for standardisation regarding additional measurements and counters
- Controllability study:
 - Determine impact of control parameter settings on KPIs
 - Identify desirable value range of control parameters
- Algorithm development:
 - Develop compensation algorithms based on observability and controllability results
 - Determine algorithm performance with simulator
 - Continue work on X-Map estimation methods





Goal	Parameters
Minimise interference	<ul style="list-style-type: none">▪ Radio bearer transmit power▪ Radio bearer assignment▪ Antenna parameters▪ Channel quality indicator thresholds for schemes switching
Balance load	<ul style="list-style-type: none">▪ Radio bearer transmit power▪ Antenna parameters▪ Handover parameters▪ Cell re-selection parameters
Maximise / Optimise coverage	<ul style="list-style-type: none">▪ Radio bearer transmit power▪ Antenna parameters



- Introduction of Self-configuration features to reduce cost for network rollout / NE deployment
- Introduction of Self-healing features to reduce operational expenses and enhance service availability, but also to enable the manageability of the network caused by its increasing size and complexity
- Management of the interrelation between use cases that aim at the modification of the same parameters still challenging
 - Dedicated part of WP3 on self-optimisation
 - Requires involvement at least of COM

