the engine of broadband wireless innovation

An Annex Deliverable by the NGMN Alliance

NGMN Informative List of SON Use Cases

next generation mobile networks

An Annex Deliverable by
the NGMN Alliance

Next Generation Mobile Networks Informative List of SON Use Cases

Release Date: April 17th, 2007

Document Information

Editor in Charge	Frank Lehser (T-Mobile)
Editing Team	NGMN Technical Working Group "Self Organising Networks", Project 12"
Document status:	Approved
Version:	1.23
Date:	April 17th, 2007

Abstract

The following use cases give practical examples for the functional split. It is not a complete list of possible use cases and may not be applicable to all operators. Nevertheless they shall give some guidance what is meant with the described self organising functionality and could be basis for discussion solutions and feasibility studies. In a realistic self-organizing solution some of the listed uses cases may be substituted by self-X (self-configuration, self-optimisation) functionality.

CONTENT

1 OVERALL GUIDELINES

Keep planned / required outage of network elements at minimum.

EXAMPLE: Avoid restart after Parameter change in NodeB

Provide fallback / backup solutions to cope with unexpected outage

EXAMPLE: aGW should allow rerouting to backup aGW in case of failure

Limit number of parameters to the minimum.

Avoid situations where network changes get lost

With any software upgrade do also provide a fallback procedure.

Provide state of the art O&M tools with the same look and feel. Make use of pull down menus, right mouse click options, easy sorting, easy filtering, wizards, Makro recorder…

Reduce power consumption to minimum

2 PLANNING RELATED USE CASES

2.1 WORKFLOW MODEL FOR PLANNING

Planning (Radio | Transport)	Task	Input	Output
NodeB Location	Complex procedure to determine location and radio requirements of new NodeB	Geographic Data, Network Data, Customer Predictions, Marketing Evaluations	Location, Radio Requirements Capacity, Coverage, (interRAT-) Neighbourhood, other boundary conditions, Node Identifier
NodeB HW Configuration	Necessary HW is chosen (manually / after proposal from supplier tool)	Location, Radio Requirements	HW list including necessary databases are generated.
NodeB Radio Parameter	Automatic Generation of the RP to fulfil Radio Requirements with the chosen HW	Radio Requirements, HW List	RP are generated and included in NodeB database
NodeB Transport Parameter	Automatic Generation of TP on base of the Location and Radio Requirements	Access Network Data, Radio Requirements	TP are generated and included in NodeB database
aGW / OMC Parameter	Configure aGW and OMC settings on NodeB	Access Network Data	Addresses of aGW(s) and OMC(s) included to Node B database

2.2 [P01]: NODEB LOCATION

This Task is currently not seen as a realistic use case for self organizing. It is listed here because it is the very first activity in the natural flow of network planning.

The output of this procedure is used as input for the following use cases.

Goal

Complex procedure to determine location; radio requirements

Description

May be very different for different operators.

Initial network planning is used to evaluate the number of required nodes as well as number of required sites and the basic network parameter. The location of the sites will be planned manually based on site availability and many different boundary conditions that cannot be automated.

Result

The location of the site is fixed.

- NodeB is being stored in Central Operator NE Database (state: planned)
- Requirements for coverage and capacity of the site are determined.
- Geographical exposition is clear. Access to site , Indoor / outdoor, height, type of site (urban, rural)
- Interaction with existing network is determined. Neighbours (LTE and InterRAT) are determined.
- Hardware capacity calculations
- NodeB hardware is determined.
- Boundary parameters: Max TX (NodeB) Max Tax (allowed).........

2.2 [P02]: NODEB HARDWARE

This Task is currently not seen as a realistic use case for self organizing. It is listed here because it is the next step in the natural flow of network planning.

Goal

The hardware for the installation is determined

Description

May be very different for different operators.

The NodeB requirements are used as input to choose the best applicable hardware.

Suppliers may provide tools for this and / or deliver intelligent licensing systems to reduce operator effort.

Result

- All hardware information of the NodeB to be installed at a specific location.
- Hardware information is being added to Central Operator NE Database (state: planned)

2.3 [P03]: AUTOMATIC GENERATION OF RADIO PARAMETERS

Goal

Automatic generation of all radio parameters of a new Macro-eNodeB.

Current Situation

Most parameters are set manually. High amount of manual inter-working required for GSM and UMTS as well.

Pre Conditions

Location, HW configuration and traffic forecast for the new eNodeB. System measurements or simulations are available to estimate coverage, capacity and performance of situation without and with new Macro eNodeB.

Trigger / Scheduling

Manually triggered as part of planning process.

Flow

Input: Location, Traffic Forecast, antenna data (height, ….)

Input: coverage, capacity and performance related measurements

Action:

Calculation of

- Output power settings (has to be automatic compared to maximum allowed power of the site as well as to the maximum supported power of the NodeB HW
- Remote electrical tilt (has to be compared with the range of the related antenna)
- Subtones for pilot channels
- Minimum number of traffic channels
- Traffic channels to minimise Inter Cell Interference
- Cellid (generated by database generator)

- Neighbourhood list (generated by the database derived from location) including inter RAT neighbours
- Trigger levels and timers
- Standard radio parameter (e.g. for congestion and admission control, …) identical initial configuration for all nodeBs, only updated by optimization

Post Conditions

Radio parameters of eNodeB calculated and stored in the OMC and /or in NodeB database

2.4 [P04]: PLANNING OF TRANSPORT PARAMETERS OF A NEW ENODEB

Goal

Automatic generation of transport parameter of a new eNodeB.

For the transport configuration bandwidth, IP addresses of related net elements as well quality of service parameter have to be defined.

Current Situation

Most parameters are set manually. High amount of manual work required.

Pre Conditions

Location, HW configuration and traffic forecast for the new eNodeB. System measurements or simulations are available to estimate coverage, capacity and performance of situation without and with new Macro eNodeB.

Trigger / Scheduling

Manually triggered as part of planning process.

Flow

Input: Location, Traffic Forecast

Input: coverage, capacity and performance related measurements

Action:

- Determine IP addresses of all network nodes to which the nodeB is connected to.
- QoS parameter of the transport interface
- Determination of timer and trigger for the transport parameter (all standard parameter copied from a standard database set)
- Pre-check that capacity of centralized nodes is appropriate

Post Conditions

Transport parameters are available (under unique nodeB identifier) and information can be used also for the planning and ordering of the related leased line.

2.4 [P05]: PLANNING OF SECURITY NODE, AGW AND OMC

Goal

Automatic planning of security node, aGW and OMC that control the NodeB.

Current Situation

Manual activity.

Pre Conditions

Location, HW-type, radio and transport parameters are available for the Node B.

Trigger / Scheduling

Manually triggered as part of planning process or automatically following the transport parameter use case [P04].

Flow

We see this as a candidate for a self configuration.

Post Conditions

New eNodeB is known to the OMC, aGW and security node.

3 DEPLOYMENT

3.1 WORKFLOW MODEL FOR DEPLOYMENT

Deployment	Task	Input	Output
HW Installation	The hardware is being installed. NodeB is connected and powered up. Installed HW is detected.	HW is delivered. Site is prepared: Antenna, power, transmission.	Hardware is physically installed. Transmission, antenna and power cables connected. Node is powered up.
Network Authentication	Establish logical connection to the Network. Authentication of the node in the network and vice versa.	Node Identifier, SecurityNode, aGW, OMC information	OK, NOK
Software Installation	The recent software is installed on the NodeB.	Recent software	OK, NOK
Transport Parameter Setup	TP are being set up according the requirements that are identified for the node	Node Identifier, Radio Requirements, Capacity Requirements	OK, NOK
Radio Parameter Setup	RP are being set up according the requirements that are expected for the node	Node Identifier, Radio Requirements, Capacity Requirements	OK, NOK
Testing	Make sure the NodeB has successfully passed the deployment procedure and can enter operational state	Radio Requirements, Capacity Requirements	Status is reported. Node can enter operational state.

3.2 [D01]: HARDWARE INSTALLATION

Goal

Physical installation of hardware.

Plug and play like installation of the Node with simple and unambiguous cabling. Antenna losses and installed hardware are detected autonomously. Node can be recognized by the means of his node identifier.

Current Situation

Dedicated teams have to deliver and install the hardware.

The assembly has to be manually configured on the Node's database due to missing self detection. Antenna losses have to be measured and respective values are stored in the database.

Pre Conditions

Site preparation is available. Antenna and feeder cable and power supply for indoor as well as required transport lines.

Node identifier from planning process is available.

Trigger / Scheduling

Installation is manually triggered.

Flow

After installation the Node needs to be connected to Antenna, power and transport network. Hardware is detected when powering up and antenna losses are measured.

Transmission is identified and basically established.

Node identifier is stored on the node.

Post Conditions

Node is up and running and ready for commissioning. Feeder losses and TMA gain are measured. Node is branded with node identifier.

3.3 [D02]: NETWORK AUTHENTICATION

Goal

Authentication of the node in the network and vice versa. Establish logical connection to the Network.

Current Situation

Note is manually configured in commissioning process with all necessary data.

Pre Conditions

Node is powered up and connected to antenna and transport network.

Trigger / Scheduling

By powering on the Node

Flow

Authentication process is currently not clear.

Post Conditions

NodeB is running and logically connected to the operator network

3.4 [D03]: SOFTWARE INSTALLATION

Goal

The recent software is downloaded from a centralized server.

Current Situation

Node is preconfigured with some software level that is usually old. A manual software update has to be triggered as part of maintenance (after deployment).

Pre Conditions

Node is installed, powered up and authenticated. Secure connection exists.

Trigger / Scheduling

Follows authentication as part of the deployment flow.

Flow

Connect to Software Management application

Automatic Download / activate / restart (if applicable) current software.

Post Conditions

Node has loaded and activated the recent software.

3.5 [D04]: TRANSPORT PARAMETER SETUP

Goal

The parameter for the transmission network are being configured with respect to the requirements that have been identified for the site (0).

Current Situation

Node is manually configured in commissioning process with all necessary data.

Pre Conditions

Node is installed, powered up and authenticated and software is updated.

Node Identifier is available on the Node.

Trigger / Scheduling

Follows authentication as part of the deployment flow.

Flow

Several solutions possible.

Assumption: Only few neighbour specific parameterisation (X2 related). Mainly default parameterisation.

Post Conditions

Node is connected to operator network with a set of transmission parameter that fulfil requirements from the initial planning (0).

3.6 [D05]: RADIO PARAMETER SETUP

Goal

Radio parameters on the node are being configured with respect to the requirements that have been identified for the site (0).

Current Situation

Node is manually configured in commissioning process with all necessary data.

Pre Conditions

Node is installed, powered up and authenticated and software is updated.

Node Identifier is available on the Node.

Trigger / Scheduling

Follows authentication (0)or transmission setup(0) as part of the deployment flow.

Flow

eNodeB is identified in OMC and appropriate default configuration is done in automatic way. Mainly default parameterisation is done. Exceptions may be neighbour specific parameters may be cell specific or site specific parameter (e.g. antenna related parameter).

Post Conditions

Node is connected to operator network with a set of transmission parameter that fulfil requirements from the initial planning (0).

3.7 [D06]: TESTING

Goal

Test new established eNode to ensure stable operational mode.

Make sure the NodeB has successfully passed the deployment procedure and can enter operational mode

Current Situation

No appropriate procedure available that performs a complete self test. Frequently sites show deployment deficiencies and require additional site visits.

Pre Conditions

All steps in deployment have successfully passed. Node is ready to enter operational state.

Trigger

Automatically as part of deployment flow.

Flow

Various tests are performed.

If any of these tests fails, the reason for the failure has to be determined and cured. Afterwards, the test has to be performed again.

Post Conditions

The Node is up and running and can enter operational state.

4 OPTIMISATION

In the following use cases are described related to optimisation procedures in the network.

4.1 OVERVIEW

Tbd

4.2 [O01] RADIO PARAMETER OPTIMISATION: NEIGHBOUR CELL LIST OPTIMIZATION

Goal

Optimisation of existing neighbour cell list of a cell with all relevant neighbours and the associated parameterisation in the neighboured cell.

Current Situation

Effort for optimizing neighbors in 2G and 3G is seen as significant: planning neighbors in planning tool, configuration of neighbors cells and the associated parameterization, optimization in case of trouble cases (handover failures, number of call drops in certain areas etc.) are sources for failures and costly trouble shooting and optimization.

Description

New neighbours are identified and included in the database and unused neighbours are deleted.

Pre Conditions

The cell to be optimised and neighbour cells are in operational mode. Following input parameter are available:

- Location of the neighbours (distance),
- Network triggered UE measurement reporting like field strength information (possibly inclusive distance information, location information)
- eNodeB radio scanning for neighbours like field strength information,
- Event counters like cell specific call drops or handover failures
- NEM/OSS configuration data
- Planning tool data: location, antenna parameter, etc.
- Handover statistics per neighbour (which neighbours defined in neighbour set are really used?)
- …

The current configuration data (means relevant parameter settings) is available.

Trigger / Scheduling

Trigger: Identification of missing neighbours or not optimal parameterisation for certain neighbours

Scheduling: On demand or periodic

Flow

An algorithm selects the neighbours and/or optimise neighbour related parameterisation based on the input parameter given in pre conditions. Following activities are triggered:

- Identification of new neighbour
  - Establish X2 interface towards neighbour eNodeB
  - Configuration of neighbour related parameter in both eNodeBs (under involvement of NEM and other relevant nodes)
- Identification of neighbours not used
  - Erasing X2 interface towards not used neighbour eNodeB
  - De-configuration of neighbour related parameter in both eNodeBs (under involvement of NEM and other relevant nodes)
- Identification of parameter which are not optimally set
  - Configuration of optimised neighbour related parameter in both eNodeBs (if any) (under involvement of NEM and other relevant nodes)
- HO parameterization optimization
  -
- Iterative optimisation loop

Post Conditions

Optimised neighbour cells list and neighbour related parameter are given and are active. This list and parameter have been sent to the NEM/OSS for potential statistical collection, acknowledgement or correction.

Exceptions

Notes

Example:

- In operational phase, a further optimisation of neighbour list (including 2G/3G) can be done considering e.g. radio measurements of eNodeBs and UEs or call events like call drops, handover problems etc. For this approach RRC connections (calls, signalling procedures) and their accompanying measurements can be used to gather the needed information about neighbours. Known neighbours can be checked if they are really appropriate concerning real RF conditions, new ones can be included based on information about detected cells in UEs.

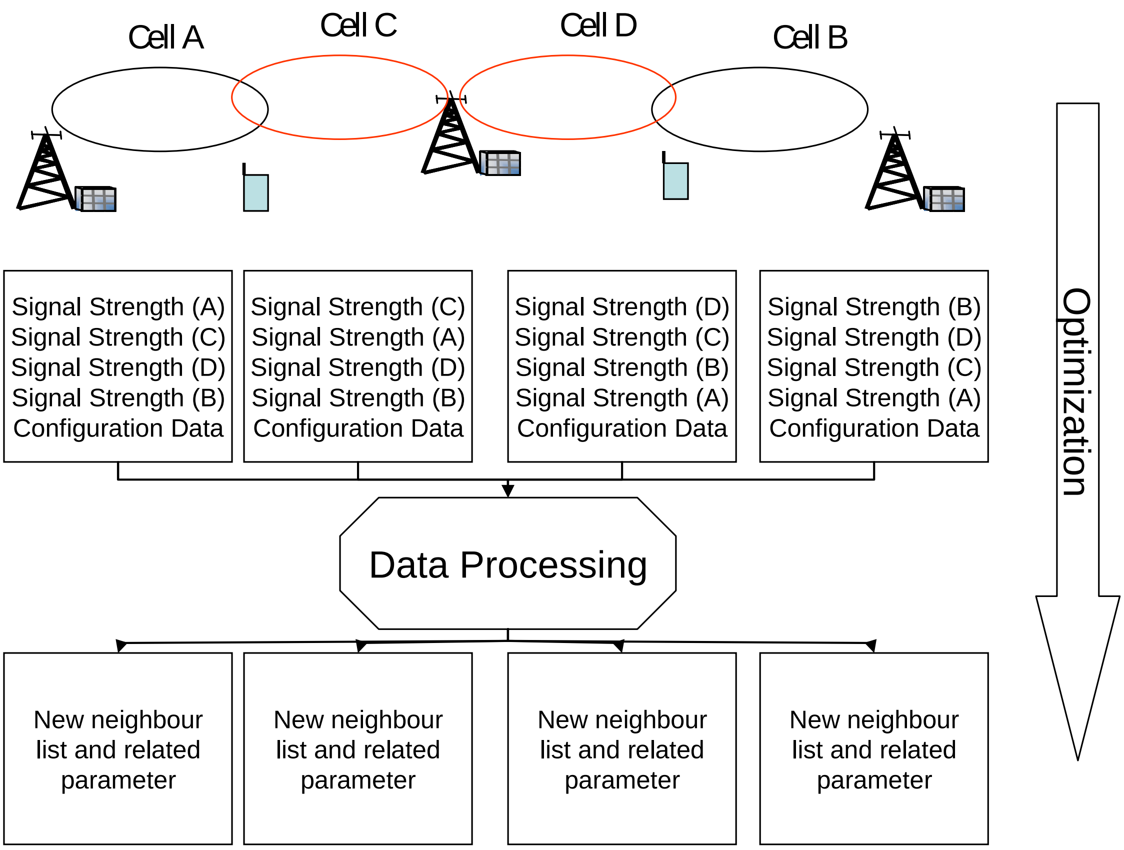


Figure 4: Example for neighbourhood parameter optimisation.

Note. Data Processing function can be performed in distributed way as well depending on chosen architecture.

4.3 [O02] RADIO PARAMETER OPTIMISATION: INTERFERENCE CONTROL

Goal

Optimize power and scheduling of sub-tone in downlink with minimal operational effort.

Current Situation

Situation in 2G (it is assumed that in LTE similar planning effort is needed for sub-tone & power planning): central planning of frequencies and power is done. Addition of new cells has got impact on frequency planning and causes regularly frequency re-definitions in wider areas.

Special problem is detection of interference between cells: in case of indicators hinting to a interference problem like significant call drop number, handover failure and customer complaints drive tests are initiated. In this tests interference measurements are taken and if inter cell interference is detected frequencies are re-planned.

The impact on planning, configuration and optimization procedures is significant.

Description

Automatic or autonomous coordination of sub-tones and allocated power with respect to the inter cell interferences.

Pre Condition

The cell is in operational mode and following measurements are available for cell and adjacent cells: interference and configured power per sub-tone.

Trigger / Scheduling

Trigger: identification of sub-tones with interference problems (based on UE measurements).

Scheduling: on demand

Flow

- Monitor interference level and power (and other measurements?) of used sub-tones
- Monitor interference level and power (and other measurements?) of neighbor's sub-tones
- Algorithm on decision on optimized sub-tone scheduling and power
- Configure sub-tone and power (open: via appropriate RRM procedure or via NEM or appropriate node)
- Loop between step 1 and 4

Post Conditions

Optimized power and scheduling of sub-tone in downlink is achieved. The changed parameter are active and are correctly set in NEM/OSS.

Exceptions

Notes

a. In LTE, there will be a need to coordinate eNB transmit power and subtones to minimize inter cell interference. Current assumption in 3GPP is that as a minimum solution a fixed planning must be done. To avoid the linked consequences of this fixed planning the fractional use of sub-tones and power considering the actual interference situation in the cell is aimed.

b. Scenario for uplink has to be analyzed.

4.4 [003] RADIO PARAMETER OPTIMISATION: HO PARAMETERIZATION OPTIMIZATION

Goal

Optimization handover and cell-reselection parameterization to minimize handover failures, ensure good quality and performance with minimal operational configuration and optimization effort.

Current Situation

HO parameterization of current 2G/3G system is a difficult task for operational staff. After defining a parameter set based on default values often no cell and neighbor individual parameterization can be done due to cost reasons. Based on performance measurements like call drops or handover failures problem areas are identified and are optimized on a case by case bases.

Description

In the early deployment phase LTE coverage will consist of islands and many locations like tunnels and parking garages will not be covered. Therefore inter-RAT handover is an important procedure. It is expected that in LTE, like in UMTS, downlink signal level and downlink C/I will be criteria for inter-RAT handover from LTE to UMTS or to GSM.

Unfortunately the threshold settings for the criteria for inter-RAT handover have to be tuned frequently. Cells at the edge of an LTE coverage island require different settings(e.g. higher setting of level threshold) than cells in the centre of the island. Cells covering mainly indoor locations require different settings (lower setting of level threshold) than cells covering mainly outdoor locations. During deployment of LTE coverage islands will grow and a cell originally located at the edge of a coverage island will be transferred into a centre cell. Furthermore a cell covering both indoor and outdoor locations may be transferred into a pure outdoor cell, because the indoor locations originally in its coverage area are served by newly deployed indoor solutions.

Pre Condition

The cell is in normal operational mode. Handover related measurements are available for a longer time period (weeks or months). Handover related measurements are: number of handovers per neighbor cell, handover failures per neighbor cell, average C/I and received signal strength values per neighbor cell, call drop rates during handover procedures per neighbor, call success rates during handover procedures per neighbour … The current configuration data (means relevant parameter settings) is available.

Trigger / Scheduling

Identification of significant problems for a certain neighbor cell concerning handover

Scheduling: on demand

Flow

- Long-term monitoring of handover related measurements per neighbor in cell
- Comparison with reference values for Handover failure rates, call drop rates, call success rates
- Support of optimal monitoring of handover related measurements by operator
- Recommendation of optimized parameter
- Target C/I values
- Target Received signal strengths
- …
- Configuration of handover related parameter (if applicable) (under involvement of NEM and other relevant nodes)
- Long-term monitoring KPIs in cell to estimate success of new parameterization
- Several iteration steps of optimization loop

Post Conditions

Cell is in operational mode and handover failure rates are below target values for all handover neighbors. The changed parameters are active and are correctly set in NEM/OSS.

Exceptions

Notes

4.5 [O04] RADIO PARAMETER OPTIMISATION: QOS RELATED PARAMETER OPTIMIZATION

Goal

Optimization QoS related parameterization to ensure good quality/performance and optimal resource utilization with minimal operational configuration and optimization effort.

Current Situation

QoS parameterization of current 2G/3G system is a difficult task for operational staff. After defining a parameter set based on default values often no cell individual configuration can found due to cost reasons. Today only general default settings are analyzed and configured in complete network.

Description

There are a lot of parameter which influence QoS. There are radio parameter like parameter controlling channel type switching, radio bearer handling etc. which influence significantly the performance experience. In future it is expected that the direct QoS parameter like traffic classes, priorities etc. are defined in nodes itself which gives room for optimization of these definitions in a cell specifc way (e.g. different delay goals depending on load situation of the cell).

Pre Condition

The cell is in normal operational mode. QoS related measurements are available for a longer time period (weeks or months). QoS related measurements are: average cell throughput, average throughput per user, target throughput parameter, average cell delay, average delay per user, cell load, … The current configuration data (means relevant parameter settings) is available.

Trigger / Scheduling

Identification of significant problems concerning QoS targets.

Scheduling: on demand/triggered by problems

Flow

- Long-term monitoring of QoS related measurements per cell and per user
- Comparison with reference values for QoS targets (KPI)
- Support of optimal monitoring of QoS related measurements by operator
- Recommendation of optimized parameter
- …
- Configuration of QoS related parameter (if applicable) (under involvement of NEM and other relevant nodes)
- Long-term monitoring KPIs in cell to estimate success of new parameterization
- Several iteration steps of optimization loop

Post Conditions

Cell is in operational mode and QoS targets are fulfilled at best level considering specifc cell situation (like load). The changed parameter are active and are correctly set in NEM/OSS.

Exceptions

Notes

4.6 [O05] RADIO PARAMETER OPTIMISATION: OPTIMIZATION SCENARIOS WITH HOME BTS/PICO BTS

Goal

Installation of Home BTS in a plug&play manner with minimal customer intervention. Side-effects on Macro layer's cells and other Home cells like interferences shall be minimized on a defined level. Customer shall experience a seamless mobility between Home BTS cell and macro layer. Includes radio parameter parameteriasation as well as transport parameter optimization.

Current Situation

Description

Home BTS are mass eNodeB installed by customer and is connected via a fixed line with the public internet - similar to WLAN access point. The user shall experience a seamless mobility so that the configuration of a Home cell as a neighbour of a Macro cell seems to be needed. Further neighbour configurations towards other Macro cells or even Home Cells is ffs.

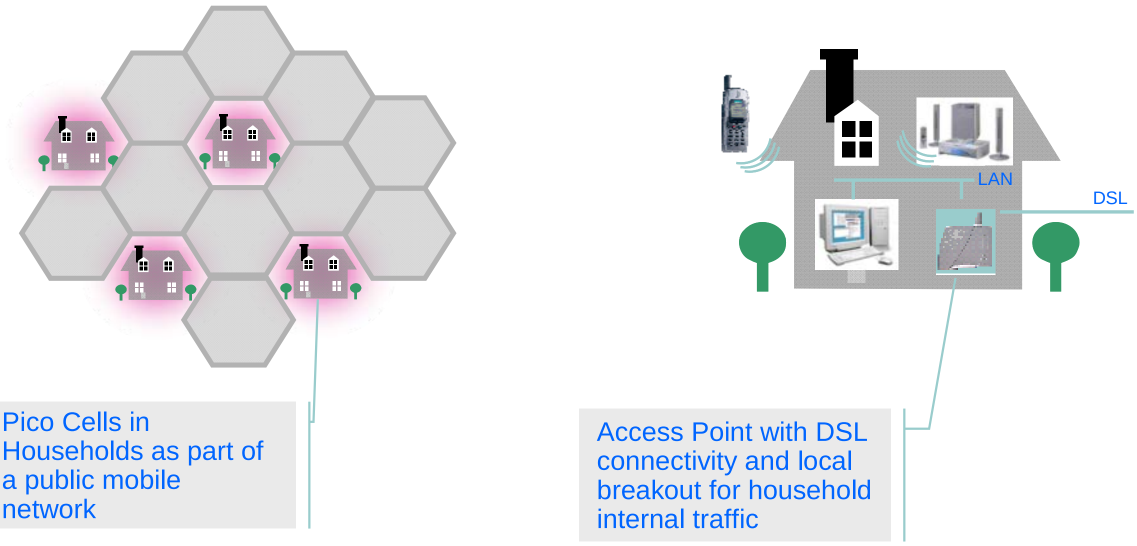


Figure 7: Home BTS

Pre Conditions

Home BTS is in operational mode. A first starting configuration is used (depending on concept: e.g. a macro neighbor, sub-tone and power configuration is defined).

Trigger / Scheduling

Identification of

- Missing or not appropriate macro neighbors
- Interference situation
- …

Flow

- Identification of better neighbors
- Based on received signal strength
- Based on interference measurements
- Re-planning of sub-tones and power
- Configuration of new neighbors, sub-tone, power and related parameter in Home BTS
- Configuration of Home Cell as neighbour in appropriate Macro Cell (under involvement of NEM/OSS and other relevant nodes)

Post Conditions

Optimal neighbours and sub-tone, power parameterization is found. The changed parameters are active and are correctly set in NEM/OSS.

Exceptions

Notes

The concept of Home BTS is currently not detailed so the usage of a dedicated frequency band is still open. Further open are questions concerning the access of Home BTS: only for one single user or the possibility to open the access also for other users.

4.7 [O06] TRANSPORT PARAMETER OPTIMISATION: ROUTING OPTIMISATION

Goal

Optimisation of data routing in a meshed network Current Situation

Description

Pre Conditions

Trigger / Scheduling

Flow

Post Conditions

Exceptions

Notes

4.8 [O07] TRANSPORT PARAMETER OPTIMISATION: OPTIMIZATION SCENARIOS WITH HOME BTS/PICO BTS

Goal

Installation of Home BTS in a plug & play manner with minimal customer intervention. Side-effects on Macro layer's cells and other Home cells like interferences shall be minimized on a defined level. Customer shall experience a seamless mobility between Home BTS cell and macro layer. Includes radio parameter parameterisation as well as transport parameter optimization.

Current Situation

Description

Home BTS are mass eNodeB installed by customer and is connected via a fixed line with the public internet - similar to WLAN access point. The user shall experience a seamless mobility so that the configuration of a Home cell as a neighbour of a Macro cell seems to be needed. Further neighbour configurations towards other Macro cells or even Home Cells is ffs.

Pre Conditions

Home BTS is in not in operational mode. The transmission must be established. Home BTS is plugged in fix line adapter by customer.

Trigger / Scheduling

Switch on the Home BTS and identifying missing contact to network

Flow

- Configuration of transmission

Post Conditions

Transmission is established.

Exceptions

Notes

The concept of Home BTS is currently not detailed so the usage of a dedicated frequency band is still open. Further open are questions concerning the access of Home BTS: only for one single user or the possibility to open the access also for other users.

4.9 [O08] REDUCTION OF ENERGY CONSUMPTION

Goal

A significant part of the operational cost of an operator is related to energy consumption. Therefore, during the periods of light/low traffic the system should work in a power-efficient way. It should consume as little energy as possibly by switching off excessive resources. These resources are for example unused subcarriers/subcarrier blocks, unused hardware boards, unused transmission links etc. In the most extreme cases, when the conditions allow it, even a complete eNodeB could be switched off.

Current Situation

The network elements (NEs) do not have power-efficient mode of operation. Switching off particular resources is done either manually or by scripts (if statistics are available about the traffic activity) that switch off BS resources at fixed time moments and days in the week. Furthermore, switching off is done in large chunks (e.g. one or more TRXs) and there is no fine granularity available for the resources that can be switched off.

Description

Power-efficient mode of operation can be deployed in different ways:

a. During light/low traffic conditions all excess RF resources could be switched off or put in stand-by mode:
    1. RF circuit chains that are involved when sub-carriers (or sub-carrier blocks) are used.
    2. Only the minimum RF resources are active i.e. transmission of system channels such as pilot, synchronization, broadcast, etc. and traffic channels that are needed to support the light/low load.

b. During light/low traffic conditions all excess transmission resources can be switched off or put into idle mode.

c. eNodeB is switched off completely if the coverage and the present light/low traffic can be supported by the surrounding cells.

d. The partial or complete release of the eNodeB resource should be accompanied by complementary actions at the neighbouring eNodeBs such as updating the neighbour lists, handover thresholds, pilot/broadcast powers etc.

Pre Conditions

The cell/system is in normal operational mode.

Traffic measurement indicators per site/cell/sub-carrier blocks are available.

Measurements regarding the achieved user experience are available.

Trigger/Scheduling

With regard to the triggers for starting releasing or activating the resources at the BS we are guided by two principles. First, the amount of active resources should match the traffic needs. Second, the QoS levels of the ongoing connections should not be jeopardized.

Therefore, we propose the following triggers for switching OFF (or ON) resources:

1. The trigger is based on the resource utilization (see Figure 1):

    1.1 When the resource utilization is below a "resource release threshold" for a sufficient amount of time (e.g. "Release interval") then resources are switched off. Note that the "resource release threshold" is a relative measure with regard to the total amount of resources during the measurement interval.

    1.2 When the resource utilization is above a "resource activate threshold" for a sufficient amount of time (e.g. "Activate interval") then resources are switched on. Note that the "resource activate threshold" is a relative measure with regard to the total amount of resources during the measurement interval.

2. The resources are released or activated as long as the system meets the desired QoS requirements per user.

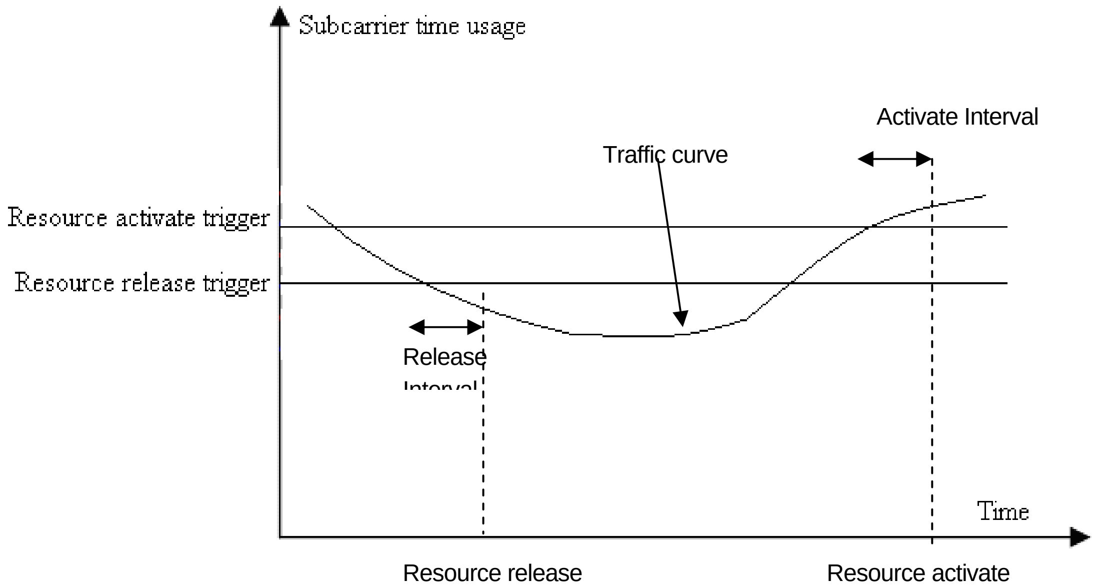


Figure 1 Utilization triggers for releasing and activating resources at the BS

Scheduling:

As an indication the check if some resources can be released could be done periodically (e.g. 15 min). However, the check to decide if resources should be made active again (e.g. if the traffic increases) should be made on demand in order to promptly react to the traffic increase.

Flow

- Identification (based on measurements) whether there is a shortage or excess of resources.
- Define appropriate actions
  - Do nothing
  - Switch off the redundant resources (RF, transmission)
  - Switch on additional resources (RF, transmission)
  - Switch on/off a complete eNodeB
- Re-configuration:
  - Reconfigure RRM parameters at the reference eNodeB (where resources are released/activated)
  - Reconfigure parameters at surrounding eNodeBs e.g. RRM parameters, pilot powers, antenna tilt, neighbor cell list, etc.
- Monitoring of impact of parameter reconfiguration

Post Conditions

- A better match between the active resource and the traffic load is achieved.
- Energy consumption is minimized.

Exceptions

Notes

It should be investigated what is the gain achieved in power savings when compared to the risk involved in the power savings process.

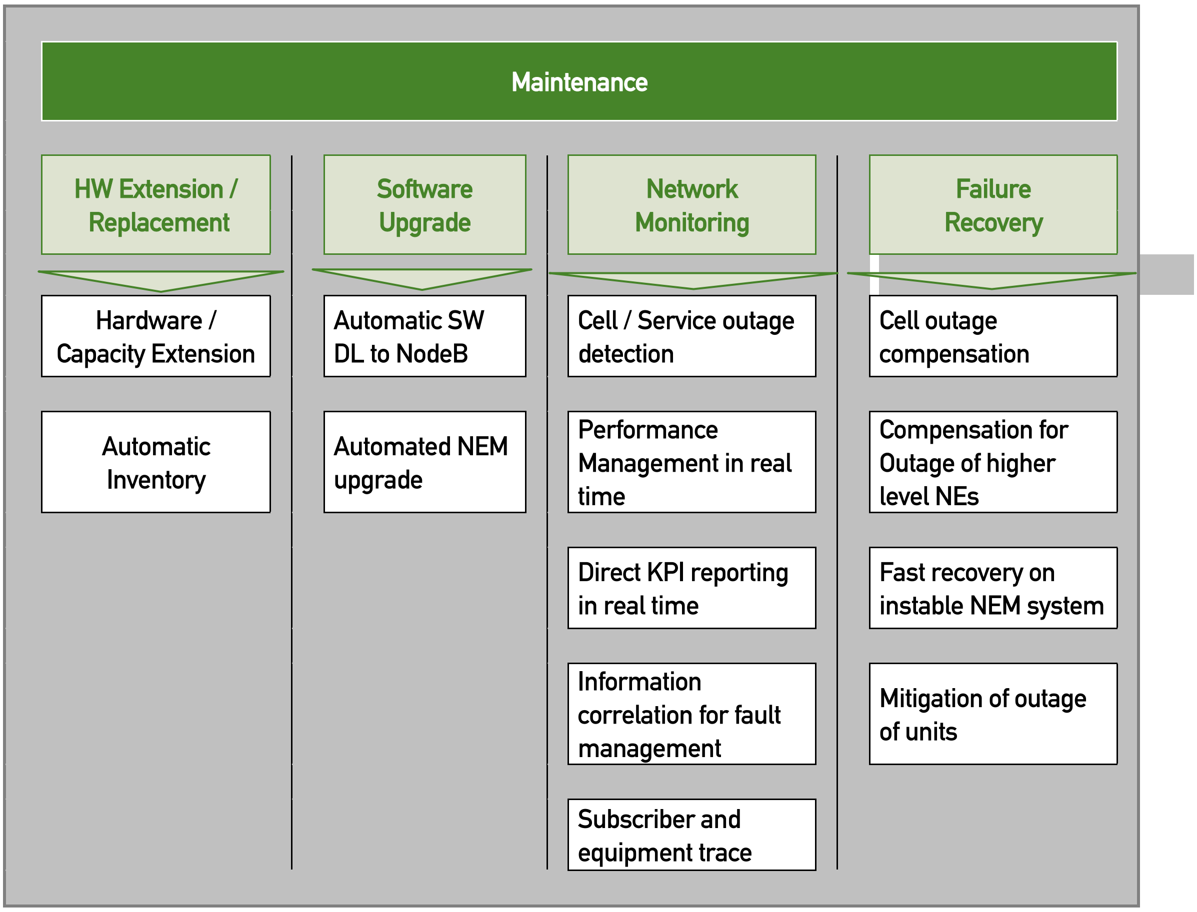
As an example of the possible benefits we give here some predictions for a GSM system. If we have 3 sector sites with frequency hopping and 2 to 6 TRXs per sector then the power saving between working TRXs and idle TRXs are approximately 10%. This is basically due to the fact that an idle TRXs still consumes considerable amount of power.

The attention points are:

1. Frequent (de)activation of RF and transmission hardware should not cost more energy than operating in steady state.
2. Frequent (de)activation of RF and transmission hardware should not decrease the reliability and robustness of the equipment.
3. The release or activation of resources should not cause instability in the system i.e. a chain of reaction via the adjacent cells propagating on the larger scale within the network.
4. A supervising module is needed that monitors the effects of the power saving procedure i.e. are the desired QoS levels maintained and do we really save power.
5. The energy consumption should be reduced without degradation of the perceived QoS level by the end users.
6. Measurements should be provided in some way for the decision logic in order to switch on a BS that has been previously switched off.

5 MAINTENANCE

5.1 OVERVIEW



The use cases can be categorized into the areas

1. ***Hardware Extension /Replacement***
   Any upgrade, extension or replacement of hardware should require minimal operator attention. Hardware shall allow plug 'n play behaviour. Technicians shall be able to handle hardware from different suppliers without special training.
2. ***Software Upgrade***
   Software update shall need minimum operator attention. Any functional outage (incl. loss of surveillance) must be minimized.
3. ***Network Monitoring***
   The system should provide sufficient measurements and analyses of RAN performance for planning further improvements. Multi-vendor scenarios should be supported without any extra stress. Tracing shall be supported for trouble shooting and for special tasks (e.g., UE analysis).
4. ***Failure Recovery***
   Recovery of NW element failures should not require complex manipulation by an expert.

5.2 [OPS01] HARDWARE / CAPACITY EXTENSION

Goal

Easy plug'n play hardware replacement with minimum service interruption

In case additional hardware has to be installed the node should be reconfigured automatically online or if offline modus is needed the configuration should be stored in temporary files and activate during low traffic periods.

Current Situation

After the installation sometimes boards have to be rearranged, inventory files have to be edited manually and firmware has to be updated / loaded, all configuration files have to be updated and in most cases the node has to be restarted.

Pre Conditions

Hardware in eNodeB has to be exchanged, added or removed.

Trigger / Scheduling

Manual plug in / removal of hardware

Flow

System recognizes new / exchanged / removed hardware configuration.

After plugging in the HW an initial procedure performs an automatic update of all hardware related settings followed by a self test and gives feedback if hardware installation was successful.

The eNodeB reconfigures to the new setting – ideally without restart.

Post Conditions

The eNodeB with the new hardware configuration has seamlessly taken over the service.

5.3 [OPS02] AUTONOMOUS INVENTORY

Goal

Every unit that can be installed shall report inventory information to the NEM / inventory database via Itf. N. There shall be no passive hardware units.

Current Situation

A mixture of active and passive units is being installed. In case of HW-failure it is not always known which spare part has to be taken on site.

Huge operational effort is spent when Inventory information is not up to date or inaccurate.

Pre Conditions

Trigger / Scheduling

A hardware unit is being plugged into an eNodeB and goes into service.

Flow

As part of the self test the hardware unit sends its inventory information to the NEM.

Post Conditions

In the NEM and OSS the HW information for each unit can be displayed on request.

5.4 [OPS03] AUTOMATIC SW DOWNLOAD TO ENODEB

Goal

Software downloads to eNodeB shall be managed from O&M system and shall not need major attention from the operator.

- Not successful downloads shall be repeated autonomously.
- Software download should not limit transmission capacity
- Final software swap on eNodeB shall be scheduled after successful software download.
- The overall process of software upgrade should not take longer than a few days
- If a new node is deployed to the network an autonomous software upgrade to the current actual software shall be done (see respective deployment use case ([D03]: Software Installation))

Network elements could pull SW or databases in an automatic way in time periods of low activity; start and end time of time period is defined by operator so that at the end of the time period the area has a defined software level. Higher network element stores information about faulty tasks and repeats automatically the tasks until it could be finalized successfully.

Current Situation

Nodes that have to be upgraded are manually selected in NEM at the starting time. The following steps are executed:

- Download: Software is downloaded to NE (sometimes including new database)
- Activation: New software / database is activated. For the activation in most cases a restart of the node is necessary. Users are affected.

Faulty software downloads/activation are difficult to find and have to be restarted manually.

It requires several days or weeks to finally download software to every NE. Huge effort is spend to identify faulty SW-downloads and to get a complete picture of the available software on the Nodes. Thus software swaps are sometimes incomplete which leads to heterogeneous software loads in the field.

Any NEs that have been installed in the meantime after triggering the software update require a manual activation for the download of the actual software,

Pre Conditions

Network is in normal operation. A newly released software update for eNodeB is available for implementation for a dedicated eNodeB type.

Trigger / Scheduling

Manual interaction: The new software is released for download by the operator at the NEM software management application (SMA). In this application a dedicated region or group of NEs can be selected.

Flow

The respective eNodeB is being notified that new software is available.

It will then start to download the software whenever there is transmission bandwidth available.

When the eNodeB finished downloading the SW the SMA is notified about the successful download. If the download is not successful in a specified time window the SMA will repeat to trigger the download.

The SMA may then coordinate the software swap on the eNodeB either on basis of traffic data or as a coordinated activity in a complete region.

Post Conditions

The new SW is installed and working on all eNodeBs in the respective region.

Notes

- Some dedicated workflow must be available if the eNodeB does not finish downloading the SW.
- A fast fallback to the previous release shall be possible for several days after the installation.
- A restart of the eNodeB shall be avoided.
- The Server for the software download must not necessarily be located on the NEM in case of a standardized software download interface. This is especially important for Home eNB's.

5.5 [OPS04] AUTOMATED NEM UPGRADE

Goal

Operators need a smooth and fast NEM upgrade that does not disturb daily operational work.

Ideally the NEM upgrade (including preparation and cleaning up) should not take longer than one day shift and the NEM outage is not longer than the NEM needs for restart (< 30 min.). Human intervention should be minimized.

Any operator specific adaptations will be implemented automatically and security hardening must be performed.

Current Situation

Currently a major upgrade of the NEM (master server plus application servers) needs huge effort in operations and testing. Upgrade procedures are very complex and time consuming. Moreover the upgrades reveal a high risk to provide proper functionality when finished. Quite often manual rework is necessary. Nightshifts are very likely.

Areas that fail most are:

- Customer specific settings (configured by the supplier to adapt the product to the operator needs) get lost
- Operator specific settings (configured by the Operator for further adaptation to its own infrastructure) are lost
- Northbound Interfaces fail
- User Rights / Privileges are lost
- Security Settings are lost (e.g. OS Hardening, ssh keys, …)

Pre Conditions

NEM is on SW load N.

Trigger / Scheduling

Operator decision to upgrade. An update script shall be carried out that requires minimum human interaction.

Flow

NEM is being upgraded to release N+1.

Post Conditions

NEM is on Release N+1

Notes

A fallback to release N shall be possible for several weeks after the installation.

A restart of the NEM shall be avoided.

5.6 [OPS05] CELL OUTAGE DETECTION

Goal

Automatic system functionality test to detect sleeping or poor performing cells.

Current Situation

Cell outage is detected by statistical analysis, alarm or customer complains. Often, it may not be detected for several hours /days (sleeping cell). This may also only refer to some service in a cell (e.g. sleeping HSDPA, sleeping GPRS)

Pre Conditions

Network is in normal operation.

Trigger / Scheduling

Fault initiated: A fault occurs in a cell.

Flow

The KPIs exceed their acceptable range or a cell goes completely out of service. An appropriate alarm is being reported to NEM.

Post Conditions

The poor performing or sleeping cell is alarmed to the NEM.

5.7 [OPS06] PERFORMANCE MANAGEMENT IN REAL TIME

Goal

PM data analysis in near real time (~minutes) shall be possible and transferred via northbound interface

The information is needed for network optimization purposes. Sub usecases would be:

- Acquire meaningful PM data if cell load is changing fast ('The train problem')
- Monitor cell load on special events (football match, rock concert)
- Control cell behaviour after cell is integrated in the network or after changing some parameters.
- Trace of an individual subscriber who has a specific problem
- Gather information on specific problems in a cell

Current Situation

Fast performance management is not a state of the art feature in 2G and 3G systems. The desire is to be able to:

- real time evaluation (<1 Minute delay) of measurement data
- record real time PM measurement data
- trace individual mobiles
- collect mobile information on cell / neighbour quality

Today the transfer is done in 3 steps:

1. Upload PM data to NEM
2. Process PM data to an acceptable format for Itf.N. transmission
3. Send data via Itf. N.

Especially step 2 is far too complicated, resource consuming and slow. It eats up major parts (50-90%) of the resources of the NEM.

The available PM data is usually older than 1 hour and can not be used for direct fault correction control.

Pre Conditions

Normal operation mode. PM data is available for a dedicated time interval (e.g. 30 minutes) for all cells with a history of x days (e.g.3-7)

Trigger / Scheduling

Operator initiated.

Flow

The operator may start the collection of RT (real time) PM data if he is interested in the situation in the particular cell or in a group of cells. Data is being transferred over Itf. N.

Although the RT PM data is recorded there will be no history from the time before the collection was started.

Post Condition

Real time PM data is recorded and can be analyzed for network optimization / trouble shooting purposes.

In parallel the conventional PM data (average values of time intervals) is transferred via Itf N. as usual.

In future the NEM may not be loaded with PM data at all. An option to bypass the NEM for PM reporting is desired.

5.8 [OPS07] DIRECT KPI REPORTING IN REAL TIME

Goal

For each eNodeB a set of standardized KPIs shall be generated. If KPIs are exceeded an alarm shall be triggered. KPIs shall also be available in near real time(~minutes).

Current Situation

A set of counters is being configured to be continuously measured. Measurements are gathered reported to NEM and after a averaging over the measurement period (e.g. 30 minutes)forwarded (via Itf. N.) to PM centres. Here data is being analyzed and KPIs are being calculated.

In case of abnormal behaviour an alarm may be triggered and respective activities will start.

This procedure has major disadvantages:

- KPIs are calculated from average data. Important problems can not be seen.
- The newest KPI is about 45 – 60 minutes old (depending on averaging interval).
- With software upgrade the calculation of the KPIs has to be adapted in PM centre since delivered measurements change frequently. This is time consuming and error prone.

Pre Conditions

KPIs are being reported to NEM

Trigger / Scheduling

KPI data exceeds acceptable range

Flow

Alarm is being generated to indicate a KPI problem.

Post Conditions

Alarm is being generated to indicate a KPI problem. KPI data is available in near real time (~minutes) to allow the operator to control the effects of corrective manners.

Notes

There may be good reasons for the unexpected behaviour. It shall be possible to acknowledge and suppress the functionality by the operator.

5.9 [OPS08] INFORMATION CORRELATION FOR FAULT MANAGEMENT

Goal

Fault management shall be simplified and partly automated with the help of an information correlation functionality. Input values and output activities shall be configurable by the operator.

In NEM functionality is available to monitor in real-time important alarms and counters as an indication of the network health status. Problems can be detected by observing certain counters or alarms or patterns of different counter and alarm values. Based on these values or patterns a first estimation can be done on root cause of the causing problem. Patterns and causes are for example:

- call drop rate
- poor Setup Success Rate
- poor average throughput
- Measurement patterns*
- many others

→

- HW defects or
- SW failures in the network,
- user failures
- wrong or not ideal parameterisation
- Coverage problems
- Resource shortage

(Patterns based on experiences like: slightly lower call drop number (compared with network average) and lower HO access rate (compared with network average) are an indication for wrong neighbour parameterisation, coverage problem.)*

Current Situation

In many cases a failure of one particular piece of hardware generates a huge number of secondary alarms.

1. To find out the root cause a huge number of manual activities have to be carried out. Therefore other information that is available (like PM data, status information in NEM, etc) is used.
2. Standard activities (block / reset device) are carried out. This solves in many cases the problem.

This manual interaction shall be transferred to the NEM.

Description

Network is in normal operational state. A network failure occurs. An information correlation system continuously monitors status of important input data (real time pm data, device status information, alarm information, UE messages).

Trigger / Scheduling

Automatic: e.g typical pattern of alarms and KPIs.

Flow

1. From the combination of the input values the root cause of the problem is detected and verified with alarm information or device status. The activities shall be configurable by the operator.
2. Some simple operator actions like reset or blocking of devices shall be done automatically. It shall also be possible to take the cell out of service rather than having it on air with poor performance.

If the actions are not successful a alarm shall be raised to NEM.

Post Conditions

If the system could solve the problem it is disappeared. Otherwise an alarm is raised summarizing what the system has already done trying to cure the problem.

5.10 [OPS09] SUBSCRIBER AND EQUIPMENT TRACE

Goal

A trace functionality similar to the one defined in 3GPP TS 32.421 / 422 /423 is desired. This shall work without the usage of additional measurement equipment but only with measurements that are available on the system.

Current Situation

Huge effort is spent in generating detailed information about node and network status. Typical sources are traces of interfaces, drive test measurements and Performance and Alarm Measurements. Subscriber specific analysis is difficult and as a result seldom done.

Pre Conditions

Network is in normal operation. There are several reasons to start trace activity:

- Gain knowledge on network quality
- A repetitive fault is detected

Trigger / Scheduling

1. Operator initiated
2. Fault initiated

Flow

Post Conditions

Traces are available.

Notes

The following sub-use cases are also taken from TS 32.421:

1. multi-vendor UE validation.
2. subscriber complaint
3. malfunctioning UE
4. checking radio coverage
5. testing a new feature
6. fine-tuning and optimisation of algorithms/procedures
7. Automated testing of Service Provider services
8. Regression testing following a network fix

5.11 [OPS10] CELL OUTAGE COMPENSATION

Goal

HW failure of eNodeB unit causes complete outage of a cell. Loss shall be compensated by the network as much as possible until the failure is removed.

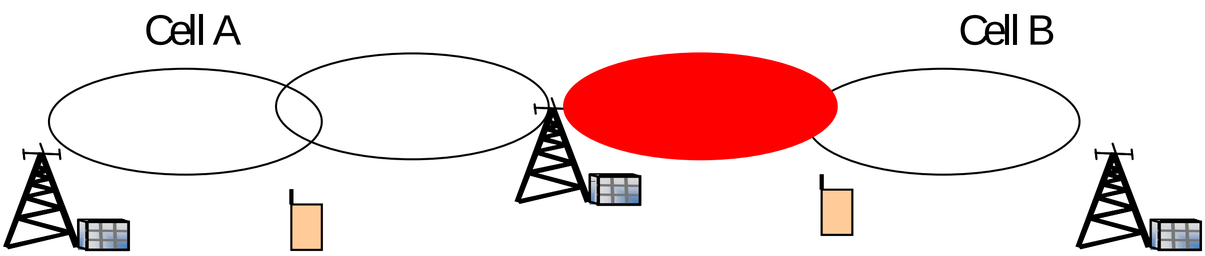


Figure 8: Outage of a cell

Current Situation

Functionality is lost in respective area. This will be detected by statistical analysis, alarm or customer complains. It may not be detected for several hours /days (sleeping cell).

Pre Conditions

Network is in normal operation.

Trigger / Scheduling

Due to a hardware defect a cell goes out of service. The loss of service is detected by the network (possible sources: Stats, Cell KPIs, RRM information in neighbour cell, UE neighbour list reports)

Flow

The network reacts to compensate the loss of service in the respective area. The procedure shall need no longer than 30 minutes.

In parallel an appropriate alarm is being reported to NEM.

Post Conditions

The network is being reconfigured to compensate the loss of service in the respective area. When the failure has been removed an autonomous reconfiguration to the initial status shall take place.

Notes

The network compensation could be:

1. Optimisation of RF parameters of neighbour cells to mitigate outage e.g. adaptation of power, sub-channels or antenna parameters
2. Neighbour lists shall be adapted.
3. Traffic may be shifted to 2G, 3G when handing over in defective cell.

5.12 [OPS11] COMPENSATION FOR OUTAGE OF HIGHER LEVEL NETWORK ELEMENTS

Goal

The network shall compensate problems on higher level network elements / lines.

A higher network element is faulty/not available. From customer point of view the network or services are not available even though the access nodes are working fine and other higher level networks elements are working.

Current Situation

Functionality is lost in higher level NE (aGW, Backbone). As a consequence customers a service is lost for the customer.

Pre Conditions

Network is in normal operation.

Trigger / Scheduling

For some reason a high level NE or a line to this NE goes out of service.

The loss of service is detected by the network (possible sources: Stats, Cell KPIs, Probes, …)

Flow

The network reacts to compensate the loss of service in the respective area. The procedure shall need no longer than 1 minute.

In parallel an appropriate alarm is being reported to NEM.

In case one of the higher network elements isn't available or the KPIs are decreasing the node should automatically cut the connection and change to alternative route.

Post Conditions

The network is being reconfigured to compensate the loss of service in the respective area. When the failure has been removed an autonomous reconfiguration to the initial status shall take place.

Notes

By using of a mashed network elements/nodes should be connected to different elements of the same kind of functionality. In case one of the higher network elements isn't available or the KPIs are decreasing the node should automatically cut the connection and change to alternative route.

5.13 [OPS12] FAST RECOVERY ON INSTABLE NEM SYSTEM

Goal

Intelligent fallback and recovery solutions are needed that do not need too much attention of the operator. This shall especially cover the northbound interfaces.

Current Situation

NEM systems become more and more powerful nodes. With the latest hardware it is possible to manage major parts of the network with one NEM. This increases the vulnerability of the operator.

Operators are concerned to guarantee continuous operations in case of any failure on their NEM system.

Suppliers shall provide easy backup and recovery solutions when designing their NEM infrastructure.

Pre Conditions

Network is in normal operation. All information is being backed up in regular intervals.

Some disturbance led to a corruption of data on the NEM. This may be in the MIB or OS.

Trigger / Scheduling

The operator decides to fall back to a backup of the data. The system shows all possible options and gives an indication about the number of changes between each backup.

Flow

The old data is restored from backups without further user intervention.

The NEM goes into service with the old database.

The NEM performs additional steps that are necessary to adjust the old database to the actual network status.

Post Conditions

The NEM is in full service again.

Notes

Basically this functionality is available today. But the practical experience on large scaled systems shows that the recovery of a live network NEM is a risky procedure and is avoided as much as possible. There are many human interactions and deep knowledge of system processes necessary to recover from a back-up.

5.14 [OPS13] MITIGATION OF OUTAGE OF UNITS

Goal

Automatic healing or mitigation mechanism for several failure classes. (e.g. reduce output power for temperature failure or automatic fallback to previous software version)

Current Situation

In case an alarm is send for a suspicious unit the operator is asked to start a diagnostic routine on this board. If the test doesn't produce a failure the unit should be resetted and monitored if the alarm occurs again.

If redundant units are affected the switch-over starts automatically in most cases but the faulty board have to be blocked manually.

In case of further outage of units depending on importance of impacted node an unplanned site visit is necessary. Depending on the priority of node the service outage with impact of customer must be accepted for some time.

Pre Conditions

Normal operation mode

Trigger / Scheduling

Trigger: outage of unit

Schedule: on demand

Flow

Appropriate activity to use redundancy or to mitigate the outage has to be taken place.

Post Condition

- Normal operation mode or
- Restricted operation mode accepted by operator (activity to solve problem from long-term perspective is scheduled)

6 ABBREVIATIONS

CM	Configuration Management
CN	Core Network
FM	Fault Management
IM	Inventory Management
Itf. N.	Northbound Interface
KPI	Key Performance Indicator
LTE	Long Term Evolution
MIB	Management Information Base
NE	Network Element
NEM	Network Element Manager
O&M	Operation and Maintenance
OS	Operating System
OSS	Operations Support System
PI	Performance Indicator
PM	Performance Management
RAN	Radio Access Network
SAE	System Architecture Evolution
SMA	Software Management Application

7 REFERENCES

R2-061545, Complexity minimisation to setup and optimise an LTE network, T-Mobile, KPN

R2-061929, Standardisation policy for plug and play RAN, NTT DoCoMo

R2-062230, Discussion on Auto-configuration and Dynamic Optimization, Lucent, T-Mobile

R2-062156, Measurements for Network Optimization, Motorola, T-Mobile

R2-062411, Support for self-configuration and self-optimisation Proposal for Stage2 (Chapter 19.1),

R2-062940, Support for self-configuration and self-optimisation Proposal for Stage2 (only RAN2 relevant part), T-Mobile

R3-061487, Self-Configuration and Self-Optimisation, Problem Statement and Definition, T-Mobile

R3-061488, Impact of Self-configuration and self-optimisation functionality on architecture & interfaces, T-Mobile

R3-061487, Self-Configuration and Self-Optimisation, Problem Statement and Definition, T-Mobile & KPN

R3-061509, Clarification of functions for self-optimization and self-configuration, NTT DoCoMo

R3-061559, Usage of Self Tuning Protocols, Nortel

R3-061482, Self-configuration and self-optimization in E-UTRAN, Lucent

R3-061530, Self optimisation Scenarios, NEC

S2-063879, Support for self-configuration, T-Mobile

R3-061715 Discussion of some solutions to Self-Configuration, Huawei

R3-061758 Self configuration and self optimisation for neighbour cell lists, Nokia

R3-061748 Consideration on Neighbours Self-Optimization LTE, Nortel

R3-061749 Consideration on Coverage-Capacity Self-Optimization LTE, Nortel

R3-061850 Self configuration & self optimization use cases, T-Mobile, KPN

R3-061974 Self configuration & self optimization use cases, T-Mobile, Nokia